Essays on Roads, Poverty, and Subjective Well-being in Ethiopia

Marshal Negussie Simie

A Dissertation Submitted

To

The Department of Economics, Addis Ababa University

Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Economics

Addis Ababa University

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Acknowledgments

As a person living in Ethiopia, it is hardly possible to ignore the poverty surrounding us in our day to day lives. It is fascinating to see how some people manage to escape deprivation, make their lives better, and lead the way for others to follow. One of those lives was my father's. Negussie Simie (PhD) was born in 1960 in a small town called Asebe Tefferi, also called Chiro, located near a national highway in the south-eastern part of Ethiopia. He lost his father at a young age and was raised by his mom. Except few it was difficult to become educated because most children spend their time working to support their families. My father was fortunate enough to be allowed to go to school, although he was still supposed to work in the morning or afternoon shifts.

Amidst of harsh economic, social, and cultural environment, Negussie went to school and managed to join one of the two universities that existed at that time. He put in decades of hard work to get a decent income and a family that would have been fantasy in the place where he was born. In his classic manner, my father set about making sure that I did better than he had done. He managed to put me (and my two brothers) in one of the prestigious private schools in Addis Ababa. He is now pleased to see that I have a standard of living that he had imagined and had been contributing for.

My father was born in abject poverty, but he now lives in comparative affluence. This is not an unusual story, yet it is far from common. Even though my father was working hard in a country that was also prospering on average, not everyone was as motivated, nor as lucky as him. He was lucky enough not to be among those who died during childhood, lucky not to die from malaria or any other disease, lucky to be born in a relatively active town, and lucky to have access to education. Hard work opens up opportunities, but not everyone is capable of seizing and capitalizing on them as evidenced across the world. Few are doing incredibly well while others are left behind in poverty and deprivation. It is a world divided between great wealth and still crippling poverty.

Ending extreme poverty will be a challenge for the coming generation and I have keen interest to get into that complexity. I believe the end of poverty is not automatic, but within reach. It is for us to take it seriously in our individual actions, businesses, academia, and workplaces so

that we can all contribute our share to its end. I want to contribute my part through this research undertaking by starting to study how this could happen.

I am grateful to my main supervisor Professor Kristofer Månsson (Jönköping International Business School, Jönköping University, Sweden) who provided me directions and advice along the way. Thanks to his guidance and patience, I found the strength to endure difficult times and complete this dissertation.

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Glory to God!

Marshal Negussie Simie
Addis Ababa, Ethiopia
May 2020

For

Mebrat,

my definition of true and beautiful

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Introduction

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Abstract

Poverty is the most pressing and unresolved economic problem in the world. Trying to combat it is natural since its existence embodies the diminution of human capabilities. But what is poverty and how do we identify the poor and the non-poor? What are the extent and trends of poverty? What are the profound effects that roads have on the level and distribution of households' poverty? How do different measurements of well-being relate to each other in terms of conveying policy implications? This dissertation asks and answers these questions in the context of Ethiopia drawing from Malthusian, welfare, and behavioral definitions of well-being. The dissertation is a composition of three standalone papers. Chapter 1 gives an introduction highlighting the structure, role, and common themes of all the papers. Chapter 2 presents the first paper that analyzes the effects of rural roads on consumption poverty. Chapter 3 covers the second paper that assesses the impact of trunk roads on multidimensional poverty. Chapter 4 gives the third paper that focuses on identifying the effects of multidimensional deprivation on subjective well-being.

Keywords: roads, well-being, Ethiopia, consumptive poverty, multidimensional poverty, subjective well-being

JEL Classification: D03, D11, D31, H54, I32, O18, P25

1. Poverty and its Measures

Poverty has been in existence for ages and continues to be a pressing problem in many developing countries (Bourguignon and Chakravarty, 2003). Measuring poverty has been one of the key challenges in the struggle against poverty. Income or consumption poverty measures have been commonly applied in the assessments of living standards and are routinely consulted by policymakers (Jefferson, 2012; Laderchi et al., 2003; Ravallion and Bidani, 1994). Historical focus on consumption as a sole measure of welfare owes to the Malthusian world during a period when the basics of economic theory were laid and most of the population was living below subsistence levels (Fischer, 2009). In this situation, an improvement in consumption led to an apparent increase in well-being which was easily measured by the amount of goods and services a household consumed (Courard-Hauri, 2007). In today's world, this is not much different from what is being witnessed in developing countries (Fischer, 2009).

Nowadays, welfare economists argue for going beyond consumption measures and propose other dimensions of well-being (Alkire, 2002; Bader et al., 2016; Bourguignon and Chakravarty, 2003; Roelen, 2017). The first practical argument against consumption measures is the poor quality of income/expenditure data in developing countries (Browning et al., 2003; Deaton, 2010). The second theoretical argument is the multidimensional nature of poverty (Alkire et al., 2015). Money plays a central role in escaping poverty, but just as important or even more so are better health, better education, and better shelter (Alkire and Santos, 2014; Nolan and Whelan, 2011). Starting with Sen's (1976), seminal work, a multidimensional approach to poverty and well-being has increasingly become popular. Currently, there are different established frameworks for measuring poverty in multidimensional environment (Alkire and Foster, 2011; Barrientos, 2013; Metz and Gaie, 2010).

However, both consumptive and multidimensional poverty measures fail to capture the emotional aspects of individual lives. Being aware of this, behavioral economists argue that subjective well-being is better suited for helping civilizations develop a better world (Diener, 2009, 2012). Proponents of subjective well-being argue in favor of taking the perspective of an individual whose life is being evaluated as a better way of evaluating well-being (Diener and Seligman, 2018; Kesebir and Diener, 2008; Tella and MacCulloch, 2006). Accordingly, subjective well-being is a broad evaluation that captures an individual's perspective on his or

her quality of life (Diener, 2009). Subjective well-being in economics goes beyond the conventional method of inferring preferences from observed choices as it provides metrics for capturing felt utility (Tella and MacCulloch, 2006).

Any measure of well-being or poverty revolves around three (consumption, multidimensional, and subjective) metrices. Previous studies show that the consumption and multidimensional measures of poverty represent different aspects of well-being and can be used for complementing any government policy's evaluation (Alkire et al., 2015; Bader et al., 2016; Nolan and Whelan, 2011). Subjective well-being functions as the bigger domain by incorporating the consumption and multidimensional status of individuals (Diener et al., 2010; Diener and Seligman, 2018; Easterlin, 1974). However, a comparison of the three well-being measures is not the intent of this dissertation. Consumption and multidimensional poverty measures are separately used, in different chapters of this dissertation for evaluating the effects of roads on households' well-being. Then, the two measures are brought together in the last chapter for analyzing their effects on subjective well-being.

2. Ethiopian Road Development

Throughout human history the most valued sites are determined by their geographical settings and accessibility to transport facilities (Hasselgren, 2018). Ancient civilizations, dependent on the gifts of nature, took things as they found them. A few favored spots on the earth had a number of essential elements (such as water, fertile soil, favorable weather, and protection against enemies) and there were ceaseless wars for controlling these places. Where transportation was possible, the missing elements were provided through trade. Advantages of transportation are regarded as equal to or even more important than rich resources (Melo et al., 2013). The fact that nearly all rich cities around the world enjoy the advantage of transportation shows the importance of transport in economic development (Owen, 1959).

Ethiopia is a landlocked country with roads functioning as the most crucial means of transportation (NBE, 2020). The country introduced the Road Sector Development Program (RSDP) in 1997 which has been responsible for the rapid expansion of roads (Ethiopian Roads Authority, 2020). The program has reached its 5th phase and was responsible for total physical works of about 153,000 km till the 2019 fiscal year (Table 1.1). The physical work includes the construction, rehabilitation, upgrading, and maintenance of roads. The RSDP program

disbursed USD 17.5 billion financed by both domestic and foreign sources. This physical work is the backbone of the project with a 69 percent performance level when evaluated against the program's plan. However, road networks in the country are still limited to a few urban centers and most areas are far removed from basic economic and social services (Nakamura et al., 2019).

Table 1.1: Performance summary of RSDP in 22 years

Program	Program Period	Physical Plan Vs Accomplishment, km		
		Plan	Actual	Percentage*
RSDP I	1997 – 2002	8,908	8,709	98
RSDP II	2002 – 2007	8,252	11,589	140
RSDP III	2007 – 2010	14,686	12,395	84
RSDP IV	2010 – 2015	97,517	85,860	88
RSDP V (4 years)	2015 – 2020	93,122	34,460.1	37
Total RSDP (22 years)	1997 - 2020	222,485.4	153,013.1	69

Note: *The percentage compares the actual with the program's plan. In RSDP II the accomplishment was more than the plan for the specified period.
Source: The Ethiopian Roads Authority (2020).

Of the total road expansion work, about 50 percent is attributed to one of the components of RSDP known as the Universal Rural Road Access Program (URRAP). It was introduced in 2010 for connecting all rural communities with standard all-weather roads that provided year-round access. In the 1st implementation period (2010-15), it was planned to construct 71,523 km of URRAP roads throughout the country, of which 62,413 km or 87 percent of the target was completed. URRAP is currently in its 2nd phase (2015-2020) and 14,902 km all-weather roads had been constructed till the 2019 fiscal year (Table 1.2). The performance of the 2nd phase is poor with only 17 percent of the plan being accomplished and with only one year remaining for the program to end.

Table 1.2: URRAP's performance under RSDP IV and V

No.	Regions*	First Phase Performance (2010-2015)			Second Phase Performance (2015-2020)		
		Plan	Actual	Percentage	Plan	Actual	Percentage
1	SNNPR	14,003	9,580	68	18,722	3,944	21
2	Amhara	18,003	12,553	70	20,488	3,245	16
3	Oromia	30,007	36,211	100	35,005	7,121.49	20
4	Tigray	2,500	3,044	100	5,164	325	6
5	B/Bumuz	1,800	488	27	1,126	163	14
6	D/Dawa	159	285	100	286	66	23
7	Harari	50	192	100	135	-	-
8	Gambella	200	60	30	428	8	2
9	Somali	3,001	0	0	6,619	-	-
10	Afar	1,800	0	0	2,027	-	-
	Total	71,523	62,413	87	90,000	14,902	17

Note: *Ethiopia has 9 regional states and 2 city administrations (Addis Ababa and Dire Dawa).
Source: The Ethiopian Roads Authority (2020).

3. The Current Study

The availability of transport services can be regarded as a measure of well-being, implying that households are poor if they do not have access to transport services of the necessary standards (Batten and Karlsson, 1996). "Even in the most remote and least developed of inhabited regions, transport in some form is a fundamental part of the daily rhythm of life" (Hoyle, 1973). Besides, where production and consumption are taken as the joining of goods and services with wants, transportation can be a main and archetypal way of raising incomes (Aggarwal, 2018; Ramessur et al., 2010). Animals, for instance, which are senior form of being as compared to plants in the classification of the scientific theory of evolution, find food through movement and can have wider place interactions. Animals move from place to place to find food and for escaping unsuitable habitats. To this, human beings have added transporting things, thus adding to their own welfare.

The first two papers in this dissertation bring different aspects of poverty and roads together and present the impact of roads on poverty reduction. The focus of traditional cost-benefit evaluations has been on roads' direct outputs, namely, road length, reduced travel times, transportation costs, number of beneficiaries, and accident risks (Jones et al., 2014). However, the effects of improved roads come more generally from integrated markets as well as improved access to key services such as healthcare and education (Castella et al., 2005; Yamauchi, 2011). Thus, the broadest evaluation of roads looks at induced changes in household well-being.

Much of the literature on the macroeconomic role of productive public expenditure is closely related to theoretical work on the contribution of infrastructure to growth (Arrow and Kurz, 1970; Barro, 1990; Ghosh and Roy, 2004). In the microeconomic context, improved road infrastructure can create opportunities for economic growth and poverty reduction through a range of mechanisms (Aggarwal, 2018; Ghani et al., 2016). Transportation costs as well as the costs of consumption and production of goods and services can be reduced through road improvements (Olsson, 2009; Storeygard, 2016). Improved roads can also expand farm and non-farm production through increased availability of relevant inputs and lower input costs, with easier access to markets and technology (Damania et al., 2017; Gollin and Rogerson, 2014; Qin and Zhang, 2016). Road development can also contribute to higher productivity and demand for labor at the household level leading to potentially greater earning opportunities

(Aggarwal, 2018; Ramessur et al., 2010). Such developments in turn can boost household consumption (Fan et al., 2000) and other household benefits such as improved education and health status (Bryceson et al., 2008; Sapkota, 2014). However, sometimes low commercial surplus coupled with domestically bound travel may result in limited or no impact of roads on people's lives (Asher and Novosad, 2020; Dawson and Barwell, 1993; Porter, 2007).

There are many diverse existing studies on this issue but most of them disagree while trying to identify the different aspects of households' lives that roads may affect (Ahlström et al., 2011; Attard, 2015; Faber, 2014; Hilbrecht et al., 2014; Yamauchi, 2011). Thus, the first paper of this dissertation argues that consumption poverty assessment can integrate the different effects that roads might have on households' economic and social activities thus providing comprehensive information. Hence, the paper investigates how important the differences in rural road access are in explaining consumption poverty's persistence over time in the context of Ethiopian rural households. The main research questions raised in this paper are: what are the extent and trends of consumption poverty in the sample households? What are the effects of roads on consumption poverty? What are the factors associated with the chances of moving into or out of poverty?

The focus of global discussions on the nexus between roads and poverty has been on single dimensional achievements alone. The of-late accepted multidimensional nature of poverty opens up an opportunity for capturing the multiple impacts of roads on different dimensions of poverty. Hence, the second paper investigates the impact of trans-regional roads on multidimensional poverty. It provides answers to questions such as: what is the level of the multidimensional poverty index (MPI)? What is the contribution of each dimension and indicator to the overall index? Are there any differences in MPI levels between the treatment and control groups over time? What is the impact of roads on overall MPI? What is the impact of roads on each dimension of MPI?

On the other hand, proponents of the behavioral aspects of well-being argue than an assessment of human well-being should be based on how people value their lives, not in terms of their access to goods and services. Following this proposition, economic literature focuses on investigating the relationship between income and subjective well-being leaving out the non-monetary aspects of objective well-being. Thus, the third paper brings non-monetary

multidimensional deprivations into the discussion and assesses their effect on households' subjective well-being. The main questions raised in this paper are: does multidimensional deprivation reduce subjective well-being? Does multidimensional deprivation affect the different components of subjective well-being equally? What other factors predict subjective well-being?

Though the concepts raised in the three papers are related, each paper is a standalone study. The questions raised in each paper are enduring, while recent methodological advances make the time particularly appropriate for this research work.

4. Methodological Approaches and Data Sources

Formulating effective responses to the questions raised in each paper requires an understanding of the overlapping concepts of well-being, proper implementation of their measurement, reliable data, and using an appropriate econometric technique. This section briefly explains the different measurement techniques and the data used in each paper.

4.1. Measuring consumption poverty and roads

In the traditional economic theory, utility is regarded as the satisfaction obtained through consumption of goods and services (Deaton and Muellbauer, 1980). The amount of income and the level of prices determine the level of utility or as Samuelson (1974) indicated this theory postulates that utility increases as income increases. This understanding clarifies the dominating role of the income measures of poverty in research work and political decision-making processes (Fischer, 2009). In the first paper of this dissertation, consumption aggregates are used for an analysis of poverty. The aggregates are also used for identifying the poor, in computing standard measures of poverty, and in identifying who is likely to benefit or lose from road construction.

It is difficult to estimate consumption poverty as there are many choices and practical problems that such an estimation entail (Ravallion, 1998). What components should be incorporated in the consumption aggregation? How should differences in economies of scale and cost of living be considered? How should the poverty line be constructed? What reference basket of goods should be used in pricing the minimum cost of basic goods? After providing a brief review of the conceptual framework underpinning typical poverty analyses, the first paper uses the

guidelines provided by Deaton and Zaidi (2002) to tackle these challenges. The paper applies a five-step procedure for constructing consumption poverty measures. First, construction of nominal consumption aggregate. Second, adjustment of the aggregate for differences in the cost of living across space and time. Third, adjustment for household composition. Fourth, construction of the poverty line. Finally, identifying the poor and calculating poverty measures using the Foster-Greer-Thorbecke (FGT) approach (Foster et al., 1984).

Considering the dynamic nature of poverty and the endogenous nature of roads the next challenge is using a credible econometric technique for estimating the causal effects of rural roads on poverty. The standard approach in literature uses continuous real consumption outcomes instead of binary consumption poverty outcomes. The availability of conventional methods such as the system GMM makes consumption changes/growth the preferable dependent variable in existing studies (Dercon et al., 2009). Consumption outcome shows the effects of roads across the whole sample, poverty outcomes have the advantage of providing insights into the distributional effects of roads. Specifically, poverty outcomes help in identifying whether the development of roads is strong enough to pull households out of poverty. However, solving endogeneity and initial condition problems is notably difficult in non-linear models which existing studies on the road-poverty nexus fail to address. Thus, the first paper uses a random-effects econometric model called the 'Wooldridge Conditional Maximum Likelihood Model' that takes care of these problems (Wooldridge, 2005). The system GMM is also estimated as a robustness check.

The first paper uses panel data for 2015, 2016, and 2017 collected by the Ethiopian Roads Authority (ERA) with support from the World Bank. The data was originally collected from the regional states of Oromia, Harari, Gambella, and Dire Dawa to evaluate the impact of URRAP on local economic outcomes. The data used a dummy variable that classifies households as having access to roads or not based on a household's distance from the nearest road. Households within a radius of less than 2 km were categorized as the 'with access' to roads group and those above 5 km were put in the 'without access' in accordance with literature and the Ethiopian Ministry of Transport's classification of accessibility. Socioeconomic information was collected from 4,474; 4,300, and 4,224 households in the first, second, and third waves of the survey respectively.

4.2. Measuring multidimensional poverty and roads

Developments over recent years in welfare economics have raised the importance of considering multiple dimensions of well-being in assessing poverty (Alkire et al., 2015; Atkinson, 2002; Sen, 1983, 2000). Quite a few methodologies have been developed to construct multidimensional indices including "the dashboard approach, the composite indices approach, Venn diagrams, the dominance approach, statistical approaches, fuzzy sets, and the axiomatic approach" (Alkire et al., 2015). Composite indices and the dashboard approach are 'marginal measures' implemented using aggregate data from different sources. They have the disadvantage of missing the joint distribution of deprivation. The remaining approaches encompass joint distribution and are applied using information on each dimension and household. The methodologies can function as vital complementary tools, but of all the methodologies, the axiomatic methodology offers a stronger tool for measuring multidimensional poverty.[1]

In measuring multidimensional poverty, a 'counting approach' is one way of identifying the poor (Sen, 1976). The counting approach entails six fundamental steps: defining a set of indicators, defining a threshold for each indicator, creating a binary deprivation status for each person in each indicator, assigning a weight to each indicator, producing a weighted sum of the deprivation, and setting a poverty cutoff. The counting approach is intuitively appealing and has become the tradition in academic and policy circles (Bourguignon and Chakravarty, 2003). Therefore, the second paper of this dissertation uses Alkire and Foster (2011) multidimensional measurement which combines the counting approach with axiomatic rigor.

The AF measure uses the counting approach as an identification strategy and extends it by using aggregation methodologies within a formal axiomatic approach. The aggregation of AF measures entails: computing the incidence of multidimensional poverty (H), computing the intensity of multidimensional poverty (A), and computing the adjusted headcount ratio (M_o). The AF measure has salient features of sub-group decomposability, dimensional decomposability, and dimensional monotonicity, which makes it appealing for transparently informing policy. Therefore, the second paper of this dissertation uses the AF measure for:

[1] See Alkire et al. (2015) for an extensive explanation of the methodologies.

producing the measures of multidimensional poverty; identifying poverty trends; monitoring the changes in a particular dimension and indicator; comparing the composition of poverty by road access groups; and evaluating the impact of access to roads on multidimensional poverty.

The next crucial step is estimating the causal effects of roads on multidimensional poverty. A key methodological concern in road-poverty causal inferences pertains to the selection of treatment and control groups. Road allocations are usually based on pre-determined criteria and the groups might be on entirely different growth paths regardless of road construction. The second paper uses the difference-in-difference (DID) method that is appropriate when randomization of a program is not feasible. The inconvenience is also addressed the inclusion of control variables in the estimation. Propensity score matching is also used to re-weigh the DID regression as a 'doubly robust' procedure.

The second paper uses household level panel data with a quasi-experimental design collected in 2012 and 2016 by ERA with support from the World Bank from four corridors that were upgraded under RSDP. The roads are Aposto-Wondo-Negele, Mekenajo-Dembidollo, Kombolch-Bati-Mille, and Ankober-Awasharba in the southern, western, north-eastern, and eastern parts of Ethiopia, respectively. The before and after project nature of the data is appropriate for the causal impact of roads on multidimensional poverty. The data identified households living within a 2 km radius of a road as the treatment group and those living further than 12km from the road as the control group. A total of 960 and 906 households were interviewed in 2012 and 2016 respectively, with 5.6 percent attrition rate.

4.3. Measures of subjective well-being

Earlier studies present well-being measures purely as a mechanical issue without a trace of its psychological makeup (Easterlin, 2014; McCloskey, 1983). When addressing what is to be measured and how, subjective judgments are not directly referenced whether it is in income terms that have historically been applied for measuring welfare or multidimensional terms that are used for capturing broader capability approaches (Kahneman and Krueger, 2006). However, religious figures, philosophers, and social scientists have for long discussed the nature and meaning of well-being in the form of happiness (Joshanloo, 2014; Rizvi and Hossain, 2017). For instance, ancient Greek philosophers like Plato and Aristotle valued eudaimonic happiness premised on virtues, skills, and positive functioning (Keyes and Annas, 2009). Similarly, the

Utilitarian notion of happiness holds the hedonic conceptualization of well-being which claims that increasing happiness entails increasing pleasure and decreasing pain (Fischer, 2009).

More recently, social scientists have started conducting 'scientific' studies of happiness in largely separate ways (Diener, 2012). Rather than focusing on dysfunctional forces such as depression, psychologists consider positive affect and an emotional state which is brought about by positive thoughts and feelings (Schimmack et al., 2010). They try and understand the determinants of happiness using survey and experimental data and by identifying different kinds of mental processes, personality traits, and environmental factors (Lykken and Tellegen, 1996; Stubbe et al., 2005). Many social scientists evaluate the state of well-being by examining how people feel about their lives in the context of their own standards (Tella and MacCulloch, 2006). This notion of happiness is interchangeably expressed as subjective well-being to use a more scientific-sounding term (Diener, 2009).

Literature has accepted that subjective well-being has cognitive and affective components (Andrews and Withey, 2012; Corrigan et al., 2013; Kahneman and Krueger, 2006). The cognitive component is an overall evaluation of life, while the affective component is a combination of positive and negative instant feelings (Emmons and Diener, 1985; Watson et al., 1988). Then these concepts of well-being are related through a 'need based' theory which postulates that the fulfillment of needs leads to subjective well-being (Maslow, 1943; Tay and Diener, 2011). Then the question arises on what constitutes a measurement of needs. Earlier literature presents basic needs purely as a monetary issue based on the implicit assumption that income adequately measures economic status (Deaton, 2007; Easterlin, 1974). This thinking justifies a discussion on income and subjective well-being. However, welfare economists recognize that income measures do not proxy other welfare indicators such as educational and health achievements (Alkire et al., 2015; Bader et al., 2016; Nolan and Whelan, 2011). Therefore, the third paper uses households' multidimensional deprivation scores in addition to consumption expenditure for identifying the effects of objective conditions on subjective well-being.

Three methodological challenges are usually faced regarding subjective well-being. The first is the yardstick for an interpersonal comparison, that is, it is important to use survey questions that literature recognizes as reliable and valid. The third paper uses a life satisfaction question

with a 11-unit scale for measuring cognitive well-being and feeling questions with a 5-unit scale for measuring affective well-being. The second problem is the ordering bias: the order of questions can affect individuals' responses (Frey and Stutzer, 2002). Thus, the third paper uses questions that are placed at the beginning of the survey. The third challenge is the bias of idiosyncratic events and personality traits. Fixed-effects estimation that corrects the bias from time invariant unobserved personality traits is used in estimating the effects of multidimensional deprivation on subjective well-being. The third paper uses the same dataset as the second paper.

5. Summary of the Papers

The first paper, 'The Effect of Rural Roads on Consumption Poverty: The case of Ethiopia' assesses how differences in access to rural roads explain poverty's persistence. Using household panel data collected in 2015, 2016, and 2017 on rural roads, this paper shows that areas with road access had a clear declining trend in poverty headcount, poverty gap, and poverty severity over time. Interestingly, the gains also went to low-income groups. Using the 'Wooldridge conditional maximum likelihood' non-linear dynamic regression model, the paper shows that access to roads leads to a lower probability of households falling into poverty. Households with access to roads have a 25 percent lower likelihood of being in consumption poverty. This result is robust to different model specifications and estimation techniques.

The paper also shows that without controlling for initial conditions and unobserved heterogeneity, it is hard to accept any test for the state dependency of poverty. The standard random-effects estimator considerably overstates a household's state dependency or a household's risk of repeated poverty. This model shows that the risk of falling into poverty in one year is noticeably higher if poverty is observed in the previous year even after controlling for observed heterogeneity. However, a continuing spell of poverty is removed when the initial conditions and unobserved heterogeneity are controlled for by using Wooldridge's original auxiliary estimator. The varying results on state dependency coupled with the strong significance of road access on poverty reduction is an indicator that rural roads are key to escaping repeated poverty traps. Therefore, considering these results, it is important to continue constructing rural roads for accelerating poverty reduction.

The second paper, ‘Roads to Multidimension Poverty? Evidence from Ethiopia,’ assesses the impact of roads on multidimensional poverty. The Alkire Foster Adjusted Headcount Ratio and its consistent sub-indices are used for calculating the multidimensional poverty index (MPI). MPI is composed of health, education, and standard of living dimensions. A total of 10 indicators with two indicators for health, two indicators for education, and six indicators for standard of living are used in calculating MPI. Based on this comparable index, it is found that multidimensional poverty in the sample fell between 2012 and 2016. Decomposing multidimensional poverty among the control and treatment groups shows that the average proportion of deprivation suffered by the poor population was larger for the control group which had higher poverty rates.

The DID estimation framework supports the existence of poverty reduction effects through road improvements. DID’s results show that investments in road development lead to an average drop in multidimensional poverty by at least 12 percentage points among treated households. This result is robust to different model specifications. A separate impact analysis of roads on the dimensions of health, education, and living standards is also done for identifying specific results. The study finds that roads have a strong impact on the standard of living, a moderate impact on health, and no statistically significant impact on education deprivation. Therefore, considering these results, it is important to develop roads to accelerate multidimensional poverty reduction. The results also suggest that a combined policy effort is needed to exploit better benefits not only by developing roads but also by enhancing complementary services like education and health.

The third paper, ‘Multidimension Deprivation and Subjective Well-being: The Case of Selected Communities in Ethiopia,’ investigates the effects of multidimensional deprivation on subjective well-being. The fixed-effects estimation results of panel data collected in 2012 and 2016 suggest that multidimensional deprivation had a significant effect on the respondents’ subjective well-being. Exhibiting the largest marginal effect, respondents who were deprived in basic needs reported lower subjective well-being. These results show that reducing multidimensional deprivation is very important for improving satisfaction with life, which is a reflective judgment on people’s lives compared to what they want them to be. Reduction of

multidimensional deprivation is also related to improvements in positive feelings and reduction of negative feelings.

Real per adult consumption expenditure has a substantial influence on life satisfaction and a relatively lower influence on positive and negative feelings. Since the study uses consumption expenditure which captures households' permanent incomes, the results show that permanent incomes are associated with stable changes in subjective well-being which is captured through satisfaction of life. In addition, the dependency ratio and unemployment effect all the three domains of subjective well-being whereas the comparison effect does not relate to subjective well-being. Social association is related to positive feelings and chronic health problems with negative feeling. Therefore, this paper maintains that it is important to devise non-monetary multidimensional interventions if society's subjective well-being is to be improved.

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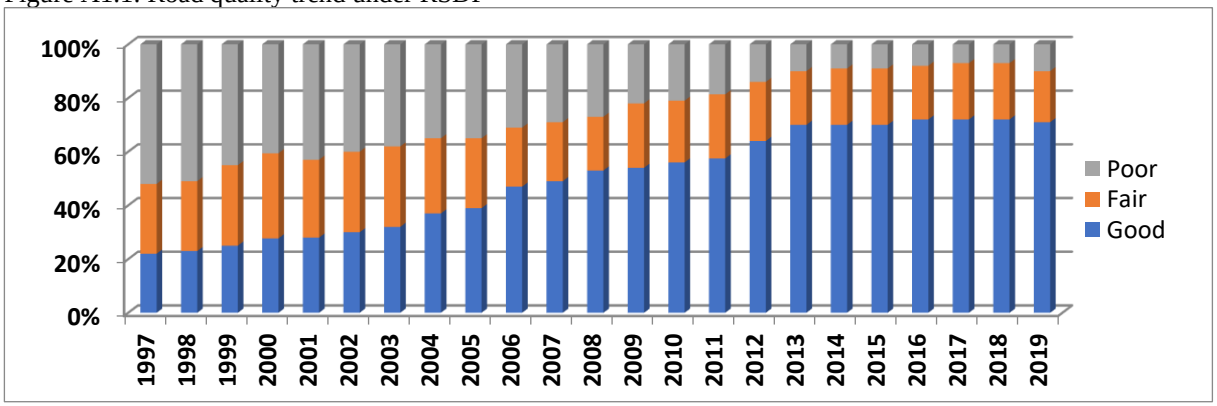
Appendix A1

Figure A1.1: Road quality trend under RSDP



Source: The Ethiopian Roads Authority (2020).

Paper 1: The Effect of Rural Roads on Consumption Poverty: The Case of Ethiopia

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The Effect of Rural Roads on Consumption Poverty: The Case of Ethiopia

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Abstract

One third of the developing world's population lives in areas far away from paved roads. This spatial isolation is a key limiting factor in their accessing socio-economic opportunities. The construction of rural roads has been emphasized by the Ethiopian government as a crucial step for reducing poverty. In view of this thinking, some questions that need to be asked are whether and to what extent road construction has facilitated the alleviation of poverty? Using a three round longitudinal data of households obtained from the Ethiopian Roads Authority, this study uses a dynamic non-linear probit model to assess the impact of rural roads on consumption poverty. The model allows accounting for initial conditions and time invariant unobserved heterogeneity. The findings show that access to rural roads reduces poverty by 25 percentage points. The analysis also indicates that initial conditions matter in estimating the trajectory of poverty dynamics.

Keywords: rural roads, consumption poverty, panel data, dynamic probit, Ethiopia

JEL Classification: C23, D12, H54, I32, O18, P25

1. Introduction

Ethiopia has made remarkable progress in its economic growth in the past decade and the incidence of consumption poverty declined from 45.4 percent in 2000 to 27 percent in 2016 (The World Bank, 2019). Developments in the agriculture and service sectors with heavy public investments in infrastructure were at the center of the country's growth experience. According to the The World Bank (2015) the country had the third highest public investment rate in the world which rose from about 5 percent in the early 1990s to 18.6 percent of GDP in 2011. In line with this development, road construction assumed a prominent portfolio in the government's spending and was an important catalyst in its economic development. The country's road network increased from 32,871 km in 2000 to 120,171 km in 2017 (NBE, 2018). However, this progress was not without costs as Ethiopia's infrastructure investment deficit is the third largest in Africa (The World Bank, 2015).

Given the large investment costs, there is theoretical and policy desire to better understand the returns from investments in rural roads (Stifel et al., 2016). In line with this, a large body of research discusses changes in poverty as an important measure of the failure or success of specific government policies (Jefferson, 2012; Ravallion and Bidani, 1994; Sen, 1983). A poverty profile is also used as an eligibility criterion for prioritizing government projects. It can be argued that well-designed economic policies supported by sound empirical evidence can provide critical assistance in the struggle against poverty (Ravallion, 1998). Therefore, it is important to gather more empirical evidence on how differences in access to rural roads explain poverty persistence, as the goal of reducing the infrastructural gap is maximizing the society's well-being.

Research shows that access to roads and transport services leads to access to opportunities which can fuel the growth process (Batten and Karlsson, 1996; Ghani et al., 2016; Stifel et al., 2016; Storeygard, 2016). Improved roads can expand farm incomes through easier access to markets and technology and increased availability of relevant inputs at lower costs (Damania et al., 2017; Qin and Zhang, 2016). Roads can also help rural households diversify their income sources by opening employment opportunities and allowing economic mobility. Diversification and expansion of incomes of the rural poor improves food security and lowers the poverty rate (Aggarwal, 2018; Ramessur et al., 2010). In general, researchers have been identifying the

diversified links through which road construction can affect a society's welfare. But instead of looking for these elusive chains, a more policy informative way, especially in developing countries, is measuring the impact of road construction on alleviating poverty. The premise of this study is that better road access is a strong enough factor for pulling households out of poverty.

However, the appeal of this type of benefit may be at odds with the increasing skepticism about returns to investments in rural roads. Domestically bound rural travel may result in a limited impact on the lives of rural dwellers (Asher and Novosad, 2020; Dawson and Barwell, 1993; Porter, 2007). Rural roads carry less traffic, are harder to maintain, and costlier to construct (Bryceson et al., 2008). Moreover, low commercial surplus coupled with high costs of wheeled transport services can lead to underuse of rural road infrastructure (Bryceson et al., 2008). All this implies that the impact of roads on society stems from how the roads are used and not from the construction of roads.

This study investigates how important the differences in road access are in explaining poverty persistence over time in the context of Ethiopian rural households. It examines the extent of consumption poverty, the role that access to roads plays in reducing rural households' absolute poverty, and the factors associated with the chances of moving into or out of poverty. The welfare economics approach (Sen, 1979) measures poverty through household utility, which in turn is usually assumed to be approximated by consumption or income-based measures. Income is generally used as a measure of household welfare in developed countries, but it tends to be seriously understated in self-employed or large agricultural populations. Whereas consumption expenditure is less underreported and more closely reflects permanent income in developing countries (Deaton and Zaidi, 2002; Haughton and Khandker, 2009). Thus, consumption aggregates are used in this study as they are more reliable and stable than income measures (Deaton and Zaidi, 2002).

Even though there has been a proliferation of research on factors affecting consumption poverty, the contribution of roads to poverty reduction in rural areas is little known. There are many recent studies which explain the impact of roads on poverty (Aggarwal, 2018; Ahern et al., 2016; Asher and Novosad, 2020; Asomani-Boateng et al., 2015; Nakamura et al., 2019; Stifel et al., 2016; Yi and Kim, 2018). Most of these studies look at the impact of urban or city

connecting highways, with an emphasis on economy-wide income and efficiency gains (Ahlström et al., 2011; Attard, 2015; Faber, 2014; Hilbrecht et al., 2014; Yamauchi, 2011). As compared to urban roads, rural roads in different contexts and reach of transport infrastructure are likely to generate different qualitative and quantitative impacts (Asher and Novosad, 2020; Stifel et al., 2016). Moreover, research findings in relation to rural roads depend on cross-sectional data which fails to control for unobserved heterogeneity. Even in studies that have longitudinal considerations, the well-recognized dynamic behavior of poverty and the associated initial condition problem are not closely examined.

Building on previous research findings, this study contributes to literature in different ways, including comparing households with and without access to rural all-weather roads, using quasi-random variations which use a straight-line distance between household location and roads. The study's focus is also on consumption poverty which integrates the different links and objectives that roads might have on households' economic and social activities. It also explores possible determinants of poverty besides roads using richer data and a richer econometric analysis than previously applied in a developing country. The study's findings have policy implications for Ethiopia, which has been investing heavily in roads and is planning to invest more in rural roads.

The rest of this chapter is organized as follows. Section 2 discusses the theoretical and empirical underpinnings of the study. Section 3 presents the context and data. Section 4 discusses the research models. Section 5 gives the empirical results followed by a discussion of the results. The conclusions are given in Section 6.

2. Literature Review

2.1. Theoretical review

Poverty, in an absolute or relative sense, is the presence of deprivation (Jefferson, 2012). Since it is a condition that exists in scarcity, it is of intrinsic interest for economists and policy makers. Examining changes in household's poverty status can be considered as one of the fundamental measures of the success or failure of government policies. Studies indicate that spatial poverty traps are a silent feature of the rural landscape in developing countries (Edmonds and de Veen,

1992; Kam et al., 2005). Lack of reliable access to social, economic, and political domains means that societies remain in poverty (Edmonds and de Veen, 1992).

Improvements in transportation are usually considered a compelling developmental intervention which covers 20 to 40 percent of the national budgets in developing countries (Jedwab and Storeygard, 2019). Multilateral organizations have also been devoting more than 20 percent of their developmental loans for improvements in transportation (The World Bank, 2002). The simple and deterministic conclusion by Lugard (1922) has long prevailed in policy frameworks of sub-Saharan countries: "the material development of Africa may be summed up in one word, transport." Literature also recognizes the contributions that road development can make in overcoming spatial poverty traps by both widening households' interactions with their surrounding environment and providing facilities that improve the quality of their lives (Aggarwal, 2018; Damania et al., 2017; Qin and Zhang, 2016; Ramessur et al., 2010; Stifel and Minten, 2017).

Improvements in the quality of transport services and reduction in transport costs because of access to roads can have positive effects on increasing households' real income and consumption through three inter-related links: first, transport services provide access to markets; second, they affect the prices of goods and services; and third, they affect productivity (Batten and Karlsson, 1996).

Missing market channel: Roads can be taken as an interface that facilitates the acquisition of goods and services and the flow of people and ideas and allows for their exchange across space. They can influence the geography of an economic activity and can contribute to the development of markets and market-related institutions (Ghani et al., 2016). A dense market cannot typically be obtained without easy means of transportation to bring in and carry back large supplies. The number of both buyers and sellers that make up a single market is also determined by the availability of transportation. With improved access to markets, buyers have the option of selecting from a wide variety of commodities and sellers find many buyers gathered in one place. Hence, the transport system plays a big role through the market system in influencing household welfare (Mu and van de Walle, 2011).

Rural remote areas usually have incomplete or non-existent markets. Given high transportation costs, concerned goods and services are not easily available in these areas (Jacoby, 2000). With better transport infrastructure, travel costs to existing markets can be reduced, relocation of existing markets can be induced, and new markets can be developed. In all cases, transport induced market development can contribute to economic activity by moving things/people into a more suitable place, improving access to various services, and promoting broader economic development. Moreover, the development of a transport-market can bring non-economic benefits such as social interactions, recreation, and exchange of ideas (Skinner, 2002). However, sometimes improved transport access may not initiate local market development, as it allows households to reach already established markets easily (Mu and van de Walle, 2011).

Price channel: Access to transportation also has the power to condition exchange values (Storeygard, 2016). Rural households participate in markets by trading resources, goods, and services. The market determines the prices of the traded goods; it also determines a large part of, if not all, households' income and consumption (Cowell, 2018). Adequate transport is expected to facilitate efficient market operations, thus having a favorable impact on prices for rural households either as producers or consumers (Minten and Kyle, 1999). For instance, rural roads may lower the prices of inputs and/or raise the prices of outputs for households in remote areas. However, access to transport can also expose rural villages to enhanced competition, implying lower producer prices and lower incomes (Asher and Novosad, 2020).

Moreover, the price of transport services relative to other goods and services affects the level of household consumption that can be achieved in the given budget constraint. Transport prices and associated modes of transport in turn depend on the availability of transport infrastructure. For instance, studies in tropical Africa document the wide practice of 'head loading' of logs, water, and crops because of the absence of roads for motorized and non-motorized means of transportation (Batten and Karlsson, 1996; Bryceson et al., 2008). The cost of transporting goods and agricultural inputs to and from markets depends on the relative cost of head loading goods (that is, using human porters) and the relative cost of trucking goods, which in turn affects household's consumption.

Productivity channel: With improved transportation, rural households can better utilize agricultural and non-agricultural opportunities by employing resources more efficiently

(Khandker et al., 2009). As improved road access leads to a reduction in transportation costs, the prices of modern inputs are more likely to fall, and farmers can apply more of these inputs for improving their farm productivity (Gollin and Rogerson, 2014). In addition, with better road access, farmers can hire skilled labor to take care of specialized agricultural production (Qin and Zhang, 2016). Better means of transportation can also improve productivity by reducing the time, energy, and boredom of walking long distances (Ramessur et al., 2010). When a reduction in transportation cost is combined with improvements in agriculture and labor productivity it results in large welfare improvements (Gollin and Rogerson, 2014).

However, all these implied links of investments in transport and poverty reduction derive not from the mere construction of transport infrastructure but from its efficient functioning (Batten and Karlsson, 1996; Owen, 1959). The construction of transport infrastructure only provides an option, but its efficient utilization depends on other exogenous factors that cannot be taken for granted in most developing countries (Asher and Novosad, 2020). Here the concerns start with public finance's focus on rural road construction. This relates to most developing countries' limited financial capacity for constructing and maintaining roads (Edmonds and de Veen, 1992). In fact, some authors argue that interventions, other than transport, with less project time and investment costs are more likely to alleviate poverty (Hirschman, 1958; Hoyle, 1973). Essentially, they argue that the construction of transport infrastructure can be politically motivated and may lead to misdirected investments (Burgess et al., 2015).

Moreover, over engineered roads may not necessarily satisfy the needs of the 'overwhelmingly rural walking world' in developing countries (Bryceson et al., 2008). The degree of available economic opportunities because of road construction, is a direct function of accessible goods and services. The rural population predominantly travels on foot with small loads over short distances. Most journeys are for purposes which do not involve buying or selling and are for meeting basic needs such as water, fuel wood, and food. In his work on the famine in Ethiopia, Sen (1982) showed that while there was clearly a shortage of food in the province of Wollo in 1973-74, two highways were used for moving food out of the area. Even with the disastrous failure of food output in Wollo during this period, the prices went up only slightly. As such, private food markets were not induced to ship more food to the province. Sen (1982) argues that the problem was not underdeveloped roads, but the collapse of the residents' earning power.

For most of the rural population in Ethiopia, even the very simple, non-motorized and intermediate means of transportation such as carts and wheelbarrows are not affordable (Edmonds and de Veen, 1992). The available non-motorized means of transportation are usually forgotten in policymaking and are put out from the market (Bryceson et al., 2008). To be economical, expenditure on providing roads must be warranted by the density of road traffic, which is less likely to occur in rural populations in developing countries.

Similarly, roads alone are not enough of a stimulus for development because roads are only part of the solution to the problems that rural populations face and their effects are context specific (Asher and Novosad, 2020; Demenge et al., 2015; Edmonds and de Veen, 1992). While the advantages of road construction tend to concentrate within a 3-km corridor along a road, its benefits are captured by the better-off population (Khandker et al., 2009; Porter, 2007). Benefits from roads also depend on the existence and efficiency of integrated development projects (Ambel et al., 2015). Thus, the benefits from improvements in transport seems to be diversified and context specific.

2.2. Empirical review

Identifying the link between poverty and road construction is important, though a complex process for directing policy interventions. Existing studies show that urban or city connecting highways are able to reduce poverty (Ahlström et al., 2011), improve trade integration (Faber, 2014), increase the value of property (Donaldson and Hornbeck, 2016; Gonzalez-Navarro and Quintana-Domeque, 2016) and improve market access (Mu and van de Walle, 2011). The effects of roads on growth seem to be mixed with studies showing positive effects (Ghani et al., 2016; Owen, 1959; Storeygard, 2016), no effects (Banerjee et al., 2012), or negative effects (Faber, 2014).

Several studies also provide evidence of the effect of roads on a wide variety of economic outcomes in rural areas (Aggarwal, 2018; Aparna et al., 2017; Asomani-Boateng et al., 2015; Bryceson et al., 2008; Damania et al., 2017; Demenge et al., 2015; Edmonds and de Veen, 1992; Khandker et al., 2009; Rammelt and Leung, 2017). Aggarwal (2018) shows that developing rural roads results in lower prices of non-local goods, higher market integration, improved agricultural technologies, and high enrollment gains. Aparna et al. (2017) provide

evidence that rural roads in India changed the trip rates of households to work, education and other places. A recent study by Asher and Novosad (2020) gives evidence that new rural feeder roads in India have no major effect on individuals' consumption, assets, and agricultural outcomes. Older studies document that development of rural roads is associated with diversified economic benefits (Bryceson et al., 2008; Edmonds and de Veen, 1992; Jacoby, 2000; Minten and Kyle, 1999).

While existing literature is very diversified when it comes to identifying the different channels at play between well-being and road provisions, their direct effects on poverty reduction seem to be under-researched. Diversified approaches are useful in fleshing out a multidimensional portrait of roads, but lack of focus can make the interpretation of this portrait difficult. A reliable way of judging the effects of road construction is through measuring their direct effect on poverty reduction. As Ravallion (1998) argues, a "credible measure of poverty can be a powerful instrument for focusing the attention of policy makers on the living conditions of the poor".

Given that measuring poverty is difficult, basic questions on the extent of poverty and how poor households respond to their economic and physical environment need to be understood in detail. Quantitative evidence on how roads affect consumption poverty measures in Ethiopia is quite scarce. One major reason for this is the difficulty in finding before and after data which can enable a causal impact evaluation. The intensive investments needed for roads also make randomized provisions of roads difficult (Aggarwal, 2018). With these difficulties, existing literature on transport infrastructure's effects has largely relied on quasi-random variations which use a straight-line distance between peripheral regions and roads.

A notable work in this respect is by Dercon et al. (2009), which examines the impact of access to roads on poverty and consumption growth by using household level panel data from rural Ethiopia. The results of their GMM estimation show positive and significant outcomes of roads on growth in consumption. They used community representatives' responses for identifying the closest town and the quality of the roads leading to that town. A complementary research by Kifle and John (2012) used a spatial equilibrium framework and found that there exists road induced growth of rural household income. However, both studies devote much attention to

linear models and solve the problems with the within estimator by using transformations to eliminate the unobserved effects. With non-linear models, transformations for eliminating the unobserved effects and solving the initial conditions problems are important (Khandker and Koolwal, 2011) and notably more difficult (Wooldridge, 2005).

Stifel et al. (2016) followed a different approach by estimating the willingness-to-pay for reduced transport costs for rural feeder roads located in rugged terrain of northwestern Ethiopia. Their result suggests that rural feeder roads were associated with high rates of returns, but they were conservative in concluding whether their result followed the geographical characteristics of the study area or transport cost-induced household behavioral differences. Another recent study by Nakamura et al. (2019) found that developing rural roads in Ethiopia increased households' consumption by 16.1 percent between 2012 and 2016. Their study applied a difference-in-difference matching approach by combining a road-network database with a nationally representative household survey. However, as the study itself states, " it is often hard to keep track of the rural road development across time and space when the program covers the entire area of a country" and depend on a causal evaluation (Nakamura et al., 2019).

This study contributes to literature by shedding light on the association between roads and the dynamic behavior of poverty. Specifically, it uses a non-linear model of consumption poverty and controls for the endogeneity problem by considering the initial conditions in estimating poverty.

3. Models and Estimators

3.1. Conceptual framework

The canonical model of consumption is based on the presumption that consumers choose the best thing that they can afford. A consumer's optimal utility is derived from selecting the best combination of commodities within a given income and price. Consider a household with a vector of characteristics $\mathbf{x}$, consuming a vector of quantities $\mathbf{q}$, and facing a vector of prices $\mathbf{p}$. The utility function $\mathbf{u}(\mathbf{q},\mathbf{x})$ represents the household's preference among affordable commodities (Ravallion, 1998). These preferences are interpretable as the consumption rate of $\mathbf{q}$ given $\mathbf{x}$. Yielding the same result, the household's expenditure function is $\mathbf{e}(\mathbf{p},\mathbf{x},\mathbf{u})$, which associates each vector of prices $\mathbf{p}$ with the minimum cost of reaching the utility level $\mathbf{u}$ for a

household with characteristics **x** (Deaton and Muellbauer, 1980). The money metric utility (Samuelson, 1974) for household **h** is defined as:

$$\mathbf{u_m^h} = c\left(\mathbf{u^h}, \mathbf{p^0} | \mathbf{x^h}\right) \quad (2.1)$$

which is the minimum cost of reaching $\mathbf{u^h}$ at prices $\mathbf{p^0}$ for a given household's characteristics $\mathbf{x^h}$. The derivatives of the expenditure function with respect to prices yields its approximation as (Deaton and Zaidi, 2002):

$$\mathbf{u_m^h} = c\left(\mathbf{u^h}, \mathbf{p^o} | \mathbf{x^h}\right) \approx \mathbf{p^0}.\mathbf{q^h} \quad (2.2)$$

which is the household's vector of consumption goods valued at reference prices.

Then, the poverty line can be interpreted as a point on the consumer's expenditure function, giving the minimum cost of the poverty level of utility at the prevailing prices and for given household characteristics (Ravallion, 1998). Let the reference utility level needed to escape poverty be represented by $\mathbf{u_z}$. Thus, the poverty line is:

$$z = e(p, x, u_z) \quad (2.3)$$

Finally, measures of poverty are obtained by comparing the information about the distribution of consumption expenditure with the poverty line.

3.2. Consumption aggregates and poverty measures

Following the more common practice and Deaton and Zaidi's (2002) guideline, this study uses a consumption-based measure of poverty. Components of consumption expenditure are aggregated into classes of food items, non-food items, and consumer durables. The food consumption sub-aggregate includes food purchased in the marketplace, food that is home produced, and food items received as gifts. The non-food items include consumption of daily use items such as soaps and cleaning supplies, kerosene and petrol, charcoal and miscellaneous personal care items, as well as other less frequently purchased items such as clothing, footwear, kitchen equipment, household textiles, and other household items. Education expenditure is also included as a non-food item. For durables, annual estimates of service values are used as a measure of consumption. The prices reported by households are used in the analysis. As housing

and rental markets are not well developed, it is difficult to calculate any serious estimate of rental values and hence this is not included in the consumption aggregate.

Consumption is expressed in per adult equivalent terms to account for economies of scale and consumption requirements. Adjustments are also made to account for differences in the cost of living by deflating the nominal food aggregate using the Paasche price index of the money metric approach (Deaton and Zaidi, 2002). Following Equation (2.2), the Paasche price index is defined as:

$$p_P^h = \frac{p^h . q^h}{p^0 . q^h} \tag{2.4}$$

Thus, the expenditure function in Equation (2.2) is approximated by:

$$\mathbf{u_m^h} = \frac{\mathbf{p^h} . \mathbf{q^h}}{p_P^h} = \frac{\mathbf{x^h}}{p_P^h} \tag{2.5}$$

Then, the poverty line is constructed using the 'cost of basic needs' approach and the price in 2015 as the base. Following recommendations for Ethiopia (MoFED, 2002), the food poverty line is estimated based on the cost of a reference food bundle that provides 2,200 Kcal per adult per day (Greer and Thorbecke, 1986). A common diet for everyone is used in each period by selecting a basket of goods consumed by the middle quantile of the sample. To this is added the non-food line by following the method set out in Ravallion and Bidani (1994) -- by regressing the actual food share of each household by the log of total actual household expenditure in relation to the food poverty line. This is expressed as:

$$s_h = \alpha + \beta \log\left({y_h}/{z^f}\right) + \epsilon_h \tag{2.6}$$

where, s_h is the share of food out of y_h total expenditure; z^f is the cost of the reference food bundle; α and β are parameters to be estimated; and ϵ is the error term. Having this, the poverty line is calculated as:

$$z = z^f(2 - \alpha) \tag{2.7}$$

The poverty status of each household is then delineated by identifying its position relative to the constructed poverty line. Those with a consumption per adult equivalent above or equal to

the poverty line are regarded as non-poor and those below the poverty line are considered poor (Ravallion, 1998).

Given the constructed information on the poverty line, the poverty headcount, gap, and severity indices are constructed (Foster et al., 1984; Sen, 1976). The poverty headcount index measures the proportion of households living in poverty. The poverty gap index adds the extent to which households on average fall below the poverty line and expresses it as a percentage of the poverty line. The poverty severity index provides the weighted sum of poverty gaps by emphasizing more on the poorest.

3.3. Regression model

Researchers have long studied the patterns and causes of consumption poverty and reached several important conclusions. As discussed in the literature review, poverty is inextricably linked to improvements in transport infrastructure. Poverty can also persist over time, that is, a previous experience of poverty makes future poverty more likely. Studies have shown that state dependency in poverty is a well-established fact (Alem et al., 2014; Biewen, 2009; Méndez-Lemus and Vieyra, 2014; Nilsson, 2012; Yildirim et al., 2018). It is interesting to investigate the extent of 'state dependency in poverty' when there are shocks to public investments such as those for road construction.

The most notable, context specific, economic, and human capital assets that might correlate with poverty are land, livestock, and literacy levels (Abro et al., 2014; Ghebru and Holden, 2019; You, 2017). Moreover, researchers agree that household structures are important as they show a possible correlation between a household's composition and its level of poverty. Gender of the household head might influence household poverty, and more specifically, households headed by women are expected to be poorer than those headed by men in the rural context (Haughton and Khandker, 2009; Kumar and Quisumbing, 2012). The aging process might also affect a household's poverty status through changing capabilities over time (Maes, 2013).

Using models where the poverty status is regressed on lagged observations is a standard approach for handling longitudinal poverty dependence (Alem et al., 2014; Biewen, 2009; Giarda and Moroni, 2015; Skrondal and Rabe-Hesketh, 2014; Yildirim et al., 2018; You, 2017).

In such a dynamic model, the probability of being poor could depend on whether a household experienced poverty in the previous period, that is, 'state dependence' is allowed through the lagged dependent variable. Even when the coefficient of the lagged dependent variable is not of direct interest, consistent estimates of other parameters can be recovered by allowing dynamism in the underlying process (Arellano and Bond, 1991; Jalan and Ravallion, 2002).

Consider the following dynamic probit unobserved effect model for the latent dependent variable of poverty status y_{it}^*, for household i at time t:

$$y_{it}^* = \gamma y_{it-1} + \mathbf{x}_{\mathbf{it}}'\boldsymbol{\beta} + c_i + u_{it}$$
$$y_{it} = 1(y_{it}^* > 0) \text{ otherwise } 0 \qquad (i = 1, \dots, N; \quad t = 2, \dots, T) \qquad (2.8)$$

where $\mathbf{x_{it}}$ is a vector of explanatory variables including road access; c_i is household specific unobserved heterogeneity; and u_{it} is assumed to have zero expectation and variance σ_u^2. The parameters γ and β are the coefficients to be estimated. The cross-section unit "N" is large but observed for a small and fixed period "T", so asymptotic properties are on "N" going to infinity.

A convenient normalization, since y is a binary variable, is $\sigma_u^2 = 1$. The probability of being poor for household i at time t, given c_i, is:

$$P[y_{it}|\boldsymbol{x_{it}}, y_{it-1}, \alpha_i] = \Phi[(\gamma y_{it-1} + \boldsymbol{x_{it}'\beta} + c_i)(2y_{it} - 1)] \qquad (2.9)$$

where Φ is the cumulative distribution function of the standard normal distribution.

An important issue in this setting is the treatment of the initial conditions, since the influence of the initial observations on each subsequent observation cannot safely be ignored when the time dimension is small (Aitkin and Alfó, 1998; Akay, 2012; Arulampalam and Stewart, 2009; Hsiao, 2014). For instance, the placement of rural roads may follow existing trails or may focus on areas with a comparatively high population density. The standard random effects model assumes c_i is uncorrelated with $\boldsymbol{x_{it}}$ and the lagged value of the dependent variable, which may be appropriate if the start of the process coincides with the start of the observation period for everyone (Card and Sullivan, 1988; Heckman, 1981). But, if poverty status in the initial year is endogenous, a correlation is induced between the error term and the lagged dependent variable

and then ignoring it will lead to a bias in the parameter's estimations (Alem et al., 2014; Fotouhi, 2005).

Two popular approaches have been proposed to handle the problem of the initial conditions. Heckman (1981) suggests 'integrating out' the individual specific error term from the likelihood function and approximating the joint distribution of the full observed endogenous variable. But this approach relies on computationally intensive methods. An alternative approach by Wooldridge (2005), specifies a density for the unobserved heterogeneity conditioned on the initial dependent variable and explanatory variables. The Wooldridge (2005) estimator has the same likelihood structure as the standard random effect probit model with the lagged and initial dependent variables among the regressors. Relatively, Wooldridge's solution has the advantage of simple computational techniques and can be estimated using standard estimation software. Thus, the Wooldridge (2005) model is used in this study to analyze the probability of being in poverty.

The original Wooldridge (2005) model specifies the auxiliary model for c_i as:

$$c_i = \alpha_0 + \alpha_1 y_{i1} + \boldsymbol{x_i}\boldsymbol{\alpha_2} + a_i \qquad (2.10)$$

where $\boldsymbol{x_i} = (x_{i1}, \ldots, x_{iT})$ and $a_i \sim$Normal $(0, \sigma_a^2)$. A more common specification for c_i, in literature uses the conditional means of the time varying explanatory variables based on all periods (Chamberlain, 1984; Mundlak, 1978). However, using longitudinally averaged variables is found to be biased unless the panel is sufficiently long (Akay, 2012; Rabe-Hesketh and Skrondal, 2013). Thus, time-varying covariates on each occasion are used in this study.

A balanced panel data is assumed in developing the Wooldridge estimator (Wooldridge, 2005). Yet, it may be applied to a sub-set of observations constituting a balanced panel and assuming that the sample dropout is ignorable. To check the robustness of the results, estimates derived using both balanced and unbalanced panels are reported in this study.

4. Context and Data

4.1. Rural roads in Ethiopia

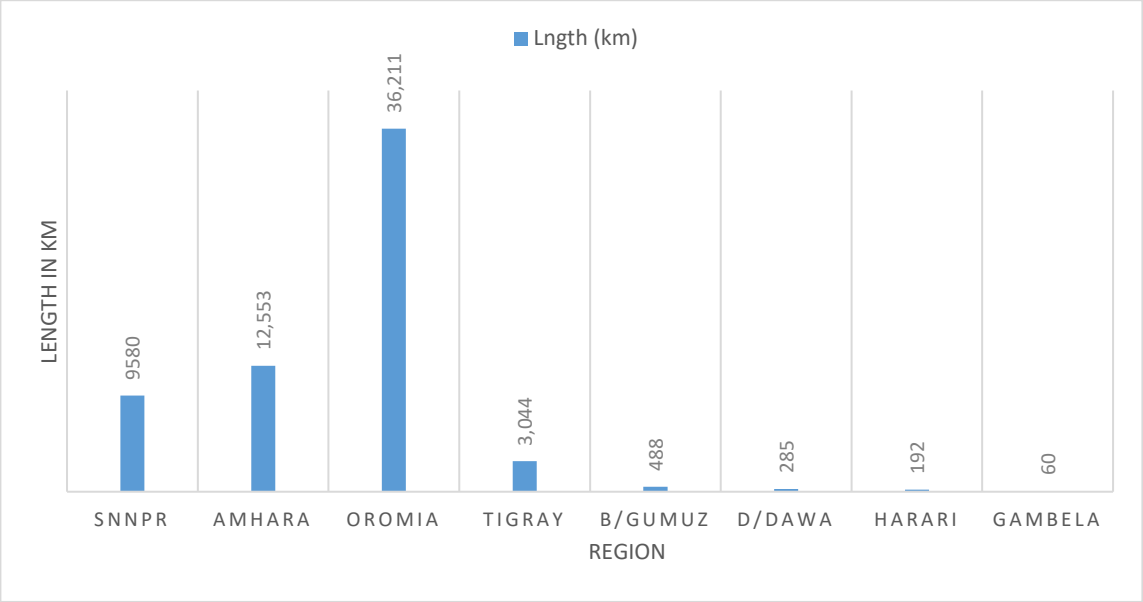
Investments in rural roads are one of the main priorities of the Government of Ethiopia as these are regarded as a mechanism for reducing poverty (International Monetary Fund, 2004). In 2010, the government embarked on the Universal Rural Road Access Program (URRAP) that set out to connect all rural villages by all-weather roads. For roads that are designated as 'all-weather roads' an improved surface, for example, gravel or something similar is required and it needs to be passable for motorized traffic in both wet and dry weather. URRAP targets delivering, expanding, and improving the conditions of rural road networks in all regions of the country (Ethiopian Roads Authority, 2009).

The full-fledged implementation of the URRAP plan will ensure that close to 80 percent of the total rural population has access to roads year-round. In the first implementation period (2010-15), it was planned to construct 71,523 km of all-weather roads throughout the country at an estimated cost of 1.4 billion dollars, of which 62,413 km of URRAP roads or 87 percent of the target for the five years has been completed (Figure 2.1). The construction of these roads increased the number of kebeles[2] connected with all-weather roads from 6,222 in 2010 to 11,871 in 2015 (Ethiopian Roads Authority, 2016). However, the extent to which these roads contributed to the welfare of society is inadequately documented.

Despite substantial improvements and the huge investments in URRAP, a large proportion of the rural population has no access to all-weather roads. In 2015, about 24 percent rural districts in Ethiopia had no access to all-weather roads. As a result, the modes of transportation for the rural population were restricted to humans and pack animals, transporting only a few agricultural products and inputs from and to the nearest markets. The government planned to construct 90,000 km of URRAP roads in the second implementation period (2015-20). However, the construction of these roads was stopped without giving any official reason.

[2] Kebele is the smallest administrative unit in Ethiopia.

Figure 2.1: Length of URRAP Roads Completed in the First Phase



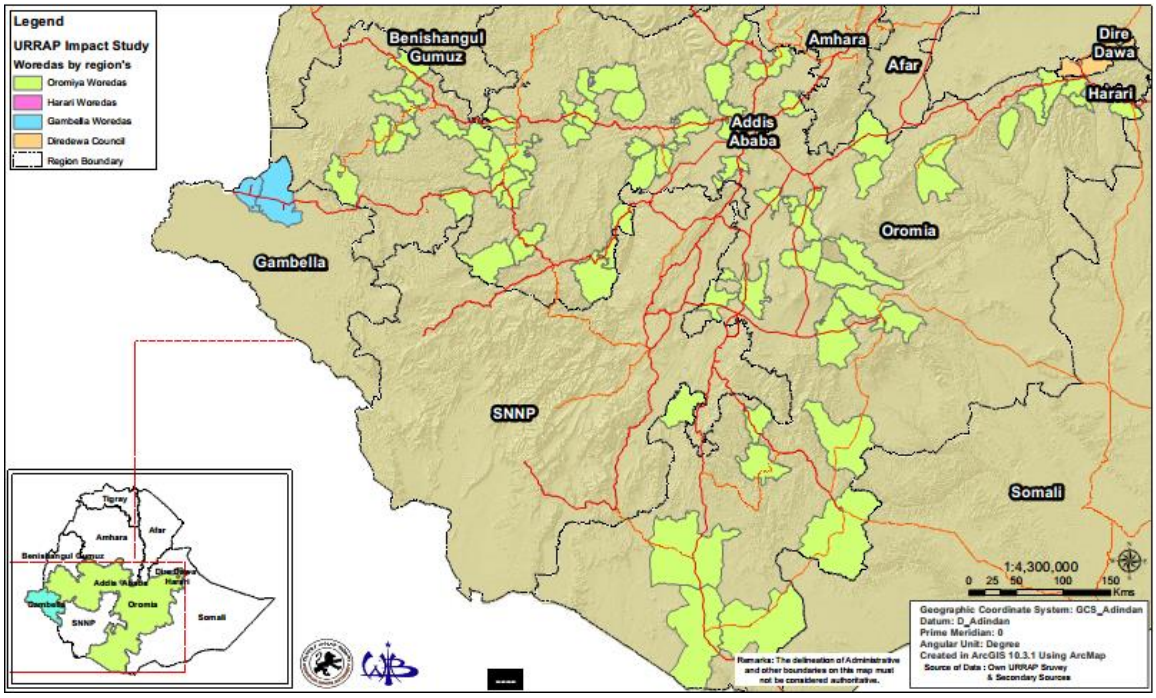
Source: The Ethiopian Roads Authority (2016).

4.2. Data

Considering the lack of proper baseline surveys and documentation of basic indicators for each URRAP road, the Ethiopian Roads Authority has collected baseline and evaluation studies of these roads for three years (2015, 2016 and 2017). The baseline studies, follow-ups, and evaluations consider both the positive and negative impacts of the roads on the rural population and their livelihoods through the selection of various economic, social, and physical indicators.

This study used the three-round longitudinal household survey of the Ethiopian Roads Authority. The baseline, follow-up, and end-line surveys were done in 2015-17 and covered the same households using the same procedures and instruments. The survey included the four regional states of Oromia, Harari, Gambella and Dire Dawa. Considering 25 percent of the sample proportion of the URRAP districts, 66 districts in Oromia, two districts in Gambella, three in Harari, and five in Dire Dawa were randomly selected using the proportion to size rule. Then, one URRAP road was randomly selected from each district, all villages crossed by the sample URRAP road were listed and two villages were randomly selected. Villages served by other road networks and nearest to the urban centers were omitted from the frame. The total number of sample villages, therefore, was 152 in 76 road networks in 76 districts. Figure 2.2 shows the study area.

Figure 2.2: Study area



Source: The Ethiopian Roads Authority.

After this, the households were categorized based on the road influence area threshold of 2 km from URRAP roads in accordance with literature and the Ethiopian Ministry of Transport's classification of accessibility. Hence, households within a radius of less than 2 km were 'with access' to roads and those above a radius of 5 km were 'without access'. In doing so, two development groups were targeted, representing those 'with access' and those 'without access' and 304 enumeration areas were selected from the sampled villages. To ensure potential for similarities in each enumeration area the type of crops, major sources of livelihood, agro-ecological zone, and distance from roads were considered. Each development group consisted of 20 to 30 households. Finally, 15 households were randomly selected from each enumeration area or 60 households per URRAP road and district. In all, 4,560 households were identified for the study (50 percent of each with and without access). The final sample households interviewed in the survey were 4,474, 4,300, and 4,224 in 2015, 2016, and 2017, respectively. Table 2.1 presents the sample size of the four regions for each round.

Table 2.1: Sample size

Indicator		Year			Attrition Rate Between 2015 and 2017
		2015	2016	2017	
Region	Oromia	3934	3799	3721	5.4%
	Gambella	120	118	120	-
	Harari	240	211	211	12%
	Dire Dawa	180	172	172	4.4%
Group	With access	2406	2311	2271	5.6%
	Without access	2068	1989	1953	5.6%
Total		**4474**	**4300**	**4224**	**5.6%**

Source: The Ethiopian Roads Authority.

Two limitations were encountered in this data. First, the data replaced the dead, ill or transferred household heads with new household heads from the same household. This might not affect household aggregate factors, but it can change a household head's characteristics such as age and sex. Second, the data was designed to evaluate the impact of roads on poverty which requires data before and after the intervention. But for some observations within the access groups the road construction was completed in the initial period and for others it was not completed even in the last round of the panel survey. Thus, households which were classified under the 'access group' in the survey design but which did not have completed roads, or had roads under construction, were treated as the 'without access' group in the data analysis and estimation. Thus, after making arrangements for road completion status and balanced data, the access classification indicated in Appendix Table A2.1 was used in the model's estimation.

4.3. Descriptive statistics

Table 2.2 shows the measures of poverty headcount, gap, and severity in 2015-17 for sub-groups of households with and without access to a road[3]. Poverty headcount declined from about 46 percent in 2015 to 42 percent in 2017. The pace of poverty reduction in the group with access to roads was strong, particularly when compared to the without access group. In 2015, both areas were nearly the same in terms of poverty incidence with 45 percent for areas with access and 46 percent for areas without access to roads. But they differed strongly through time

[3] Poverty headcount index measures the proportion of households living in poverty, poverty gap index adds up the extent to which households on average fall below the poverty line and poverty severity index provides the weighted sum of poverty gaps by emphasizing more on the poorest.

as the poverty incidence in areas with road access declined dramatically. In 2017, the poverty incidence ratio for observations for the access to roads group was about 37 percent while for those without access group it was about 45 percent. This reduction mainly took place between 2015 and 2016.

Table 2.2: Poverty profile across time and by access groups

Welfare Measure	Year			Difference (2015 and 2017)
	2015	2016	2017	
Poverty Headcount /Incidence/	**0.4551**	**0.4286**	**0.4221**	**-0.0330 (0.0106)** ***
With access	0.4501	0.3775	0.3668	-0.0833 (0.0160) ***
Without access	0.4608	0.4546	0.4533	-0.0075 (0.0146)
Poverty Gap /Depth/	**0.1630**	**0.1681**	**0.1505**	**-0.0124 (0.0049)** **
With access	0.1615	0.1360	0.1251	-0.0364 (0.0072) ***
Without access	0.1647	0.1844	0.1649	0.0002 (0.0067)
Poverty Severity	**0.0797**	**0.0882**	**0.0729**	**-0.0068 (0.0022)** **
With access	0.0789	0.0694	0.0609	-0.0180 (0.0046) ***
Without access	0.0807	0.0977	0.0797	-0.0011 (0.0042)

Note: ** p<0.05, and *** p<0.01. Standard errors in parentheses.
Source: Author's calculations.

Moreover, for observations for the without road access group, poverty remained widespread and the very poorest did not see any significant improvements. This is evident from the small reduction in poverty depth and severity from 2015 to 2017 in these areas. There was even worsening of poverty depth and severity from 2015 to 2016 in this group. In contrast, for the with road access group there was a continuous and statistically significant decline in both poverty depth and severity in the study period. This indicates that those who were poor in 2016 and 2017 were on average nearer to the poverty line than those who were poor in 2015, implying a shared prosperity for the group with road access.

Table 2.3: Descriptive statistics of the variables by group and over time

Variable	With Access		Without Access		T-test of Difference in Mean
	Mean	Std. Dev.	Mean	Std. Dev.	
2015 Round					
Age of household head	41.987	14.657	43.032	14.393	1.044**
Male household head	0.924	0.265	0.892	0.310	-0.032***
Literate household head	0.295	0.456	0.309	0.462	0.014
Employed household head	0.973	0.163	0.972	0.164	-0.001
Land size in hectares	1.156	1.081	1.474	1.315	0.318***
Tropical livestock unit	3.878	4.637	4.211	4.908	0.333*
Observations	949		3525		
2016 Round					
Age of household head	43.052	13.697	43.834	14.074	0.783*
Male household head	0.904	0.295	0.890	0.314	-0.015
Literate household head	0.322	0.468	0.332	0.471	0.010
Employed household head	0.982	0.133	0.981	0.135	0.001
Land size in hectares	1.449	1.328	1.427	1.252	-0.022
Tropical livestock unit	1.766	2.995	1.909	2.995	0.143
Observations	1449		2851		
2017 Round					
Age of household head	44.364	14.331	44.917	14.292	0.553
Male household head	0.891	0.312	0.892	0.311	0.001
Literate household head	0.318	0.466	0.300	0.459	-0.018
Employed household head	0.970	0.171	0.965	0.183	-0.005
Land size in hectares	1.437	1.265	1.493	1.174	0.056
Tropical livestock unit	2.876	3.260	3.203	4.046	0.328***
Observations	1524		2700		
Summary of all Rounds with Balanced Data					
Age of household head	43.403	14.212	43.845	14.225	0.443
Male household head	0.903	0.297	0.894	0.308	-0.009
Literate household head	0.313	0.464	0.314	0.464	0.001
Employed household head	0.976	0.154	0.973	0.161	-0.002
Land size in hectares	1.375	1.257	1.463	1.251	0.088***
Tropical livestock unit	2.710	3.672	3.173	4.194	0.464***
Observations	3827		8806		

Note: * p<0.1, ** p<0.05, and *** p<0.01.
Source: Author's calculations.

Table 2.3 gives the mean and standard deviations of the explanatory variables for each survey year by disaggregating them in terms of road access. It can be observed from the table that both the survey groups had similar characteristics. The mean age of the sample group was around the mid-40s dominated by male headed households. The proportion of uneducated household heads was larger with about 69 percent being unable to read and write. On average, households owned low agricultural assets like land and livestock. Except for livestock units, which registered relatively low levels in 2016, similar characteristics were seen across time.

5. Results and Discussion

To check whether the changes in poverty incidence can be attributed to roads, the marginal effects of probit models on the probability of being in poverty are given in Table 2.4. Columns 1 and 2 give marginal effects of the standard dynamic random effect estimator and Columns 3 and 4 give Wooldridge's (2005) maximum likelihood estimates. The coefficients are interpreted as marginal effects on the likelihood of being in poverty. Negative coefficients indicate a poverty alleviating effect.

Columns 1 and 3 in Table 2.4 provide basic results where lagged poverty status, road access group, initial poverty status in 2015, and time dummies are included as explanatory variables. The marginal effects of access to roads are statistically significant in both standard and Wooldridge's estimators, and households living in areas without road access are more likely to be deprived. According to the analysis, access to rural roads reduces the likelihood of a household being poor by 25 percentage points. This shows that providing access to roads has a significant effect on reducing poverty, even within a short period of time.

The results do not tell us why we observe this effect, but two general thoughts can be raised based on previous research. First, Melo et al. (2013) in their meta-analysis of the empirical evidence on the output elasticity of transport infrastructure, show that road development can have a strong impact when implemented in areas working in the primary sector. Given that many of the areas where the rural roads program has been introduced are engaged in the agriculture sector and that they were formerly with very limited access to roads its significant effect within the short period of time is in line with the findings of Melo et al. (2013). Spillover effects and contamination are also expected to be minimal with-in this short period (Khandker and Koolwal, 2011), resulting in a significant difference between the two groups. Second, Bryceson et al. (2008), show that rural road networks' expansion in Ethiopia will enhance accessibility rather than mobility. This means that rural local markets, which have links with urban centers, will be attracted to enter deep into the rural areas, and this in turn will enable households to access local markets easily.

Table 2.4: Marginal effects of dynamic random effects probit models: poverty correlates

	Standard Dynamic Random Effects Model		Wooldridge Maximum Likelihood Model	
	(1)	(2)	(3)	(4)
Lagged poverty	0.311***	0.304***	-0.009	-0.012
	(0.048)	(0.043)	(0.065)	(0.067)
With access to road	-0.220***	-0.191***	-0.250***	-0.207***
	(0.032)	(0.046)	(0.038)	(0.051)
Year 2017	-0.008	0.112	-0.015	0.184
	(0.029)	(0.244)	(0.030)	(0.266)
Initial poverty status			0.354***	0.345***
			(0.057)	(0.058)
Age of household head		0.057***		0.061***
		(0.007)		(0.007)
Age of household head squared/100		-0.055***		-0.059***
		(0.007)		(0.007)
Male household head		-0.466***		-0.515***
		(0.076)		(0.085)
Literate household head		0.007		-0.008
		(0.047)		(0.053)
Employed household head		-0.517**		-0.515**
		(0.163)		(0.181)
Land size in hectares		-0.092***		-0.101***
		(0.019)		(0.021)
Tropical livestock unit		-0.019*		-0.020*
		(0.008)		(0.009)
Gambela		-0.421**		-0.469**
		(0.135)		(0.152)
Harari		-0.474***		-0.526***
		(0.102)		(0.115)
Dire Dawa		-0.318**		-0.347**
		(0.109)		(0.121)
Access in 2017		-0.062		-0.083
		(0.063)		(0.067)
Age in 2017		-0.003		-0.003
		(0.002)		(0.002)
Male in 2017		-0.208*		-0.249*
		(0.102)		(0.108)
Literacy in 2017		0.054		0.100
		(0.067)		(0.073)
Land in 2017		0.015		0.010
		(0.027)		(0.029)
Livestock in 2017		-0.026*		-0.030**
		(0.010)		(0.011)
Gambela in 2017		-0.544*		-0.727**
		(0.214)		(0.229)
Harari in 2017		0.266		0.164
		(0.140)		(0.147)
Dire Dawa in 2017		0.460**		0.494**
		(0.147)		(0.152)
σ_u^2	-1.747***	-2.029***	-0.721***	-0.854***
Log likelihood	-5596.2	-5435.2	-5573.4	-5414.3
Observations	8422	8422	8422	8422

Note: * p<0.05, ** p<0.01, and *** p<0.001. Asymptotic standard errors in parentheses.
Source: Author's calculations.

Columns 1 and 2 in Table 2.4 show that the coefficients of the lagged dependent variable are statistically significant in the standard dynamic random effect estimator. This implies that the longitudinal poverty dependence is wholly due to state dependence, with a marginal effect estimate of 31.1 percent. But the estimate becomes statistically insignificant, with a much lower magnitude and a different direction once the endogeneity of the initial condition is controlled for with Wooldridge's model (Column 3). This is an interesting result, especially when considering the important role that roads might play in breaking the poverty state dependency curse. Moreover, the initial value of poverty status given in Wooldridge's estimator is significant. This implies that there is a substantial correlation between the unobserved heterogeneity and the initial conditions. In fact, the coefficient of initial poverty (0.354) is much larger than the coefficient of lagged poverty (-0.009). Thus, the estimates using Wooldridge's model suggest that the longitudinal dependence is due to unobserved heterogeneity.

To explicitly control for some observed heterogeneity, Columns 2 and 4 in Table 2.4 include other confounders. Except the lagged dependent variable, the estimates are very similar for the two models. Age has marginally significant positive linear relationship with the probability of being poor. To assess the possibility of a non-linear relationship, a quadratic component of age is included which is statistically significant. The positive effect of age and a negative effect of age squared means that as people get older the effect of age on poverty lessens. Male household heads are more likely to be out of poverty. Being employed also has a statistically significant negative effect on poverty. As expected, the estimated results for both the models show that accumulating more wealth in terms of land and tropical livestock units, is associated with reduced poverty. Compared to Oromia region the remaining three regions in the sample have lower poverty rates. The time and variable interactions are also included in the models to allow for a correlation between unobserved heterogeneity and the observed ones. The interaction of male household heads, tropical livestock units, and the regional dummy for Gambela and Diredawa with year 2017 were statistically different from zero.

5.1. Robustness checks

Consumption headcount poverty is a binary variable derived from a measure of real consumption and thus, by definition, entails a loss of information relative to using real consumption trend as the outcome; this is a standard approach followed in literature (Dercon et

al., 2009) along with using conventional methods (like panel GMM) for estimation purposes. While consumption outcome shows the effects of roads across the whole sample, poverty outcomes have the advantage of providing insights into the distributional effects of roads. Specifically, poverty outcomes help in identifying whether the development of roads is strong enough to pull households out of poverty. Moreover, solving initial condition problems is notably difficult in non-linear models, which is also a problem previous poverty-road studies have failed to address. Thus, this study focuses on poverty outcomes. However, to check the robustness of the results with respect to the behavior of the dependent variable, a 'system GMM' regression model was estimated by treating 'log transformed household consumption' as the dependent variable. The results in Column 1 of Table 2.5 show that rural road development led to higher consumption levels.

Another problem that is usually raised in road-poverty studies is the endogeneity of road placements. Even with the status variability of the data used in this study and the universality of the program across the rural areas of the country, the endogenous road placement might be an issue. For instance, the initial placement of rural roads may follow existing trails or may focus on areas with comparatively high population densities. The Wooldridge conditional maximum likelihood estimation used in this study allows us to take care of this problem by controlling for initial conditions that may affect subsequent outcome trends.

To make the results even more convincing, a robustness check of the results for sample variations in treatment status was done using a sub-sample which included only those areas without access to roads in the initial period of the sample. This means that in the initial period of the sub-sample, households which were not exposed to URRAP were selected (3,332 households), and some of these households were exposed to the project (had access to roads) in the subsequent periods. Having these, the Wooldridge conditional maximum likelihood estimation was undertaken for the sub-sample and the results Column 2 of Table 2.5 show that access to rural roads reduced poverty by 17 percentage points.

Moreover, the Wooldridge conditional maximum likelihood estimation in Table 2.4 used balanced data. To check the robustness of the results, the estimates derived using unbalanced panels are reported in Column 3 of Table 2.5. The results of the unbalanced data are consistent with the results of the balanced data.

Table 2.5: Robustness check

	(1) Consumption System GMM	(2) Poverty Wooldridge Sub-Sample	(3) Poverty Wooldridge Unbalanced data
Lagged ln(consumption)	0.048**		
	(0.022)		
Lagged poverty		-0.015	-0.002
		(0.076)	(0.066)
Initial poverty status		0.366***	0.345***
		(0.067)	(0.058)
With access to road	0.211***	-0.172***	-0.198***
	(0.067)	(0.065)	(0.050)
Age of household head	-0.029***	0.052***	0.062***
	(0.004)	(0.008)	(0.007)
Age of household squared/100	0.030***	-0.051***	-0.060***
	(0.004)	(0.008)	(0.007)
Male household head	0.239***	-0.550***	-0.500***
	(0.033)	(0.093)	(0.083)
Literate household head	-0.008	-0.007	-0.004
	(0.021)	(0.060)	(0.052)
Employed household head	0.104*	-0.487**	-0.474***
	(0.056)	(0.203)	(0.178)
Land size in hectares	0.023**	-0.104***	-0.102***
	(0.012)	(0.024)	(0.021)
Tropical livestock unit	0.046***	-0.018*	-0.020**
	(0.011)	(0.010)	(0.009)
Gambela	0.226***	-0.527***	-0.479***
	(0.078)	(0.158)	(0.151)
Harari	0.380***	0.004	-0.531***
	(0.060)	(0.224)	(0.114)
Dire Dawa	0.275***	-0.566***	-0.337***
	(0.055)	(0.175)	(0.120)
Year 2017	0.059***	0.343	0.213
	(0.020)	(0.299)	(0.263)
lnsig2u		-0.774***	-0.879***
N	12811	9996	12811

Note: * p<0.05, ** p<0.01, and *** p<0.001. Standard errors in parentheses.
Source: Author's calculations.

6. Conclusions

This study assessed how differences in access to rural roads explain poverty persistence. Relating road improvements/construction to poverty dynamics could well be far more than a descriptive tool as it may also hold the key to escaping spatial poverty traps. Using household panel data collected in 2015, 2016, and 2017 the effects of roads on the incidence of poverty was analyzed using the Wooldridge conditional maximum likelihood non-linear dynamic regression model.

This study showed that areas with road access had a clear declining trend in poverty headcount, poverty gap, and poverty severity over time. Interestingly, the gains also accrued to low-income groups. Moreover, access to roads led to a lower probability of households falling into poverty. Households with access to roads had a 25 percent lower likelihood of being in consumption poverty. This result is robust to different model specification and estimation techniques. Therefore, considering these results, it is important to continue constructing rural roads for accelerating poverty reduction.

Without controlling for the initial conditions and unobserved heterogeneity, it is hard to accept any test for the state dependency of poverty. The standard random effects estimator considerably overstates a household's state dependence or a household's risk of repeated poverty. This model indicates that the risk of falling into poverty in one year is noticeably higher if poverty is observed in the previous year even after controlling for observed heterogeneity. However, the continuing poverty spell is removed when the initial conditions and unobserved heterogeneity are controlled for by using Wooldridge's original auxiliary estimator. The varying results on state dependency coupled with the strong significance of road access on poverty reduction might be an indicator that roads are the key to escaping repeated poverty traps.

It should be noted that a further disaggregation of road quality matters in estimating the trajectory of the impacts that roads have. A casual observer travelling widely along rural roads in Ethiopia will be struck by the differences in road quality, even though they are accommodated in the same rural roads program. The limitation of the data did not allow us to consider the quality of rural roads. Thus, a further analysis considering the differences in the quality of these roads will have a potential policy benefit.

This study focused on the effects of roads on consumption poverty within the short-run, but it is worth investigating these effects in the medium and long-run where spillovers and time variant unobserved heterogeneity are expected to exist. Moreover, since roads have multidimensional effects on households' activities, it will also be interesting to investigate their impact on multidimensional welfare in future research.

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Appendix A2

Table A2.1: Sample size after adjustment for balanced data and road completion status

Group	Year			Total
	2015	2016	2017	
Without access	3,332	2,783	2,691	8,806
With access	879	1,428	1,520	3,827
Total	4,211	4,211	4,211	12,633

Source: The Ethiopian Roads Authority

Paper 2: Roads to Multidimensional Poverty? Evidence from Ethiopia

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Roads to Multidimensional Poverty? Evidence from Ethiopia

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Abstract

This study assesses the impact of roads on multidimensional poverty in Ethiopia. Using two rounds of panel data from 2012 and 2016, it estimates the multidimensional poverty index using the Alkire Foster Adjusted Headcount Ratio and its consistent sub-indices. It also studies the impact of road infrastructure's expansion using the difference-in-difference approach. It finds that multidimensional poverty declined by 12.2 percent among respondents with access to roads during the two periods. When the propensity score matching specification is applied in combination with the difference-in-difference approach, a similar estimate of the impact of roads is obtained. By further decomposing the multidimensional poverty index into health, education, and standard of living dimensions it is found that the impact is mainly a result of better standard of living. The study argues for integrated infrastructural policy interventions for capturing a better outcome in the reduction of multidimensional poverty.

Keywords: multidimensional, poverty, roads, health, education, standard of living, impact, panel data, Ethiopia

JEL Classification: C23, D03, D11, D31, H54, I32, O18, P25

1. Introduction

The influence of improvements in transport infrastructure on economies has been debated for long (Aggarwal, 2018; Linneker and Spence, 1996; Owen, 1959). Developments in transport infrastructure are usually subjected to a cost benefit analysis, and such an analysis has a purely pre-project focus capturing only the project's direct effects. However, recent trends in developmental thinking and planning have brought in additional knowledge about a road project's indirect development effects (Ahlström et al., 2011; Melo et al., 2013; Yi and Kim, 2018). Some authors also highlight the importance of considering broader development implications of transport infrastructure in post-project evaluations (Banister and Berechman, 2001; Olsson, 2009). Connecting towns may be a major objective of constructing trunk roads, but roads also have the potential of developing the welfare of households living on the sides of the roads (Aggarwal, 2018; Dercon et al., 2009).

In global discussions on the road-development nexus, decisions have for long been dictated by a focus on single dimensional achievements alone. Transport infrastructure and land use linkages have been conceptualized in different ways as a branch of natural resources (Castella et al., 2005; Etter et al., 2006; Laurance et al., 2002). Transport infrastructure is also related to socioeconomic factors such as income, employment, and production systems (Ahern et al., 2016; 2004; Kam et al., 2005; Olsson, 2009). Ahlström et al. (2011) found that access to towns was more important than access to markets while explaining why some rural households were able to increase their consumption levels more than the others. Based on evidence from Ethiopia, Bryceson et al. (2008), show that road improvements may catalyze the expansion of social service provisions, but it is not a sufficient condition for enhancing the mobility of the rural poor.

Similarly, unidimensional poverty approaches based on income or consumption measures have been the dominant approach in roads-poverty literature. However, these measures are criticized for being limited as they do not sufficiently proxy other gaps such as lack of electricity, water, and health facilities (Alkire and Santos, 2014; Nolan and Whelan, 2011). Moreover, these measures are susceptible to measurement errors and are likely inaccurate (Browning et al., 2003; Deaton, 2010). Of late, it has been understood that poverty is multifaceted (Sen, 1979, 2000) and coherent frameworks for measuring poverty in multidimensional environments have

been developed (Alkire and Foster, 2011). Multidimensional measures can sufficiently capture the multiple and overlapping impacts of roads on poverty. Such information is useful in understanding the impact of roads on poverty in all its dimensions and also for coming up with integrated approaches for policy design and resource allocations (Bucheli et al., 2018).

So, the question is, can road development lead to a successful reduction of disadvantages that blight people's lives? This is a very crucial question in Ethiopia's context, where enhancing transport infrastructure has been a vital strategy for sustainable development (MoFED, 2002). Ethiopia has experienced high economic growth in the past decade, and income poverty too has declined dramatically at the same time (The World Bank, 2019). However, during this period, the annualized multidimensional poverty index (MPI) has remained high (OPHI, 2018) and practically without change (Ambel et al., 2015). This confirms that economic growth on its own is not enough to reduce multidimensional poverty, opening a line of enquiry for further research (Alkire et al., 2017).

This paper studies the impact of roads on multidimensional poverty in Ethiopia, using the Alkire Foster Adjusted Headcount Ratio and its consistent sub-indices. The Alkire-Foster methodology assesses the simultaneous or 'joint' deprivation that households experience in a set of indicators (Alkire and Foster, 2011). This approach provides answers to questions on the congruency and contribution of each dimension to the overall index by allowing the estimation of a composite index and disaggregating it into individual dimensions. This measure has been commonly used in recent policy frameworks and welfare economics research (see, for instance, Alkire and Seth, 2015; Bucheli et al., 2018; Levine et al., 2014).

To the author's knowledge, only Bucheli et al. (2018) have examined how multidimensional poverty is affected by road development in Nepal. There are very few studies, (see, for instance, Demenge et al., 2015; Dercon et al., 2009) that investigate the impact of roads on poverty in Ethiopia; these studies are limited by their lack of ability to control for selection into the program based on both observable and unobservable variables. As assignments to the road program are not random, these studies' causal inferences are hindered due to a selection bias. A randomized control trial is not feasible as construction of roads requires large investments. Thus, in this study a quasi-experimental method of difference-in-difference regression is applied to panel data from a treatment group and a control group at the baseline and end-line.

However, if the parallel trend assumption in treatment and control groups does not hold, the causal effect using the difference-in-difference approach could overestimate (or underestimate) the results. Thus, to check the robustness of the results, this study also does propensity score matching in combination with the difference-in-difference approach (Bucheli et al., 2018). In doing so, this study contributes to the body of empirical evidence on the links between road construction and multidimensional poverty at least in the case of Ethiopia.

The remaining part of this paper is organized as follows. Section 2 discusses the theoretical and empirical underpinnings of the study. Section 3,4 and 5 present the research methodology. Section 6 gives the empirical results followed by a discussion of the results and Section 7 gives the conclusion.

2. Literature Review

Poverty is increasingly understood as inherently multidimensional (Alkire et al., 2015; Sen, 1979, 2000). Simultaneously, road construction helps tackle multiple problems of households (Ahern et al., 2016; 2004; Kam et al., 2005; Olsson, 2009). Road impact evaluations often present a long list of outcome variables, treating each one separately without a unified framework for identifying the impact of roads on poverty. Hence, it is important to examine the multidimensional behavior of both poverty and roads through an integrated framework.

2.1. Roads investments and economic development

Most of the literature on the macroeconomic role of productive public expenditure is closely related to theoretical work on infrastructures' contribution to growth. A formal analysis of the effects of public capital on output and welfare under alternative financing schemes was first done by Arrow and Kurz (1970). In the context of the Ramsey model with long-run growth exogenously determined, public capital enters the framework as an input in the economy's aggregate production function. Barro (1990) developed the first endogenous growth version of this basic model by assuming that the government's contribution to current production was driven by its flow of productive expenditure. In the past decades, this theoretical literature has grown enormously by exploring a multitude of variants of the basic model such as adding public capital services to the utility function, allowing for public infrastructure congestion, and

considering public capital and productive current spending flows simultaneously (see, for example, Ghosh and Roy, 2004; Glomm and Ravikumar, 1997; Turnovsky, 1997).

In the microeconomic context, improved road infrastructure can create opportunities for economic growth and poverty reduction through a range of mechanisms (Aggarwal, 2018; Ghani et al., 2016). Transportation costs as well as the costs of consumption and production of goods and services can be reduced through road improvements (Olsson, 2009; Storeygard, 2016). Improved roads can also expand farm and non-farm production through increased availability of relevant inputs and lower input costs, with easier access to markets and technology (Damania et al., 2017; Gollin and Rogerson, 2014; Qin and Zhang, 2016). Road development can also contribute to higher productivity and demand for labor at the household level leading to potentially greater earning opportunities (Aggarwal, 2018; Ramessur et al., 2010). Such developments in turn can boost household consumption (Fan et al., 2000) and other household benefits such as improved education and health status (Bryceson et al., 2008; Sapkota, 2014).

The direct outputs of roads including road length, reduced travel time, transportation costs, number of beneficiaries, and accident risks, have been the focus of traditional cost-benefit evaluations (Jones et al., 2014). However, more generally, the effects of improved roads spring from integrated markets as well as improved access to key services such as healthcare and education (Castella et al., 2005; Yamauchi, 2011). Thus, the broadest evaluation looks at induced changes in households' living standards as well as health and education indicators including accumulation of physical assets, changes in human capital accumulation patterns, and interactions with healthcare services.

While the impact of improved roads has multiple dimensions, empirical studies typically take a one-dimensional measure of well-being. Considering the multidimensional effects of road infrastructure, this study uses a multidimensional poverty analysis to set forth a systematic account of indices summarizing information on poverty.

2.2. Empirical review

Literature provides heterogenous evidence on the impact that road improvement projects have on households' welfare. Economic studies show that the impact of roads on mobility is potentially all encompassing, and this can impact a range of economic variables including occupations, incomes, education, and health positively. Aggarwal (2018) found that farmers with access to new roads in rural India were more likely to increase the use of agricultural technologies to pull teenagers (14-20 year olds) out of school to join the labor force and for enrolling younger children (5-14 year olds) in school. Using data from Ethiopia, Dercon et al. (2009) found that access to all weather roads reduced poverty by 6.9 percentage points and increased consumption growth by 16.3 percentage points. They showed that the beneficiaries who joined rural local markets because of reduced transportation time and costs had better chances of affording more assets and improving their welfare. Similarly, research by Demenge et al. (2015) in Ethiopia shows that road construction interlinked with hydrological resources provided better potential for development.

Previous research also shows that the benefits of roads are dependent on several elements such as the spatial distribution and magnitude of opportunities, the characteristics of the transport system in terms of the ease of reaching destinations, and the socioeconomic characteristics of the beneficiaries. For instance, Khandker et al. (2009) found that the implementation of a rural road development project in Bangladesh led to an 11 percent increase in the average household annual per capita consumption and also had positive effects on men's agricultural wages. The effects on per capita consumption were larger for poorer households than for their wealthier counterparts. Yamauchi (2011) showed that it became safer and less costly in monetary terms for households to reach academic institutions with improved road quality. The beneficiaries of improved roads were more likely to attend school if the marginal monetary and time costs of travelling decreased even if the marginal utility from education remained unchanged.

However, road transport can also lead to some potential negative externalities like congestion, noise, pollution, accidents, expropriation of settlers, environmental damage, increased threat to heritage, and dependence on oil (Anderson et al., 1996; Santos et al., 2010). Empirical studies in the food and nutrition field have found that improved access to roads led rural households to

diversify their diets, but markets were often flooded with nutrient-poor commoditized foods (Dickerson et al., 2008; Lopez et al., 2018). A recent study by Asher and Novosad (2020) shows that construction of rural roads in India had no major effect on consumption, assets, or agricultural outcomes. These results reflect the heterogeneous impact of improved access to roads and make forming generalizations about the advantages of better roads problematic.

Relatively speaking, more analysis has been done on urban city roads than on trans-regional roads. Moreover, except Bucheli et al. (2018), empirical studies have failed to consider the impact of roads on household poverty as an integrated multidimensional problem. The dominant approach in literature is studying unidimensional monetary poverty which does not consider its potential multidimensional impacts. Poverty has been found to be multifaceted (Sen, 1979, 2000) and monetary measures are limited to the ability to spend on goods and services and do not sufficiently proxy other capabilities (Nolan and Whelan, 2011). Empirical studies have also shown that nearly half of those who are identified as monetarily poor are not multidimensionally deprived, and conversely (Alkire and Seth, 2015; Laderchi et al., 2003). Moreover, the collection of monetary data in some settings may be inaccurate, inconsistent, and incomplete and/or biased, raising methodological debates (Browning et al., 2003; Deaton, 2010).

This study discusses the impact of the trans-regional development of roads on multidimensional poverty and identifies how the treated and control sub-groups are affected by these developments. The results of the decomposition of the multidimensional poverty index provide an understanding of the channels through which development of roads' programs might affect different dimensions of poverty and different groups.

3. Multidimensional Poverty

Consumption or asset space has been a major framework in traditional unidimensional poverty studies (Laderchi et al., 2003). However, welfare economists have recently identified poverty as being multidimensional with a pluralist conception as compared to traditional economists (Alkire, 2002; Bader et al., 2016; Bourguignon and Chakravarty, 2003; Roelen, 2017). Sen (2000) observes that "human lives are battered and diminished in all kinds of different ways, and the first task, seen in this perspective, is to acknowledge that deprivations of very different

kinds have to be accommodated within a general overarching framework." In fact, the importance of considering poverty as the multidimensional nature of deprivation is now recognized in empirical and policy frameworks (Alkire and Foster, 2011; Alkire et al., 2015; Sen, 1979).

Based on this conceptual evolution a number of frameworks for multidimensional poverty have been advanced (Barrientos, 2013; Jenkins and Micklewright, 2007; Metz and Gaie, 2010). Among them, the capability approach is a prominent framework which broadens the interlocked dimensions of non-monetary depravations such as health, education, food, and assets (Narayan et al., 2000). As Nolan and Whelan (2011) point out, the capability perspective of multidimensional deprivation "can bring out what it means to be poor, help to do a better job than income on its own in identifying the poor, and also directly capture the multifaceted nature of poverty."

The United Nations Development Program (UNDP) and the Oxford Poverty and Human Development Initiative recently developed a direct method to index the multidimensional aspect of poverty called the multidimensional poverty index (Alkire and Foster, 2011; UNDP, 2010). MPI is a direct measure of acute poverty, understood as having dual cut-off characteristics. First, it defines a household's inability to reach the minimum internationally agreed standards in indicators related to the millennium development goals (Alkire and Foster, 2011; Alkire and Santos, 2014). The indicators include core functioning such as drinking clean water, being educated, and/or being well nourished. Second, MPI identifies those experiencing multiple deprivations at the same time (Alkire and Foster, 2011). It sets the criteria on how many indicators a household must be deprived in to be considered poor, for instance, identifying households which are both undernourished and do not have adequate sanitation.

MPI has a robust functional form and its property of decomposability allows for comparisons across groups (Alkire and Santos, 2014). It is particularly suitable for policy analyses and targeting as it shows how much each dimension and each indicator contributes to overall poverty (Levine et al., 2014).

3.1. Dimensions, indicators, and unit of analysis

This study adopts the global MPI which is based on three dimensions: health, education, and living standards (Alkire and Foster, 2011). Unavailability of data on social, political, and environmental aspects prevent this study from considering other dimensions which are getting recent recognition in literature. Alkire and Santos (2014) provide four important justifications for focusing on the three chosen dimensions. First, the dimensions have intrinsic value and can also be a valuable instrument for many other vital outcomes. Second, parsimonious communication can be established since MPI's dimensions mirror the dimensions included in the Human Development Index. Third, there is wide consensus regarding the importance of the three dimensions among scholars and practitioners. Fourth, the validity, strength, robustness, and limitations of MPI's dimensions are well established.

The Alkire and Foster (2011) MPI methodology identifies a set of indicators for each dimension and applies a vector of deprivation cut-offs for each indicator. As can be seen in Table 3.1, the three dimensions are measured using 10 indicators. In this paper, the indicators and the associated deprivation cut-offs are selected by considering common empirical practice, the country's policy, data considerations, and international standards such as the MDGs. Any available information on household members is used for identifying whether a household is poor or not. Individual considerations would have been ideal, but the extent of available data prevents this study from doing an intra-household analysis. Despite these limitations, using a household as the unit of identification allows for smoothening, interactions, and sharing among members of a household, and can help create policy efficiencies (Alkire and Santos, 2014; Angulo et al., 2016). However, while the unit of identification remains the household, it is also usual for the unit of analysis to be an individual (Alkire et al., 2015).

Following the global MPI and Alkire and Santos (2014), two indicators are used for education. The first indicator identifies a household as deprived if none of the household members have six years of schooling. A household member is expected to complete primary education and have basic educational skills of literacy, numeracy, and understanding information. The second indicator is whether all school-age children are attending school. A child in Ethiopia is expected to attend Class 1 at the age of 7 years and complete Grade 10 at the age of 16 years. Thus,

school attendance is used as an indicator of whether a child between 7 and 16 years is being exposed to education. If any child is not exposed to a learning environment, the household is considered deprived in the education indicator.

When it comes to the health dimension, this paper follows a path different from the global MPI as information on anthropometric measures or child mortality is not available. Instead, two indicators are used: whether the household faced any food shortages and whether the household has access to medicines. While information on nutrition value, health insurance coverage, or child mortality would be desirable as indicators, the selected indicators provide a rough proxy of the health measures. Food shortages make a household's members vulnerable to other health problems which may also result in lifelong problems (Ogachi, 2001). Thus, a household is identified as deprived if there was a time when the household did not have enough food to eat in the past 12 months. Lack of access to essential medication implies the non-fulfilment of the right to access healthcare (Strauss and Horsten, 2013). A household is considered deprived in medication if there is no adequate access to medicines.

The standard of living dimension has six indicators. Access to safe drinking water is one of the indicators and a household is considered as deprived when it has no access to drinking water or when the time to access water exceed 30 minutes. Access to improved sanitation is the second indicator and households without access to a sewer system or a latrine are considered deprived. The use of clean cooking fuel is the third indicator and if a household uses wood, charcoal, or dung for cooking it is regarded as deprived. These three indicators are also included in the MDGs; these affect women in particular. The other two indicators are electricity and flooring material which can be taken as a proxy for the quality of housing. The final indicator 'assets' is associated with consumer goods such as radios, mobile phones, and televisions.

Suppose the number of households within the sample are n, and assume that poverty is assessed by d indicators, such that $n, d \epsilon N$. The achievement of household i in indicator j is denoted by $\boldsymbol{x_{ij}} \in \mathbb{R}_+$ for all $i = 1, \dots, n$ and $j = 1, \dots, d$. The achievements of all households are summarized by an $n \times d$ achievement matrix $\boldsymbol{X} \in \mathbb{R}_+^{nd}$. The deprivation cut-off z_j identifies whether a household is deprived or not in each indicator j. From the achievement matrix $\boldsymbol{x_{ij}}$

and deprivation cut-off z_j, each household is assigned a deprivation status value g_{ij}, such that $g_{ij} = 1$ whenever household i is deprived in indicator j and $g_{ij} = 0$ otherwise.

3.2. Indicators' weights

Weights are deprivation values which indicate the relative importance of dimensions and they are used for guiding the trade-offs between dimensions. A wide range of methods have been developed to weigh relevant dimensions including equal weighting, frequency-based weighting, most favorable weighting, multivariate statistical weighting, regression based weighting, and normative weighting (Decancq and Maria Ana, 2009). Alkire and Santos (2014) used a normative assessment approach to show that health, education, and standard of living had equal intrinsic values. According to their study, MPI weights are explicit, transparent, and robust to a range of weights. Equal weight can also facilitate an easy interpretation of the index. Following Alkire and Santos (2014), this study weights each dimension equally, and indicators within each dimension too are weighted equally (Table 3.1). Using these weights, a 'deprivation score' is calculated which is a weighted sum of deprivations for each household.

The relative importance of indicator j is given by weight w_j, such that $w_j > 0$ and $\sum_{j=1}^{d} w_j = 1$. The sum of a household's weighted deprivation gives the deprivation score denoted by c_i. Mathematically, it is given as $c_i = \sum_{j=1}^{d} w_j g_{ij}$, such that $c_i \in [0,1]$.

3.3. Poverty cut-off (k)

The poverty cut-off (k) is the share of the weighted deprivations required (minimum deprivation score) for a household to be considered multidimensionally poor. MPI uses a poverty cut-off of 33.33 percent but its results are robust in a range of different poverty cut-offs. This specific cut-off point provides a wide distribution of poverty's results (Alkire and Santos, 2014). Thus, this study uses a cut-off point of 33.33 percent meaning that a household is identified as multidimensionally poor if its deprivation score is at least 33.33 percent, that, is, $c_i \geq k$.

Table 3.1: The Multidimensional Poverty Index and its weighting structure

Dimension	Weight	Indicator	Deprived
Education	**1/3**		
	(1/6)	Schooling	If no household member has completed 6 years of schooling
	(1/6)	Attendance	If any school aged child (7-18 years) in the household is not attending school in the academic year of the study
Health	**1/3**		
	(1/6)	Medicine	If the household has no adequate access to medicines
	(1/6)	Food	If there was a time when the household did not have enough food to eat in a year
Standard of Living	**1/3**		
	(1/18)	Energy	If the household has no electricity
	(1/18)	Water	If the household does not have access to safe drinking water
	(1/18)	Sanitation	The household's sanitation facility has not improved, or it is shared with other households
	(1/18)	Flooring	If flooring is made of earth, sand, or dung
	(1/18)	Cooking fuel	If wood, charcoal, or dung is used as cooking fuel
	(1/18)	Assets	If the household does not own more than one radio, television, or mobile phone

Note: Nested weights in parentheses.
Source: Alkire and Santos (2014).

3.4. The adjusted headcount ratio (M_0)

MPI uses two important aspects for measuring poverty: the incidence of multidimensional poverty (headcount ratio) and the intensity of multidimensional poverty (Alkire and Foster, 2011). The incidence of poverty shows the proportion of households (of the total observations) which are identified as multidimensionally poor. Let the number of poor households identified be denoted by q. Then, the incidence of poverty (H) is given by:

$$H = q/n \tag{3.1}$$

The intensity of multidimensional poverty (A) shows the average proportion of weighted deprivations experienced by poor households. It is the average deprivation score of the identified poor households. It is obtained by adding the deprivation scores of poor households and dividing them by the total number of poor households as:

$$A = \sum_{i=1}^{q} c_i(k)/q \tag{3.2}$$

The adjusted headcount ratio (M_0) is the product of the two previous partial indices (Equations 3.1 and 3.2):

$$M_0(X;z) = H \times A = H = \frac{1}{n}\sum_{i=1}^{n} c_i(k) = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{d} w_j g_{ij}(k) \quad (3.3)$$

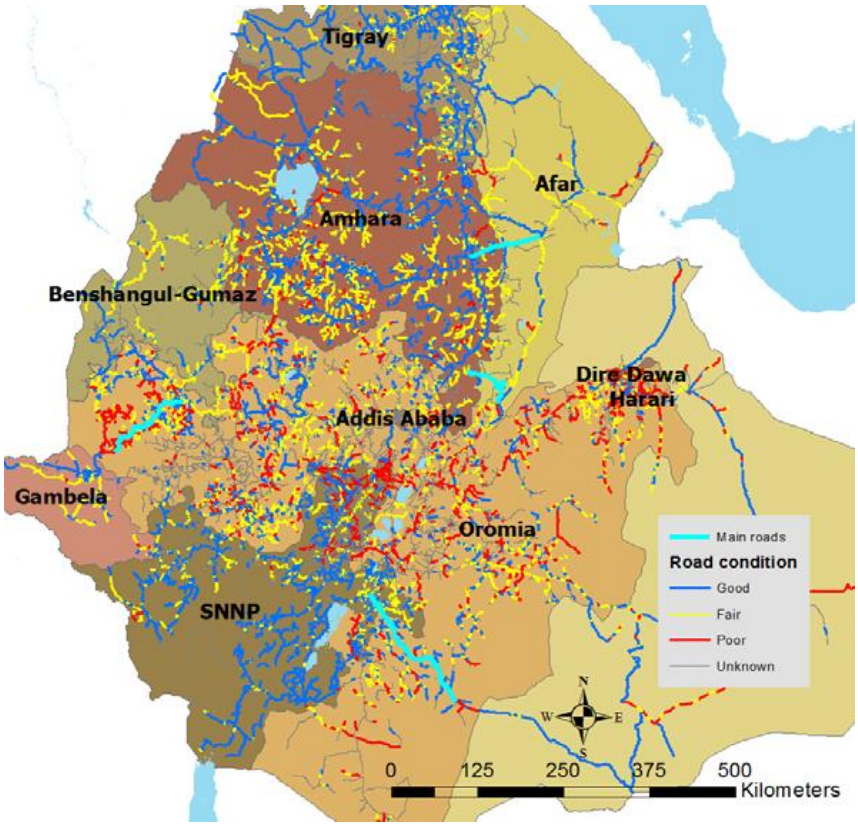
M_0 is interpreted as "the proportion of weighted deprivations the poor experience in a society out of the total number of deprivations this society could experience if all people were poor and were deprived in all dimensions" (Alkire et al., 2015). The M_0 measure has certain important characteristics. The first is sub-group decomposability, which means that M_0 can be broken down for mutually exclusive and collectively exhaustive sub-groups. Thus, M_0, H, A, and each dimension can be disaggregated by access to roads (treatment and control groups). The second property is dimensional breakdown, meaning that M_0 can also identify the proportion of the population that is simultaneously multidimensionally poor and deprived in an indicator. The third is dimensional monotonicity, implying that M_0 is sensitive to changes in a poor household's deprivation status for an indicator (Alkire et al., 2015).

4. Data and Descriptive Statistics

4.1. Sample selection

This study uses longitudinal data collected by the Ethiopian Roads Authority from four road corridors that were upgraded/improved under the Road Sector Development Program: Aposto-Wondo-Negele Road (268 km), Mekenajo-Dembidollo Road (181 km), Kombolcha-Bati-Mille Road (133 km), and Ankober-AwashArba Road (89 km) (Figure 3.1). While the first two roads pass through Oromia and SNNPR regional states, the last two connect Amahara and Afar regional states. The four roads are asphalt links to other major roads that connect regional cities with Addis Ababa, the country's capital. A quasi-experimental design with pre-post surveys was employed in collecting the data. The baseline survey was conducted in 2012 before the major construction work started and each household was repeated for each indicator and survey questions in 2016 (end-line survey).

Figure 3.1: Road Network in Ethiopia



Note: Main roads are the roads being studied.
Source: The Ethiopian Roads Authority.

Data was collected both from project villages in the area of a road's influence (treatment group) and from a control group with similar socioeconomic characteristics except the road intervention. A stratified 3-stage cluster sample design was used for identifying the required sample households from each road corridor. Local communities, segments of local communities/localities/villages, and households were the sampling units which were chosen in the first, second, and third stages of the sampling, respectively. The survey targeted 15 to 20 villages, which were stratified based on distance along the starting, middle, and ending point of each road. The treatment group lived in an area which was in less than a 2 km corridor on either side of the intervention road and the control group lived in areas further than 12 km from the road.

This identification strategy enabled comparisons of 'with' and 'without' project interventions since there were both beneficiaries and non-beneficiaries within the same local area along a given road. However, it is plausible to expect that those who lived closer to a road may be

systematically different from the remote households. In the 2012 round, 960 households (480 households in the treatment group and 480 in the control group) were interviewed using a pre-tested structured questionnaire. In the 2016 round, 906 households (474 households in the treatment group and 432 households in the control group) were interviewed.

4.2. Multidimensional poverty estimates

Table 3.2 presents the level of MPI or adjusted headcount ratio and its composing sub-indices: incidence (H) and intensity (A). The first insight from the analysis is that there was a statistically significant reduction in multidimensional poverty levels over time. In 2012, 80 percent of the people in the sample were multidimensionally poor and the average poor were deprived in 56.9 percent of the weighted indicators. In the same year, the multidimensionally poor people experienced 45.5 percent of the total deprivations that would have been experienced if all people were deprived in all indicators at the same time. These rates for incidence, intensity, and adjusted multidimensional headcount declined in 2016 to 67.8 percent, 54.2 percent, and 36.8 percent, respectively. A T-test of equality of means is given in Appendix Tables A3.1 and A3.2.

The multidimensional poverty level between the treatment (32.2 percent) and control groups (58.8 percent) in the base year was not similar. This shows a potential difference in the pre-program local area endowments and the need to control for heterogeneity in the program implementation. Both control and treatment groups experienced reduction in their MPI between the two observed points in time. The reduction in MPI was a consequence of reductions in both incidence and intensity of poverty. The average proportion of deprivations suffered by the poor population (A) was larger for the group with a higher poverty rate (H), which is in line with international evidence (Alkire and Santos, 2014).

Table 3.2: Multidimensional Poverty

Group	Baseline Period (2012)			Follow-up Period (2016)		
	Adjusted Multidimensional Headcount (MPI = H * A)	Percentage of Poor People (H) (k = 33.3%)	Average Intensity Across the Poor (A)	Adjusted Multidimensional Headcount (MPI = H * A)	Percentage of Poor People (H) (k = 33.3%)	Average Intensity Across the Poor (A)
Aggregate	0.455	0.800	0.569	0.368	0.678	0.542
	(0.009)	(0.013)	(0.006)	(0.010)	(0.016)	(0.007)
Treatment	0.322	0.652	0.494	0.223	0.481	0.464
Control	0.588	0.948	0.620	0.530	0.898	0.590

Note: Standard errors in parentheses.
Source: Author's calculations.

To have a sense of absolute deprivation levels in each indicator, the third and fourth columns of Table 3.3 present the censored headcount ratios, namely, the proportion of people identified as multidimensional poor who experienced deprivation in each indicator. As can be observed, many indicators showed a decline in headcount ratio as one moved from 2012 to 2016. In terms of absolute levels of deprivation within the health dimension, 55.8 and 54.2 percent of the people did not have adequate access to medicines in 2012 and 2016 respectively whereas 72.6 percent and 52.4 percent were deprived in food in the respective years.

Within the education dimension, the schooling indicator had substantially higher headcount ratios: 36.9 percent of the people were deprived in schooling in 2012 and this percentage was 30.1 percent in 2016. Deprivation in attendance showed the lowest levels of deprivation in general. In 2012 people had a censored headcount ratio of 11 percent in school attendance; this was 10.1 percent in 2016.

Table 3.3: One-dimensional deprivation headcount ratio versus contribution to overall MPI

(1) ** Dimension	(2) Indicator	Percentage deprived* in an indicator		Contribution to M_0	
		(3) Year 2012	(4) Year 2016	(5) Year 2012	(6) Year 2016
Health	Medicine	55.833	54.190	0.185	0.208
	Food	72.604	52.402	0.249	0.216
	Sub-total			0.434	0.424
Education	Schooling	36.875	30.056	0.132	0.132
	Attendance	11.042	10.056	0.040	0.038
	Sub-total			0.172	0.170
Standard of Living	Energy	39.375	37.654	0.046	0.053
	Water	64.896	61.676	0.073	0.079
	Sanitation	24.583	12.402	0.028	0.018
	Floor	83.229	79.218	0.088	0.094
	Cooking Fuel	96.875	93.631	0.095	0.098
	Asset	54.479	45.587	0.064	0.063
	Sub-total			0.394	0.406
Total				1	1

Note: *Deprived: Percentage of individuals whose indicator values are below the threshold.
**: The numbers in parentheses are column indicators.
Source: Author's calculations.

Regarding the standard of living dimension, deprivations in energy and sanitation showed low levels. The proportion of people deprived in sanitation was 24.6 percent in 2012 and 12.4 percent in 2016. Deprivation in energy was 39.4 percent in 2012 and 37.7 percent in 2016. Deprivation in cooking fuel shows the highest levels in general. The proportion of people

deprived in cooking fuel was 96.9 percent in 2012 and 93.6 percent in 2016. The floor indicator too had a substantially high censored headcount ratio: 83.2 percent in 2012 and 79.2 percent in 2016. Water and assets were relatively at a moderate level. When it comes to water, 64.9 percent of the people did not have access to safe drinking water in 2012; this figure declined to 61.7 percent in 2016 while 54.5 percent of the people were deprived in assets in 2012 and 45.6 percent were deprived in 2016.

The contribution of the different dimensions and indicators to the overall multidimensional poverty are given in Columns 5 and 6 of Table 3.3. Among the three dimensions considered by the index, the health dimension stands out as the largest contributor to MPI in both the years (43.4 percent and 42.4 percent). In both baseline and follow-up years, most of the contribution to MPI was by the food deprivation indicator (24.9 percent). Compared to 2012, the contribution of the health dimension fell in 2016; this was compensated for by an increase in the standard of living dimension. The contribution of education to multidimensional poverty was almost identical in both the years.

4.3. Descriptive statistics of the relevant variables

Table 3.4 presents the means and standard deviations of key variables along with t statistics for the null hypothesis so that the means are equal in the treatment and control groups. As the table shows, there are large variations between the mean values of the two groups. In 2012, 95 percent of the control groups lived in rural areas, compared to 8 percent of the treatment groups. Moreover, there was a lower proportion of female household heads in the control groups. The treatment groups were more mature in terms of age, had smaller household sizes, and had higher engagement in non-agricultural activities as compared to the control groups. In 2016 a similar trend was witnessed between treatment and control groups. The only variable that did not show any systematic difference between the two groups is being a member of saving and credit institutions.

The T-test for the equality of means between the treated and control groups at the base year shows that there was a statistically significant difference in the initial observable characteristics. This is also an indication of selection bias implying that those who lived closer to a road corridor were systematically different from remote households even before the intervention. This is

expected, especially when considering that the study used 12 km as a threshold for identifying control variables. For instance, a household that lived 12 km from a trunk road was most likely to reside in a rural area. Another related point to consider is that the construction, upgrading, or rehabilitation of roads is usually influenced by initial economic activity (Khandker et al., 2009; Nakamura et al., 2019). This implies that the two groups are likely to be on entirely different growth paths regardless of the road upgrade.

Table 3.4: Descriptive Statistics of Key Variables

Variable	Control		Treated		T-test of equality of means
	Mean	Std. Dev.	Mean	Std. Dev.	
2012 Round					
Household lives in rural area	0.950	0.218	0.080	0.274	54.40***
Female household head	0.144	0.351	0.283	0.451	5.35***
Age of household head	42.783	14.425	45.504	15.563	2.81***
Household size	5.473	2.282	4.190	2.117	9.03***
Head with saving/credit account	0.833	0.373	0.842	0.365	0.35
Farming as occupation of hh	0.748	0.435	0.106	0.308	26.38***
Observations	480		480		
2016 Round					
Household lives in rural area	0.995	0.068	0.042	0.201	93.69***
Female household head	0.125	0.331	0.283	0.451	5.95***
Age of household head	45.271	13.785	48.329	14.904	3.19***
Household size	5.368	2.147	4.432	2.135	6.57***
Head with saving/credit account	0.771	0.421	0.699	0.459	2.44**
Farming as occupation of hh	0.590	0.492	0.122	0.328	16.97***
Observations	432		474		

Note: *** p<0.01, ** p<0.05, and * p<0.1.
Source: Author's calculations.

5. Econometric Analysis

5.1. Difference-in-difference

Impact evaluation is about attributing a change in an outcome of interest to an intervention. Impact is evaluated or casual effects are proved by answering the counterfactual: contrary to the actual state what would have happened in the absence of the intervention (Roy, 1951; Rubin, 1974). In practice, to prove causality, individuals in treatment and control groups with similar characteristics should be observed at some time after the treatment, and the differences in outcomes between the treatment and control groups is understood as an impact of the treatment (Angrist, 2009; Imbens and Wooldridge, 2009).

In this study, the quasi-experimental difference-in-difference (DID) regression is used for estimating the causal effects of roads on multidimensional poverty. DID is typically used when randomization is not feasible (Lechner, 2011), as is usually the case in the development of road infrastructure (Khandker et al., 2009). The DID's design compares changes in outcomes before and after an intervention for treatment and control groups (Bertrand et al., 2004). A 2-period and 2-group DID design is used in this study.

The multidimensional poverty outcome Y_{idt} for household i at time t in group d (treatment or control) can be written as a function of:

$$y_{idt} = \alpha_d + \theta_t + \beta_1 d + \beta_2 t + \beta_3 d.t + u_{idt} + \varepsilon_{idt} \tag{3.4}$$

where $y_{idt} = 0$ for a multidimensionally non-poor household and $y_{idt} = 1$ for a multidimensionally poor household; α_d captures group level time invariant 'fixed effects'; d is an indicator variable for treatment (=1) or control (=0) groups; t is an indicator variable for baseline (=0) or end-line (=1) measurements; the β_s are the regression coefficients to be estimated; u_{idt} captures household level factors that vary across groups and over time; and ε_{idt} captures the random error.

The average treatment effect (or the DID impact) is given by:

$$\begin{aligned}(y_{i11} - y_{i10}) - (y_{i01} - y_{i00}) \\ = \beta_3 + (u_{i11} - u_{i10} - u_{i01} + u_{i00}) + (\varepsilon_{i11} - \varepsilon_{i10} - \varepsilon_{i01} + \varepsilon_{i00})\end{aligned} \tag{3.5}$$

$$DID\ Impact = \beta_3 + (u_*) + (\varepsilon_*) \tag{3.6}$$

Equation 3.6 clarifies the assumptions needed to infer causality from the DID's design (Imbens and Wooldridge, 2009). First, it is expected that the regression error term has a distribution with mean 0, so that ε_* is also distributed with mean 0. Second, it is assumed that the time variant differences over time in the treatment and control groups are equal, thus cancelling each other out ($u_* = 0$). This is a strong assumption made in a DID analysis, allowing for a causal analysis despite the absence of randomization. So, conditioning on covariates, treated and control households would on average be expected to experience the same change in outcomes in the absence of the treatment (Blundell and Dias, 2002).

A possible problem in the road sector is a selection bias, as road allocations in developing countries are usually based on pre-determined criteria (Burgess et al., 2015). This problem is also evident in this study (as indicated in Tables 3.2 and 3.4), that is, even if the treatment and control groups were selected from the same village, they were on different growth paths even before the road upgrade. The advantage of the DID estimator is that it controls for time invariant unobserved heterogeneity so the bias cancels out through differencing, while requiring common trends (Lechner, 2011). However, prima facie there is a serious reason to believe that the parallel trend assumption may not hold, in which case the causal interpretation would fail. Thus, a robustness analysis is needed to check whether the results are influenced by this problem.

5.2. Propensity score matching with DID

One possible solution to the selection problem is applying propensity score matching, that is, matching procedures based on the probability of participating in a program given observable characteristics X (Caliendo and Kopeinig, 2008). But propensity score matching makes a strong assumption that all variables that influence treatment assignment and potential outcomes must be observed simultaneously (Imbens, 2000). If this assumption is not justifiable, propensity score matching can be combined with the DID approach to explicitly allow selection of unobservable variables. As a robustness check, this study also presents the results of the DID approach combined with propensity score matching.

This study uses the logit model for estimating the propensity score, that is, the probability of participation versus non-participation. The choice of the functional form is not critical for the logit and probit models for a binary treatment though the logit distribution has more density mass in the bounds (H. L. Smith, 1997). Including covariates in the propensity score model requires that only variables that influence the selection decision and the outcome variable simultaneously should be included in the model. Moreover, it is only those variables that are unaffected by the treatment that should be included in the model (Caliendo and Kopeinig, 2008). Hence, economic theory, previous research, institutional settings, and availability of data in the sample are considered while deciding which variables to include in the model (J. Smith and Todd, 2005).

This study uses the Kernel non-parametric matching algorithm as the propensity score matching algorithm. Kernel matching uses weighted averages of all households in the control group to construct a counterfactual outcome. It is a weighted regression of the counterfactual outcome on an intercept with Kernel weights (J. Smith and Todd, 2005). The advantage of this approach is the lower variance, which is a result of more information, but there is a possibility of using observations that are bad matches. However, alternative estimating approaches such as nearest neighbor and stratification also give similar results in this study.

6. Results and Discussion

This section looks at the impacts of roads on the overall MPI. Table 3.5 reports the estimation results of the DID model with and without additional controls. In the first DID specification (basic model), the treatment and time variables and the interaction between the two is included. To check the robustness of the results for a baseline imbalance, the second regression controls for different household characteristics in the DID analysis. The coefficients in the table are interpreted as percentage point effects of a variable on multidimensional poverty. Negative values indicate a poverty alleviating effect, while positive coefficients suggest an increase in household multidimensional poverty. The control and treatment groups are represented by 'road treatment' and the baseline and follow-up years are represented by 'period'. The interaction term (road treatment_period) provides the impacts of roads on multidimensional poverty.

The results in Table 3.5 show that providing access to roads was very helpful in reducing the multidimensional poverty of the sample households. The statistically significant coefficient of the interaction term of the basic model shows that household multidimensional poverty declined by 12.2 percentage points in areas where the roads were improved. These results remain consistent when controlling for household characteristics. Moreover, other control variables included in the regression, except household size, concomitantly affected multidimensional poverty. To ensure that the exogeneity assumption was not violated, only variables that were not influenced by the treatment were included in the regression. Through a joint significance test it was obtained that the covariates had statistically significant explanatory powers at the 1 percent significance level.

Table 3.5: DID Estimations, the impact of roads on MPI

	(1) Basic Model	(2) Model with Additional Controls	(3) DID Matched
Road treatment_period	-0.122***	-0.132***	-0.133***
	(0.036)	(0.036)	(0.039)
Road treatment	-0.296***	-0.244***	-0.315***
	(0.024)	(0.028)	(0.026)
Period	-0.050***	-0.027	-0.050***
	(0.018)	(0.018)	(0.018)
Female household head		0.081***	
		(0.024)	
Age of household head		0.001**	
		(0.001)	
Household Size		-0.006	
		(0.004)	
Head saving or credit participation		-0.115***	
		(0.024)	
Farming as occupation of household		0.117***	
		(0.021)	
Constant	0.948***	0.767***	0.948***
	(0.010)	(0.050)	(0.010)
R^2	0.188	0.220	0.215
F	147.8	72.89	144.8
Observations	1855	1853	1688

Note: *** p<0.01, ** p<0.05, * and p<0.1. Robust standard errors in parentheses.
Source: Author's calculations.

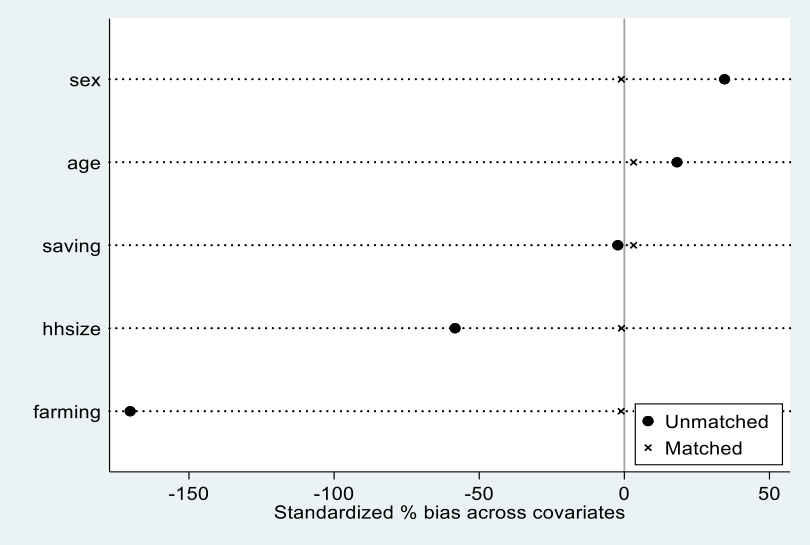
As a robustness check, the last column of Table 3.5 presents the estimates of the propensity score matching in combination with DID. As a first step in this estimation, Kernel matching was done to improve the comparability of households in the control and treatment groups. The matching led to a drop of 167 observations which were outside the common support of the treatment group (Figure 3.2). Moreover, as presented in Table 3.6, the difference in mean values of the covariates between the control and treated groups in the initial period was sufficiently reduced. After finding this, a DID estimation was done on the matched sample. When compared to the unmatched results, the impact remained statistically significant with an expected direction and a slightly larger impact. This result indicates that multidimensional poverty in the treated groups was 13.3 percent lower than it was in the control groups. Overall, road improvements influenced multidimensional poverty that went in a direction consistent with policy expectations and in line with previous consumptive poverty studies in Ethiopia (such as those by Dercon et al., 2009 and Nakamura et al., 2019).

Table 3.6: An evaluation of the matched sample

Variable	Unmatched Matched	Mean Treated	Control	%bias	%reduct |bias|	t-test t	p>|t|
Sex	U	1.283	1.144	34.5		5.35	0.000
	M	1.274	1.278	-1.1	96.9	-0.15	0.882
Household size	U	4.190	5.473	-58.3		-9.03	0.000
	M	4.236	4.257	-1.0	98.3	-0.16	0.873
Age	U	45.504	42.783	18.1		2.81	0.005
	M	44.745	44.269	3.2	82.5	0.48	0.634
Saving or credit participation	U	0.158	0.167	-2.3		-0.35	0.727
	M	0.159	0.148	3.2	-40.6	0.50	0.618
Farming as occupation	U	0.106	0.748	-170.3		-26.38	0.000
	M	0.108	0.113	-1.1	99.3	-0.21	0.835

Source: Author's calculations.

Figure 3.2: Evaluation of the matched samples



Source: Author's calculations.

One of the key advantages of the MPI indicator is its property of dimensional decomposability. Table 3.7 presents the impact of roads on each dimension of MPI using the DID model. The coefficients have the same interpretations as earlier and the term 'road treatment_period' provides the effects of roads on the health, education, and living standard dimensions. The estimation of health deprivation in Table 3.7 shows that improvements in roads impacted the reduction of health deprivation at the 10 percent significance level. This is in conformity with previous studies that argue that the building of roads is a public health issue (Egan et al., 2003). However, looking into the health components in Table 3.3 and Table A3.2 in the Appendix shows that the changes in the health dimension only come from the food indicator implying that a reduction in multidimensional poverty and a reduction in health deprivation was a result of increased food consumption. As a result of improved access, households had a better

opportunity for diversifying their diets (Dickerson et al., 2008; Lopez et al., 2018; Minten and Kyle, 1999). However, access to medicines did not show an improvement for the sample households.

Table 3.7: DID Estimations of health, education, and living standard deprivations

	(1) Health Deprivation	(2) Education Deprivation	(3) Living Standard Deprivation
Road treatment_period	-0.066*	-0.002	-0.149***
	(0.034)	(0.045)	(0.036)
Road treatment	-0.146***	-0.242***	-0.352***
	(0.021)	(0.031)	(0.025)
Period	-0.060***	-0.064	-0.005
	(0.019)	(0.033)	(0.017)
Constant	0.942***	0.575***	0.929***
	(0.011)	(0.023)	(0.012)
R^2	0.0722	0.0657	0.234
F	49.03	44.12	189.7
Observations	1855	1855	1855

Note: *** p<0.01, ** p<0.05, and * p<0.1. Robust standard errors in parentheses.
Source: Author's calculations.

Unfortunately, roads appear to have no statistically significant effect on education deprivation in the sample households. This result is contrary to some existing studies (for example, Fafchamps and Wahba, 2006; Khandker and Koolwal, 2011; and Yamauchi, 2011) suggesting that human capital critically depends on spatial connectivity. However, other recent studies (for example, Bucheli et al., 2018 and Peng et al., 2019) show that complementary infrastructure such as schools need to be available to reap the benefits of road construction. The impact of roads on living standard is found to be statistically significant with the expected sign (Column 3 in Table 3.6). Road improvements provide easy access to assets, fuel, housing, sanitation, water, and energy which improve the standard of living. This finding is in accordance with existing literature (Dercon et al., 2009; Kifle and John, 2012; Nakamura et al., 2019).

From a policy perspective, the results for the education and health dimensions should not be undermined as it is difficult to find a substitute for these specialized services. Even when families can afford to send their children to school or to see a doctor, if there are no formal academic centers or health institutions within a reasonable distance, there is nothing that the households can substitute them with. Alternatively, the degree of substitutability of assets and construction material is considerably higher, making it easier to lessen the deprivation in these areas than in health and education.

The importance of roads is limited to improving access to economic centers, without any plans for intermediary development initiatives. Investments in road construction might not be sufficient for poverty reduction as complementary factors also play a role. For instance, improvements in health and education require investments in health centers and schools. For roads to have poverty alleviating effects, they must reach schools and clinics with properly trained professionals. These considerations point to the necessity of integrated infrastructural development to reap the benefits of roads in a broader sense.

Another possible explanation for the results is how households prioritize investments in one dimension over another. The improvements and construction of roads expand families' choice sets but deciding among these alternatives may be difficult because the stakes are high, there is a high degree of uncertainty, and individuals might not have previous experience at taking such decisions. The alternative that a household chooses determines the outcomes for all family members. Sometimes, households opt for a dimension that benefits everyone equally, which could be investing in home improvements rather than sending a child to school. For instance, better access to markets and production factors could lead to higher incomes. In this case, increased expected profits combined with low perceived long-run returns from education could increase the likelihood of parents pulling their children out of school and putting them to work.

7. Conclusions

This study discussed the impact of roads on multidimensional poverty using the DID impact evaluation method. The Alkire Foster Adjusted Headcount Ratio and its consistent sub-indices were also used for calculating the multidimensional poverty index. Multidimensional Poverty Index (MPI) is composed of health, education, and standard of living dimensions. A total of 10 indicators with two indicators for health, two indicators for education, and six indicators for standard of living were used in calculating MPI. Based on this comparable index, it was found that multidimensional poverty in the sample fell between 2012 and 2016. Decomposing multidimensional poverty among the control and treatment groups showed that the average proportion of deprivation suffered by the poor population was larger for the control group which had higher poverty rates.

Looking at the composition and censored headcount ratios of poverty, child enrollment showed the lowest level of deprivation while cooking fuel had the highest level of deprivation. Moreover, looking at the contribution of the dimensions to overall multidimensional poverty, the health dimension stood out as the largest contributor to MPI in both the periods even though its rate declined over time. The decline in health's contribution to MPI was compensated for by an increase in the standard of living dimension.

The DID estimation framework supported the existence of poverty reduction effects through improvements of roads. DID's results showed that investments in road development led to an average drop in multidimensional poverty by at least 12 percentage points among treated households. This result was robust to different model specifications. A separate impact analysis of roads on the dimensions of health, education, and living standard was also done to identify specific results. The study found that access to roads had a strong negative impact on deprivation of standard of living, a moderate negative impact on deprivation of health, and no statistically significant impact on education deprivation.

Despite the economic impact observed in this study, the development of roads in recent years has been slowing down due to, among other things, lack of financial resources. In light of these results, it will be important to develop roads to accelerate multidimensional poverty reduction. The results also suggest that a combined policy effort is needed to exploit better benefits not only by developing roads but also by enhancing complementary infrastructure like schools, education, and health.

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Appendix A3

Table A3.1: Two-sample T-test of indicators deprivation by group

Deprivation	2012			2016		
	Control	Treated	T-test of equality of means	Control	Treated	T-test of equality of means
H	0.948	0.652	12.319***	0.898	0.481	14.894***
MPI	0.588	0.322	18.468***	0.530	0.223	19.428***
Medicine	0.631	0.485	4.595***	0.634	0.460	5.286***
Food	0.848	0.604	8.793***	0.674	0.390	8.846***
Schooling	0.488	0.250	7.860***	0.447	0.170	9.466***
Attendance	0.125	0.096	1.442	0.104	0.097	0.326
Energy	0.717	0.071	27.260***	0.671	0.112	21.062***
Water	0.848	0.450	14.194***	0.924	0.341	22.350***
Sanitation	0.331	0.160	6.265***	0.227	0.032	9.247***
Floor	0.931	0.733	8.502***	0.920	0.678	9.307***
Cooking Fuel	0.977	0.960	1.484	0.979	0.900	4.981***
Asset	0.719	0.371	11.539***	0.657	0.275	12.379***

Note: *** p<0.01.
Source: Author's calculations.

Table A3.2: Two-sample T-test of indicators' deprivation by year

Indicator	Control Group			Treated Group			Both Groups		
	2012	2016	T-test of equality of means	2012	2016	T-test of equality of means	2012	2016	T-test of equality of means
H	0.948	0.898	2.826***	0.652	0.481	5.405***	0.800	0.678	6.040***
MPI	0.588	0.530	3.891***	0.322	0.223	6.660***	0.455	0.368	6.956***
Medicine	0.631	0.634	-0.0721	0.485	0.460	0.793	0.558	0.542	0.711
Food	0.848	0.674	6.299***	0.604	0.390	6.763***	0.726	0.524	9.196***
Schooling	0.488	0.447	1.222	0.250	0.170	3.061***	0.369	0.301	3.114***
Attendance	0.125	0.104	0.985	0.096	0.097	-0.085	0.110	0.101	0.6899
Energy	0.717	0.671	1.475	0.071	0.112	-2.222**	0.394	0.377	0.761
Water	0.848	0.924	-3.597***	0.450	0.341	3.453***	0.649	0.617	1.438
Sanitation	0.331	0.227	3.494***	0.160	0.032	6.874***	0.246	0.124	6.802***
Floor	0.931	0.920	0.665	0.733	0.678	1.876***	0.832	0.792	2.216**
Fuel	0.977	0.978	-0.167	0.960	0.898	3.770***	0.967	0.936	3.310***
Asset	0.919	0.657	1.997*	0.371	0.275	3.159***	0.545	0.456	3.841***

Note: *** p<0.01, ** p<0.05, and * p<0.1.
Source: Author's calculations.

Paper 3: Multidimensional Deprivation and Subjective Well-being:

The Case of Selected Communities in Ethiopia

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3

Multidimensional Deprivation and Subjective Well-being: The Case of Selected Communities in Ethiopia

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Abstract

Although being poor brings many problems for subjective well-being, existing studies have not examined the possibility that multidimensional deprivation moderates these problems. Since the non-fulfillment of needs is presumed to hinder survival, this study hypothesizes that multidimensional deprivation diminishes subjective well-being. Conversely, adaptation theory contends that the poor get used to their destitution and any achievement or deprivation will have no permanent effect on their subjective well-being. To test these hypotheses, this paper investigates the effects of multidimensional deprivation on subjective well-being using two rounds of household panel data collected in 2012 and 2016 for selected communities in Ethiopia using the fixed effects regression model. The results show an increase in multidimensional deprivation is associated with a decrease in life evaluation, a decrease in positive feelings, and an increase in negative feelings with statistically significant levels. Thus, this study maintains that it is important to devise non-monetary multidimensional interventions if society's subjective well-being is to be improved.

Keywords: subjective well-being, multidimensional deprivation, adaptation, life satisfaction, feeling, panel data, Ethiopia

JEL Classification: C23, D03, D11, D31, I3, P36

1. Introduction

An assessment of human well-being should not only be seen in terms of access to goods and services but also how people value these goods and services and also their social conditions. Economists have tried to find the key to achieving a desirable life by typically inferring preferences from observed choices (Kesebir and Diener, 2008; Lyubomirsky et al., 2005). However, departing from this tradition, recent studies show that a meaningful and useful measure of the quality of life can be provided by simply asking people how happy they are with their lives (Diener and Seligman, 2018; Kesebir and Diener, 2008; Tella and MacCulloch, 2006). This approach is a mental-state account which allows people to decide what they mean by well-being and lets them decide how well they feel by their own standards. This notion of well-being is referred to as subjective well-being (Diener, 2009).

Following Easterlin (1974) pathbreaking work, there is an increasing interest in understanding the factors that predict subjective well-being (Diener et al., 2006). Economic literature focusses on assessing whether money buys happiness (Deaton, 2007). Within this circle of interest, there are discussions on the phycological makeup, adaptation, and individuals' relative standing. Studies show that the ebb and flow of absolute income as well as relative standing as compared to others matter for perceptions of well-being (Anderson et al., 2016; Diener, 2012; Easterlin, 1974; Ng and Diener, 2014). These results are context specific, differing, for instance, among rich and poor nations, and have different effects on different types of subjective well-being (Diener et al., 2010).

What is ignored in this line of inquiry is a comprehensive measure of non-monetary achievements that has been separately pioneered by welfare economists. Empirical studies (such as those by Alkire, 2002; Alkire and Santos, 2014; Bader et al., 2016; Sen, 2000, 2001) observe that monetary capabilities do not necessarily represent the levels of achieved functioning in social indicators. Thus, most of them recommend that a direct multidimensional conceptualization of capabilities which complements the indirect methods of income, consumption, or monetary measures should be incorporated in any assessment of welfare (Alkire and Foster, 2011; Alkire et al., 2015; Bourguignon and Chakravarty, 2003; Duclos and Tiberti, 2016). In other words, the multidimensional measure of capability is likely to give a better signal of the relative magnitude of citizens' welfare in terms of the quantitative

assessment of researchers or self-reported valuations of welfare. In this context, it is important to check whether non-monetary multidimensional deprivation is associated with subjective well-being.

Does multidimensional deprivation reduce subjective well-being? Studies show that high subjective well-being is associated with meeting basic material needs and attaining a better standard of living (Bellani and D'Ambrosio, 2011; Cuesta and Budría, 2014; Diener et al., 2010; Haushofer and Fehr, 2014). However, material deprivation and subjective well-being are not always negatively correlated. For instance, there might be a case where deprived households get used to their destitution and are adaptively cheerful. Biswas-Diener and Diener (2001) show that slum dwellers in Kolkata, India enjoyed relatively high levels of well-being even in adverse circumstances. Similarly, Deaton (2012) showed that economic recession in the US in 2008-09 led to small effects on subjective well-being.

The Ethiopian context raises an interesting puzzle in this aspect. The country saw strong real gross domestic product growth averaging 10.9 percent per annum during 2004 to 2014 (The World Bank, 2016). However, even with these improvements in macroeconomic conditions, Alem et al. (2014) document that subjective poverty barely changed in urban Ethiopia. OPHI's, (2018) report on the country shows that the multidimensional poverty index was 49 percent in 2016, a very high rate by any measure. Moreover, Conzo et al. (2017) argue that economic variables were relatively insignificant as predictors of subjective well-being in Ethiopia; instead they emphasize on demographic and sociological factors. Hence, it is not clear how objective conditions add to subjective well-being at least in the case of Ethiopia. This gap provides room for further research on this issue.

This paper contributes to literature in three ways. First, it brings together two separately researched areas of monetary and non-monetary capabilities together and evaluates their effect on the ultimate goal of societies: happiness. Specifically, it emphasizes the independent role of multidimensional deprivation in subjective well-being, which has been largely ignored in previous studies (Bellani and D'Ambrosio, 2011; Cuesta and Budría, 2014). It uses the Alkire and Foster (2011) multidimensional index/score that is composed of education, health, and standard of living to represent non-monetary capabilities as a predictor of subjective well-being.

Second, this paper relies on a 2-round panel data in the context of a developing country, with fixed effects estimations that account for unobserved heterogeneity. In the empirical study it is noticeable that subjective well-being is underexamined particularly in developing countries. Even the studies that are done (Kingdon and Knight, 2007; Ravallion and Lokshin, 2010) use one-time data which does not allow comparisons over time or accounting for unobserved individual heterogeneity. This distinction is important as controlling for unobserved heterogeneity takes care of personality traits and can influence the results substantially (Ferrer-I-Carbonell and Frijters, 2004).

Third, this paper examines whether the different types of subjective well-being are equally affected by income and multidimensional deprivation. Studies in most developed countries argue that subjective well-being is composed of cognitive and affective elements (Arthaud-day et al., 2005). However, studies (Alem et al., 2014; Bellani and D'Ambrosio, 2011; Conzo et al., 2017; Cuesta and Budría, 2014; Ravallion and Lokshin, 2010) in developing countries have focused mainly on life evaluations, while ignoring affective elements. A life evaluation on a '0' to '10' rating scale is used in this paper, with the worst possible life as '0' and the best possible life as '10' to capture the cognitive element of subjective well-being (Corrigan et al., 2013). Moreover, a Likert scale of positive and negative feelings is used for capturing the affective components.

In general, what is clear from the developmental perspective is that it is important to understand the nature of subjective well-being and there is a need for a mechanism to address what affects it. Most developed countries and international organizations are increasingly regarding subjective well-being as a comprehensive policy indicator (Diener and Seligman, 2004, 2018; OECD, 2013). However, in developing countries like Ethiopia the research and policy framework follows a cautionary approach while considering happiness. Thus, subjective well-being studies of this kind can initiate and direct policymakers towards societies' preferences.

The rest of this paper is organized as follows. Section 2 provides an overview of literature. Section 3 gives the research methodology. Section 4 gives the results and a discussion on them while Section 5 gives the conclusion.

2. Literature Review

2.1. Theoretical review

2.1.1. Economics and subjective well-being

The official methodology used in economics has long been guided by the principle that what people say is irrelevant for an understanding of their behavior (Easterlin, 2014; Kahneman and Krueger, 2006). As McCloskey (1983) describes it "crude positivism labels such issues as meaningless, nonscientific or just matter of opinion". However, in recent years subjective testimony has become influential in the economics discipline, particularly in the 'behaviorist' orthodoxy of economics (Diener, 2009, 2012). The economic study of subjective well-being is based on a felt utility which represents an individual's preferences as tractable objects (Tella and MacCulloch, 2006). This is a straightforward strategy since individuals are expected to be good judges of their own quality of life.

Of related relevance to economics is the question whether a higher socioeconomic status provides higher subjective well-being (Easterlin, 1974). It is widely assumed that more is better and people with high economic power have more opportunities to attain whatever they desire resulting in higher well-being (Cowell, 2018). This thinking is reflected in the rational choice theory, which assumes that individuals take decisions that maximize their utility, and that utility increases as income increases (Deaton and Muellbauer, 1980). Put another way, it is reflected in the notion of efficiency which is used for evaluating the state of an economy. Every decision has an opportunity cost implying that an economy cannot produce any more of a good or service without reducing something else. Since social action entails costs for some individuals, it is often impossible to make a Pareto-improving proposal. Thus, evaluation of individual utility can help in identifying net effects (Frey and Stutzer, 2002).

Moreover, in standard economics with revealed preferences it is hard to distinguish between people as rational consumers or people limited by their willpower. Sometimes people judge their own decisions as irrational after pursuing activities that are addictive (Frey et al., 2005; Gruber and Mullainathan, 2002; Oswald and Powdthavee, 2007). In such self-control problems people focus on the present at the expense of their well-being over time. For studies on subjective well-being a valuable source of information about the possibility of bounded

rationality in people's decision making can be identified. People can easily judge situations after taking decisions (Kahneman and Krueger, 2006).

By capturing individuals' preferences, the subjective well-being approach is also directly relevant for government policies (Dolan et al., 2011). Proposals for the provision of public goods are usually expected to be backed by cost-benefit analyses. Since public goods are not exchanged in markets, their benefits and costs are inherently difficult to measure (Fifer et al., 2014; Kahneman and Sugden, 2005). However, public goods can be directly evaluated in utility terms by using subjective well-being as a proxy measure for individual welfare (Dolan et al., 2008). By correlating the amount of public goods with an individual's reported subjective well-being, the marginal utilities or disutilities of public goods can be estimated easily (Kahneman and Sugden, 2005).

2.1.2. Indicators of well-being

There are at least three main concepts associated with different traditions in measuring well-being. The first is subjective well-being, measured through subjective evaluations (Diener and Seligman, 2018; Kesebir and Diener, 2008; Tella and MacCulloch, 2006). The second is monetary capabilities measured through estimated consumption or income (Haughton and Khandker, 2009; Ravallion and Bidani, 1994). The third is non-monetary capabilities measured through multidimensional objective conditions of life (Alkire et al., 2015; Sen, 2000, 2001). Theoretical literature is inclined to come to the conclusion that objective conditions determine subjective status, implying that subjective well-being is an overarching concept that subsumes the other two (Diener et al., 2010; Diener and Seligman, 2018; Easterlin, 1974).

The 'need based' view provides the basis for relating the three concepts by suggesting that subjective well-being is derived by the fulfillment of needs. Based on Maslow (1943) hierarchy of needs, this theory postulates that the more the needs that are fulfilled, the higher the subjective well-being. Embodied in the idea of needs is the fact that some portion of the variance in subjective well-being is explained by the amount of needs that an individual's life circumstances allow to be fulfilled. If fulfillment of needs is presumed to aid survival, better achievements of needs can be taken as rewarding and their deprivation as punishment. This view is a bottoms-up approach which argues that external events, demographics, and objective life circumstances influence subjective well-being. The need-based theory assumes that

societies can be more or less effective in meeting collective provisions and subjective well-being depends on whether these provisions fit with individual needs and capacities. In this sense, it is possible to create greater well-being for a greater number by gratification of human needs.

An issue related to this is the representation and universality of human needs. Earlier literature presents basic needs purely as a monetary issue based on the implicit assumption that income or consumption adequately measures economic status (Deaton, 2007; Easterlin, 1974). However, recent studies show that income or consumption measures do not proxy trends in non-monetary deprivations (Bader et al., 2016). As Sen (2000) describes it "Human lives are battered and diminished in all kinds of different ways, and the first task … is to acknowledge that deprivations of very different kinds have to be accommodated within a general overarching framework." Money-metric measures or single non-income deprivation measures do not accurately represent the simultaneous deprivations that poor people experience (Alkire and Foster, 2011; Alkire et al., 2015; Bourguignon and Chakravarty, 2003; Duclos and Tiberti, 2016). Thus, in addition to income, a joint distribution of non-monetary deprivations is a better way of representing basic goods.

However, two theories have emerged that differentiate subjective well-being from income and multidimensional measures of well-being. These theories are social comparison and personality theory (Veenhoven and Ehrhardt, 1995). Comparison theories contend that individuals evaluate their well-being relative to those around them (Clark et al., 2008; Easterlin, 1974). The idea is that individuals acquire society's 'consumption norms,' and contrast those norm in relation to the self, such that one should be happy if a higher level of consumption is attained and unhappy if less is attained. In its simplest incarnation, the consumption norm is society's median and individuals compare their position against this median which results in a variety of cognitive and affective responses. The notions of relativity can be expanded to include comparisons with aspirations, goals, or some other external standards.

Personality theories are predicated on the notion that subjective well-being is a hardwired temperament characteristic resulting from a combination of early life experiences, cultural socialization, and genetic inheritance (Lykken and Tellegen, 1996; Stubbe et al., 2005). Psychologists regard this as a top-down approach which emphasizes the influence of personality

traits on subjective well-being. In the same way that people lean towards a given level of extroversion and neuroticism, they also lean toward a certain level of subjective well-being (Schimmack et al., 2009). This is usually expressed in terms of 'set-points' in which life events may temporarily move people to either high or low subjective well-being but they eventually revert to their original set points over time (Veenhoven and Ehrhardt, 1995). A major implication of this theory is that improving objective living conditions has no effect on a subjective appraisal of life. However, it opens the door for specific strategies that can make day-to-day lives more pleasing.

Comparisons and personality-based theories endorse that subjective well-being cannot be permanently improved whatever the intervention taken to improve consumption or/and non-monetary multidimensional deprivation. If subjective well-being is stable, a personality trait or relatively determined, it will return to its set points with any kind of change in consumption or multidimensional deprivation. In general, the stakes involved in how subjective well-being is theorized are enormous in that both comparisons and personality theory suggest that improving living conditions will not affect subjective well-being.

2.1.3. Components of subjective well-being

Several components of subjective well-being can be identified in literature. Although they vary in detail, their commonalities can be distinguished as affective and cognitive aspects of well-being (Andrews and Withey, 2012; Corrigan et al., 2013; Kahneman and Krueger, 2006). The affective aspects involve an individual's pleasure-pain feeling which is distinguished further as positive and negative affect (Emmons and Diener, 1985; Watson et al., 1988). Relying on the experience of positive and negative feelings, the affective component measures an individual's experienced utility (Kahneman and Krueger, 2006; Kahneman and Sugden, 2005). This idea has led to the idea of regarding utility as the motive for 'what is' and the criteria to judge 'what ought to be' (Keyes and Annas, 2009).

On the other hand, the cognitive aspect involves a perceived individual evaluation of life satisfaction and relates it to decision utility (Campbell et al., 1976; Diener et al., 1985; Pavot and Diener, 2009). In this case, the outcome is a cognitive process which considers the whole-time horizon of life evaluation. The cognitive components are susceptible to adaptation effects or 'duration neglect', implying that instant reactions may disguise (or have no) effects on a

decision's utility (Fischer, 2009). Thus, the cognitive component of subjective well-being is important when the interest is making changes in individuals' real-life behavior from a long-term perspective (Kahneman and Krueger, 2006).

Accordingly, subjective well-being can be considered as having positive, negative, and life satisfaction components (Arthaud-day et al., 2005). However, many of the existing research uses affective and cognitive components of subjective well-being interchangeably (Alem et al., 2014; Bellani and D'Ambrosio, 2011; Conzo et al., 2017; Cuesta and Budría, 2014; Ravallion and Lokshin, 2010). It assumes that day-to-day emotional encounters tend to influence the evaluation of life events and circumstances, and such influence in turn tends to induce emotional responses. Yet, when life evaluation, positive feelings, and negative feelings are assessed as independent components, they make distinct contributions to subjective well-being (Arthaud-day et al., 2005) and they are not equally related to factors such as income (Diener et al., 2010). This 3-factor model of subjective well-being has gained wide acceptance as a good working approach (Diener, 2012; Diener et al., 2010).

2.2. Empirical literature

A question that has generated immense interest in subjective well-being literature is whether objective achievements are associated with subjective well-being. Some studies show that non-monetary achievements or deprivations matter for subjective well-being. Based on data for European countries, Bellani and D'Ambrosio (2011) found that indices of deprivation and social exclusion were negatively associated with life satisfaction after controlling for individuals' relative incomes. Cuesta and Budría (2014) came up with similar results with non-monetary deprivations including durables, accommodation, health, and social relations in Germany. A recent study by Haushofer and Fehr (2014) found that poverty led to psychological consequences that led to stress and negative affective states.

Studies also show that multidimensionally deprived people usually strive for their day-to-day essentials and have fewer choices in terms of capabilities and functioning (Alkire and Santos, 2014; Alkire and Seth, 2015; Haughton and Khandker, 2009). In developing countries, where resource for socioeconomic achievements are limited, such situations are even more severe and constrain the poor from achieving their desires (Ambel et al., 2015). However, there are cases where the poor adapt to their destitution and their subjective well-being remains unchanged.

For example, Biswas-Diener and Diener (2001) used the multiple measures approach to empirically explore the linkage between destitution and life satisfaction in Kolkata, India. Their study found that slum dwellers reported higher life satisfaction than the well-off comparison groups. Similarly, Su et al. (2020) show that Chinese entrepreneurs in social and economic poverty were enabled to achieve subjective well-being by creating high trust working environments.

Empirical studies also show that the interplay between pecuniary factors and subjective well-being is different for poor and rich countries. Inglehart (1997) argues that developing countries are more concerned with the treatment of economic deprivation, leading societies to place more importance on material values and economic security. However, as an economy develops, people will develop new priorities such as self-expression values and quality of life. Correspondingly, the determinants of subjective well-being will change. Using data on college students an early study by Diener and Fujita (1995) showed that resources were more strongly correlated with life satisfaction when they are relevant to an individual's personal goals. Similarly, a meta-analysis of research in developing countries by Howell and Howell (2008) showed that achieving material security was important for life satisfaction in low-income developing economies.

Literature has mainly used income or consumption measures to refer to socioeconomic status (Diener, 2012; Diener and Oishi, 2000; Howell and Howell, 2008). Studies examining the relationship between income and subjective well-being measured at a point in time and place reveal an unequivocal association between the two (Diener et al., 2010). People with higher incomes, on average, report higher subjective well-being (Clark et al., 2008). Diener et al. (2010) found that subjective well-being's association with log transformed income was linear but convex with raw income, demonstrating that there was diminishing marginal utility of money. Income also exhibits different relationship patterns among different components of subjective well-being. Income is strongly related to life evaluation but is a weaker predictor of emotional well-being (Diener et al., 2010).

However, starting with the pioneering contribution of Easterlin (1974), some economists have found that subjective well-being does not increase over time across countries despite economic growth (Blanchflower and Oswald, 2004; Easterlin, 1995, 2001; Easterlin and Angelescu, 2009;

Frey and Stutzer, 2002; Layard, 2005). The point and across time relationship between income and subjective well-being cannot be aligned easily: a phenomenon that has been called the Easterlin paradox. Reactions to the Easterlin paradox have led to discussions in two directions. One reaction focus on challenging the empirical findings and argues for a change in methodology and data (Diener and Oishi, 2000; Stevenson and Wolfers, 2008).

The other direction seeks to develop a psychologically sound concept of utility to come up with a plausible explanation for the paradox highlighted by Easterlin (1974). The explanations can be classified into two groups. The first group argues that extra pleasures wear-off and disappear with continued consumption (Diener et al., 2006; Frey and Stutzer, 2002) and sometimes individuals do not act 'rationally,' for instance, when taking decisions about television viewing (Frey et al., 2005), smoking (Gruber and Mullainathan, 2002), and obesity (Oswald and Powdthavee, 2007). The second group argues that individuals try to compare their incomes with others around them, and the feelings they experience depend on the outcome of this comparison (Clark et al., 2008; Easterlin, 2001; Frey and Stutzer, 2002; Ravallion and Lokshin, 2010; Veenhoven and Ehrhardt, 1995).

Beyond the relationship between wealth and subjective well-being, research focusing on psychological variables has also got considerable attention in recent empirical literature (Anglim et al., 2020). Diener et al. (2010) found that fulfillment of psychological needs such as social support, respect, mastery, and autonomy, are strongly related to the effective components of subjective well-being. Studies (Bassi et al., 2014; Costa and McCrae, 1980; Lucas and Baird, 2004) have also highlighted the correlation of extraversion and neuroticism with positive and negative effects of subjective well-being.

Beyond research's interest in whether pecuniary or psychological factors determine subjective well-being for individuals, subjective well-being has become an important measure of assessing the costs and benefits of public policies (Dolan et al., 2011; Dolan et al., 2008; Frey et al., 2009; Luechinger, 2010). There is also considerable literature that examines the correlates of subjective well-being including how it depends on personal factors like sex, age, marital status, unemployment, and health problems (Nguyen et al., 2016; Stam et al., 2016; Stutzer and Frey, 2010; Waddell et al., 2019).

Relatively few subjective studies on well-being have been undertaken in sub-Saharan African countries. Ravallion and Lokshin (2010) found that relative deprivation was not a concern for the comparatively poor in Malawi. Similarly, a study by Kingdon and Knight (2007) raises questions about the determinants of subjective well-being in South Africa. Their study found that both absolute and relative income influenced subjective well-being. Alem et al. (2014) investigated the persistence of life satisfaction in Ethiopia and showed that it was strongly determined by the households' relative economic positions. Conzo et al. (2017) showed that fertility was positively linked with life satisfaction in the old age.

In general, the focus of most studies has been on the income measure as representative of households' economic situation. However, income alone is not comprehensive enough to account for people's needs, functioning, and quality of living. Accordingly, it will be beneficial if other proxies of socioeconomic status are incorporated in the analyses of subjective well-being. Thus, this study builds on existing studies and investigates the effects of multidimensional deprivation on subjective well-being along with other covariates including income and relative standing.

3. Empirical Strategy and Descriptive Statistics

3.1. Data and empirical model

The data used for this study is from the Ethiopian Roads Authority. The study uses data from two waves of longitudinal panel data collected in 2012 and 2016 from the road corridors Aposto-Wondo-Negele, Mekenajo-Dembidollo, Kombolcha-Bati-Mille, and Ankober-AliyAmba-Awash Arba. The roads are in Oromia, Southern Nations Nationalities and People, Amhara, and Afar regions in Ethiopia (Graph A4.1, in the Appendix). About 250 households selected from 15 to 20 villages along each road were targeted in each round. Distance to the road was used for stratifying villages and households along the starting, middle, and end points of the road. The survey was originally done with the intention of assessing the overall impact of roads on poverty reduction. However, the survey collected comprehensive information on the subjective and objective characteristics of households, which provides an opportunity for analyzing the well-being of the sample households.

The data includes rich information on households' consumption, life satisfaction, feelings, labor market status, income, health, and socioeconomic variables. A total of 960 and 906 households were surveyed in the first and final waves of the survey, respectively. A section at the beginning of the questionnaire asked the household head's opinion about the household's satisfaction with life and feelings (elaborated in the next section). Even though the questions on well-being were forwarded to the head, they were about the well-being of the household. Thus, the household is the unit of analysis.

3.1.1. Measures of subjective well-being and multidimensional deprivation

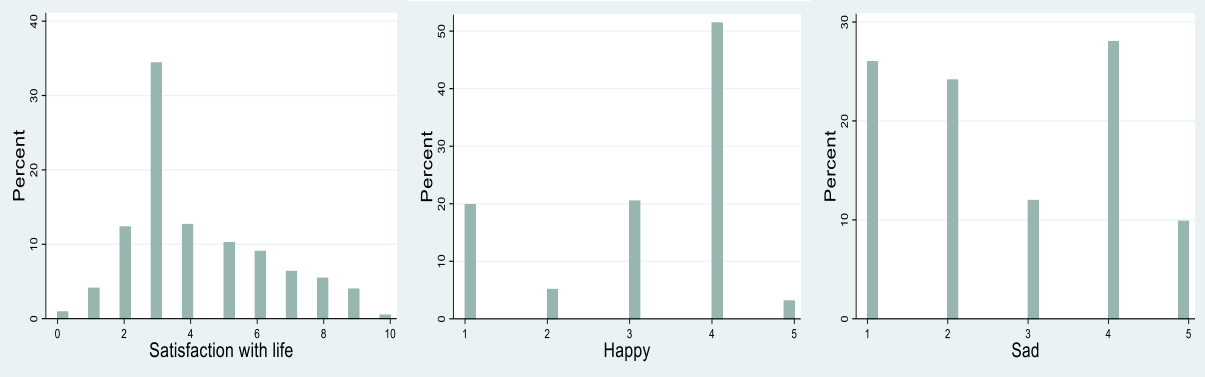
As described in the literature review, subjective well-being is composed of cognitive and affective components (Andrews and Withey, 2012; Corrigan et al., 2013). The former relate to a retrospection of life spanning from the present to the distance past, while the latter implies instant feelings (Fischer, 2009). A key issue in measuring subjective well-being is the problem of valid interpersonal comparisons both in terms of what is measured as well as the yardstick used for classifying people into different categories (for example, poor or non-poor) (Layard, 2005). This difficulty is the reason why subjective approaches have often been viewed critically, especially when individuals in different contexts have different reference points (Pavot and Diener, 2009).

As a response to this problem, literature has identified reliable and valid survey-based questions that facilitate interpersonal comparability and policy assessments of subjective well-being (Arthaud-day et al., 2005). The cognitive aspect of subjective well-being is widely assessed using 'satisfaction-with-life questions' recorded on a 10- or 11-point scale (Pavot and Diener, 2009) while the affective aspects are addressed through 'affect-balance questions' recorded on a 3- to 5-point scale (Watson et al., 1988). Studies show that the reliability test for these kinds of questions in panel data settings yields correlations of around 0.7 (Ehrhardt et al., 2000; Fischer, 2009; Schimmack et al., 2010). Their validity has also been confirmed as they correlate well with a variety of relevant measures and can be improved further by using analytic models that account for personality traits and cultural norms (Fischer, 2009; Kahneman and Krueger, 2006).

This paper measures subjective well-being using life satisfaction, positive feelings, and negative feelings. For the life satisfaction measure the survey question is: "Taking everything

into account, how satisfied is the household with the way it lives?" The respondents were to answer on a point scale from '0' to '10' where '0' is 'completely dissatisfied' and '10' is 'completely satisfied.' Further, for affective well-being the respondents were requested to report how often had the household felt happy and sad in the past two weeks. For each question, they were required to choose from a scale with the lowest value (1) labelled as 'very rarely' and the highest value (5) labelled as 'very often.' The distribution of both cognitive and affective measures is given in Graph 4.1.

Graph 4.1: Distribution of subjective well-being measures



Source: Author's calculations.

The next fundamental question is, how can objective goods and circumstances be measured? So far in literature, income measures have been the dominant approach in analyzing the relationship between objective conditions and subjective well-being. But it has been shown that income measures do not adequately proxy other welfare indicators such as educational level, health status, and living standards (Alkire and Santos, 2014; Nolan and Whelan, 2011). Recognizing this limitation, complementary solutions using different ways of measuring multidimensional capabilities have been proposed by welfare studies (Alkire and Foster, 2011; Barrientos, 2013; Jenkins and Micklewright, 2007; Metz and Gaie, 2010; Sen, 1979, 2000). Among them, the multidimensional poverty index has become a prominent approach as it captures households' multifaceted deprivation levels based on internationally agreed standards (Alkire and Foster, 2011; Alkire and Santos, 2014; UNDP, 2010).

This study uses the calculated household deprivation score to represent a household's inability to reach a minimum core functioning level and basic needs. The score is a multidimensional index calculated based on the method developed by Alkire and Foster (2011). Multidimensional

deprivation is calculated using health, education, and standard of living dimensions, with equal weight allocated to each of them (Alkire et al., 2015). In calculating deprivation scores, two indicators of health, two indicators of education, and six indicators of standard of living are used.[4] The value of the deprivation score ranges between 0 and 1, with 0 representing a household with no deprivation and 1 representing a household deprived in all indicators.

3.1.2. Econometric technique

Provided that self-reported subjective well-being is a valid and empirically adequate measure for human well-being (Arthaud-day et al., 2005), statistical analyses can be conducted that allow exploring the relationships between the known determinants and subjective well-being. However, studies show that it is difficult to unravel these relationships as most of the explanatory variables would likely be correlated with unobserved heterogeneity. The findings concerning what does and does not affect subjective well-being can be influenced by controlling for the idiosyncratic unobserved heterogeneity (Ferrer-I-Carbonell and Frijters, 2004). Therefore, it is necessary to use credible econometric techniques that address this issue. Further, with panel data setting the trend of variables over time can provide important insights. Having these, Equation 4.1 summarizes the empirical model of subjective well-being with a panel data setting as:

$$s_{it} = \beta d_{it} + \boldsymbol{\gamma}\mathbf{x_{it}} + \alpha_i + u_{it} \qquad (4.1)$$

where s_{it} represents subjective well-being of a household i at time t; β is the coefficient of multidimensional deprivation (d_{it}); $\boldsymbol{x_{it}}$ represents a vector of other control variables; α_i captures time-invariant idiosyncratic effects such as personality traits, motivation, language, ethnicity, and cultural biases; and u_{it} is an error term.

Studies in sociology and psychology consider subjective well-being (s) as cardinal and run OLS regressions. However, Equation 4.1 can be estimated using OLS only if there is no correlation between the control variables and α_i, otherwise OLS will be biased and inconsistent. There are, however, many reasons for assuming that this correlation exists in subjective well-being studies. For instance, changes in multidimensional deprivation will be correlated with

[4] The description and the deprivation cut-off for each indicator are given in Table A4.1 in the Appendix.

motivation, personality traits, and cultural heritage that are assumed to be fixed household traits (Lykken and Tellegen, 1996; Schimmack et al., 2010; Stubbe et al., 2005).

The fixed effect model in which the time invariant idiosyncratic effects can be controlled for, is the most robust way of estimating Equation 4.1, especially when the interest is in time varying variables (Wooldridge, 2010). It identifies the effects of explanatory variables on subjective well-being through an OLS estimation of the within transformation of Equation 4.1. Since it assumes a continuous dependent variable, it can be easily estimated and interpreted. However, the fixed effect estimator has the disadvantage of dropping out the effects of time-invariant observable characteristics (Hsiao, 2014).

As an alternative to the linear models, most studies in economics consider the ordinal nature of subjective well-being responses and estimate Equation 4.1 using ordered logit/probit models with the random effect estimator. This estimator works under exogeneity and orthogonality assumptions between the control variables and α_i, thereby not taking a satisfactory account of time-invariant household traits. However, Ferrer-I-Carbonell and Frijters (2004) show that the treatment of subjective well-being as cardinal or ordinal does not affect the results of its determinants while the bias that arises by not considering unobserved fixed personality traits is a serious problem. Therefore, though OLS estimates and those of the ordered probit models are presented, this study primarily discusses the results of the fixed effect regressions.

3.2. Descriptive statistics

Table 4.1 gives the descriptive statistics of subjective well-being and control variables. For the sample households, satisfaction with life had an average value of 3.78 in 2012 and 4.58 in 2016. These values are lower than the neutral value of '5' indicating that, on average, the sample households had low levels of life satisfaction. Moreover, the affective elements with positive feelings had an average value of 3.09 in 2012 and 3.40 in 2016. The sample average for negative feelings in 2012 and 2016 was 2.97 and 2.67, respectively. The average multidimensional deprivation score of the sample households was 0.496 in 2012 which declined to 0.428 in 2016.

Household income is represented by the logarithm of real per adult expenditure per year. Measuring household welfare using consumption expenditure in developing countries is common as income data is generally unreliable (Deaton and Zaidi, 2002). Consumption is

relatively smooth, and households are in all probability unable to report reliable information about income because of secrecy, poor memory, or lack of numeracy. This study uses measures of consumption expenditure composed of both food and non-food components. The calculated yearly consumption expenditure is converted into real terms by using constructed price indices from the survey. The real total expenditure is divided by adult equivalent of a household to account for the differences in needs and intra-household expenditure. Finally, the real per adult expenditure per year is transformed to logarithmic form to ensure the normality of the variable. Similarly, the log median real per adult expenditure of the community is used for capturing the comparison effect. Studies show that status relative to others can have a big impact on a household's sense of well-being (Alem et al., 2014; Kingdon and Knight, 2007).

Table 4.1: Descriptive statistics of the variables over time

Variable	2012		2016		T-test
	Mean	SD	Mean	SD	
Satisfaction with life	3.788	1.938	4.581	2.187	-8.282***
Positive feelings	3.094	1.281	3.399	1.163	-5.359***
Negative feelings	2.969	1.443	2.673	1.443	4.417***
Multidimensional deprivation	0.496	0.203	0.428	0.217	6.956***
Income (log real per adult expenditure)	9.133	1.056	9.655	0.930	-11.267***
Relative income (log cluster median)	9.181	0.592	9.667	0.524	-18.660***
Female household head	0.214	0.410	0.209	0.407	0.242
Age	44.144	15.059	46.892	14.521	-3.996***
Dependency ratio (percentage)	98.294	88.418	84.932	82.389	3.360***
Head participated in social associations	0.668	0.471	0.722	0.448	-2.528**
Chronic health problems	0.034	0.182	0.018	0.133	2.216**
Head is unemployed	0.079	0.270	0.051	0.221	2.414**
Head is monogamous	0.753	0.431	0.764	0.425	-0.559
Head is polygamous	0.031	0.174	0.023	0.151	1.025
Head is single	0.035	0.185	0.027	0.162	1.063
Head is divorced	0.049	0.216	0.053	0.223	-0.349
Head is widowed	0.115	0.319	0.128	0.335	-0.917
Head is separated	0.017	0.128	0.004	0.067	2.545**
Observations	960		895		

Note: *** p<0.01, ** p<0.05, and * p<0.1.
Source: Author's calculations.

The average log real per adult expenditure in the sample was 9.1 in 2012 which increased to 9.7 in 2016. Studies show that there exist significant positive correlations between income and subjective well-being at the household level (Diener and Biswas-Diener, 2002; Diener and Oishi, 2000; Stevenson and Wolfers, 2008). At the household level, the correlation between subjective well-being and income is small, ranging from 0.10 to 0.20 (Diener and Biswas-Diener, 2002).

About 21 percent of the sample was female headed households. Even if the sex variable is expected to be the same, there was a small variation across the two panels. In 2012, the average age in the sample was about 44 years. The average dependency ratio[5] of the sample respondents was 98 percent in 2012 and this ratio decreased to 82 percent in 2016. The effects of demographic characteristics such as age, sex, and dependency ratio on subjective well-being are often small and complex (Conzo et al., 2017). For instance, age is associated with more positive affect and less negative affect (Mroczek and Kolarz, 1998). However, the relation between age and positive affect is linear among men, but curvilinear among women. Similarly, a high dependency ratio implies a burden on the family's workforce, but it is also associated with support and intangible values (Conzo et al., 2017).

This study uses membership status of households in traditional associations called 'idirs' as a measure of a social bond. Idir is a long-term social association established among neighbors to raise funds that are used during emergencies and celebrations. This social association is widely practiced in Ethiopia. About 67 and 72 percent of the sample households were members of a social association in 2012 and 2016, respectively. Studies such as those by Diener and Seligman (2002) and Oishi et al. (2013) show that having a strong social bond is a necessary component of subjective well-being.

In standard economics, unemployment is considered as an economic bad with negative consequences for individuals. In 2012, about 7 percent of the sample respondents were unemployed; this decreased to about 5 percent in 2016. The basic finding from happiness studies is that unemployment reduces individual well-being of those personally affected (Clark, 2003; Frey and Stutzer, 2002; Stutzer and Lalive, 2004). For instance, Clark and Oswald (1994) summarize their result for Britain as: "Joblessness depresses well-being more than any other single characteristic including important negative ones such as divorce and separation."

Marital status is another variable expected to be associated with subjective well-being (Bailey and Snyder, 2007). As Table 4.1 shows there is no significant difference between the two panel periods regarding relationships in households. About 80 percent of the sample households were married (monogamous and polygamous), about 3 percent were single, about 15 percent were

[5] Dependency ratio is the within household ratio of those in the age range of 0 to 14 and 65+ years and those in age range of 15 to 64 years.

divorced or widowed, and about 1 percent were separated from simple relationships. Stable romantic relationships are key components of a healthy lifestyle and are strongly associated with subjective well-being. For example, people in romantic relationships tend to be happier (Diener and Seligman, 2004) and suffer fewer psychological symptoms of stress than those in platonic relationships (Barger et al., 2009).

4. Results and Discussion

Tables 4.2, 4.3, and 4.4 present the regression results on life satisfaction, positive feelings, and negative feelings, respectively. The regressions are estimated for the same model using the pooled ordinary least squares (OLS), fixed effect (FE), random effects (RE), and random effect ordered probit (OPROBIT) estimators. As the Hausman test rejects the RE estimator, the discussion focusses on the results of the FE estimator. The advantage of the FE estimator is that it controls for unobserved personality traits which are assumed to be stable in individuals' lifespans.

The regression results in Table 4.2 show that multidimensional deprivation is a large and statistically significant determinant of life satisfaction. Increased multidimensional deprivation is associated with lower life satisfaction. The coefficient of the between estimator (OLS) is higher than the FE estimator which applies a within transformation to address unobserved household heterogeneity. The result imply that multidimensional capability is much more than the fulfillment of needs, it is important in prolonging household's quality of life. The result is retrospective as education, health, and standard of living dimensions are basic needs that people pursue during most of their lives. The result is in line with the findings of Bellani and D'Ambrosio (2011) and Cuesta and Budría (2014) who found that deprived individuals were less satisfied with their lives.

The results in Tables 4.3 and 4.4 show that multidimensional deprivation also has the expected signs for the affective components of well-being. Higher multidimensional deprivation is related with lower positive feelings (Column 2 in Table 4.3). Multidimensional deprivation is also associated with high presence of negative feelings (Table 4.4) at the 1 percent significance level. This imply that multidimensional deprivation has the power to influence the respondent's mood and emotion. The results are consistent with Haushofer and Fehr (2014) who showed that poverty was related to day-to-day experience of emotions.

Table 4.2: Life satisfaction regressions

	(1) OLS	(2) FE	(3) RE	(4) OPROBIT
Multidimensional deprivation	-0.924***	-0.842***	-0.921***	-0.646***
	(0.262)	(0.263)	(0.216)	(0.207)
Log real per adult expenditure (income)	0.610***	0.230***	0.425***	0.424***
	(0.068)	(0.066)	(0.054)	(0.056)
Relative income (log cluster median)	-0.230**	0.134	-0.013	-0.046
	(0.110)	(0.130)	(0.093)	(0.091)
Age	0.071***	0.097***	0.085***	0.099***
	(0.016)	(0.020)	(0.015)	(0.015)
Age squared	-0.001***	-0.001***	-0.001***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)
Dependency ratio	-0.004***	-0.003***	-0.003***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Head's participation in social associations	0.233**	-0.010	0.103	0.137
	(0.115)	(0.115)	(0.097)	(0.095)
Chronic health problems	-0.380	0.177	-0.004	-0.046
	(0.268)	(0.228)	(0.206)	(0.213)
Unemployment	-0.360*	-0.446**	-0.402***	-0.453***
	(0.194)	(0.177)	(0.148)	(0.145)
Head is single	-0.406	-0.543*	-0.500*	-0.486*
	(0.312)	(0.312)	(0.269)	(0.260)
Head is divorced	0.004	-0.619***	-0.363**	-0.359**
	(0.244)	(0.206)	(0.182)	(0.170)
Head is widowed	0.231	0.055	0.100	0.143
	(0.195)	(0.179)	(0.151)	(0.143)
Head is separated	-0.535	-0.503	-0.474	-0.476
	(0.371)	(0.354)	(0.277)	(0.311)
Head is polygamous	0.372	-0.216	0.009	0.061
	(0.270)	(0.290)	(0.237)	(0.218)
Regional Fixed Effects	Yes	No	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.193	0.315		
sigma_e		1.100	1.100	
Rho		0.723	0.657	
F	27.76***	21.60***		
Wald chi2			514.01***	370.77***
Observations	1855	1855	1855	1855

Note: Robust standard errors in parentheses. * p < 0.10, ** p < 0.05, and *** p < 0.01.
Source: Author's calculations.

In general, climbing out of non-monetary multidimensional deprivation, people experience an increase in their subjective well-being. This finding falsifies the personality-based theory, which endorse that people adapt to their destitution and public policies are powerless to deliver lasting gains in subjective well-being. Indeed, the finding is in line with the need-based theory, according to which fulfillment of needs derive greater subjective well-being. This finding is also in agreement with previous studies which have documented that fulfilling basic needs is associated with better subjective well-being (Diener and Fujita, 1995; Diener et al., 2010;

Howell and Howell, 2008; Inglehart, 1997). This is especially true for poor societies where the focus is more on survival and material needs.

Table 4.3: Positive feelings' regressions

	(1) OLS	(2) FE	(3) RE	(4) OPROBIT
Multidimensional deprivation	-0.475***	-0.648***	-0.485***	-0.503***
	(0.130)	(0.200)	(0.130)	(0.185)
Log real per adult expenditure	0.041*	0.091**	0.043*	0.068**
	(0.023)	(0.041)	(0.023)	(0.033)
Relative income (log cluster median)	0.073	-0.020	0.067	0.082
	(0.058)	(0.121)	(0.058)	(0.079)
Age	0.018**	0.036***	0.020**	0.031***
	(0.008)	(0.012)	(0.008)	(0.011)
Age squared	-0.001**	-0.001***	-0.001**	-0.001**
	(0.001)	(0.001)	(0.001)	(0.001)
Dependency ratio	-0.007***	-0.007***	-0.007***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
Head's participation in social associations	0.995***	0.982***	0.994***	0.995***
	(0.072)	(0.095)	(0.071)	(0.108)
Chronic health problems	-0.227**	-0.282	-0.235**	-0.320**
	(0.115)	(0.187)	(0.116)	(0.142)
Unemployment	-0.333***	-0.425***	-0.342***	-0.872***
	(0.084)	(0.134)	(0.085)	(0.116)
Head is single	-0.244	-0.208	-0.244	-0.201
	(0.168)	(0.181)	(0.167)	(0.239)
Head is divorced	-0.024	-0.033	-0.026	0.032
	(0.122)	(0.179)	(0.123)	(0.177)
Head is widowed	0.029	-0.050	0.024	0.010
	(0.089)	(0.154)	(0.090)	(0.124)
Head is separated	0.014	-0.383*	-0.016	0.083
	(0.207)	(0.226)	(0.205)	(0.296)
Head is polygamous	-0.004	0.100	-0.004	-0.080
	(0.138)	(0.246)	(0.142)	(0.216)
Regional Fixed Effects	Yes	No	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.486	0.409		
sigma_e		0.854	0.854	
Rho		0.395	0.0905	
F	100.4***	35.10***		
Wald chi2			1936.0***	353.45***
Observations	1855	1855	1855	1855

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.
Source: Author's calculations.

Interestingly, the predictive power of multidimension deprivation on subjective well-being is generalizable across different groups in the sample study. Table 4.5 present the fixed effect estimation of multidimensional depravation on subjective well-being by categorizing households in terms of residence area, sex, and income/consumption group. A separate estimation was made on each sub-group and only the coefficients of multidimensional

depravation is presented for easily reference. There is a consistent prediction of multidimensional deprivation on life satisfaction for every group. For urban household's, female household heads and all income groups multidimensional deprivation has a statistically significant effect on all aspects of subjective well-being. This indirectly shows that dimensions used in the calculation of multidimensional deprivation-education, health, and standard of living-derived from the basic human needs are important determinants for subjective well-being. The universality of these human needs and their importance for subjective well-being can be explained by the proposition that deprivation in these needs provoke desires to fulfill the missing encounters. Even at higher levels of income, people do not position away from these needs. Thus, the findings support the proposition that education, health and living standards signify universal and essential needs, and are not mere economic values that people start to emphasize only before or after attaining financial security.

The regression results in Column 2 (FE) of Tables 4.2, 4.3, and 4.4 show that income is a statistically significant determinant of subjective well-being. The results show that doubling one's per-capita income increases life satisfaction by about 0.23 (Table 4.2), increases positive feelings by 0.09 (Table 4.3), and reduces negative feelings by about 0.12 (Table 4.4). The relation of income and subjective well-being is strong for life evaluations but weaker for feelings. These findings are consistent with Diener (2009) and Luhmann et al. (2011), who conclude that changes in permanent incomes are more related to changes in life evaluations than to changes in positive and negative feelings.

This paper also found that households' relative standing was not a statistically significant determinant of subjective well-being. The regression results suggest that being rich or poor as compared to others in the community does not matter for subjective well-being. This result is against many existing studies which found that relative income had a negative effect on subjective well-being. The reasons for this negative relationship include a sense of unfairness, rivalry with the reference group, and envy (Alem et al., 2014; Kingdon and Knight, 2007). But none of these reasons seems to matter in this paper. This is an indication that distribution is not a dominant concern, rather it is absolute levels of living that matter in the setting being studied. Ravallion and Lokshin (2010) show that relative deprivation is not relevant for welfare in poor

countries as much as it is in rich countries, otherwise the priority given to economic growth over inequalities in current policies would be questioned.

Table 4.4: Negative feelings' regressions

	(1) OLS	(2) FE	(3) RE	(3) OPROBIT
Multidimensional deprivation	0.933***	0.701***	0.931***	0.569***
	(0.147)	(0.251)	(0.147)	(0.132)
Log real per adult expenditure	-0.143***	-0.118**	-0.143***	-0.106***
	(0.031)	(0.059)	(0.031)	(0.028)
Relative income (log cluster median)	0.136*	0.089	0.134*	0.116*
	(0.070)	(0.152)	(0.070)	(0.063)
Age	-0.018	0.014	-0.017	-0.010
	(0.011)	(0.018)	(0.011)	(0.011)
Age squared	-0.001	-0.001**	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Dependency ratio	0.005***	0.005***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Head's participation in social associations	0.113	0.163	0.114	0.083
	(0.073)	(0.120)	(0.073)	(0.066)
Chronic health problems	0.921***	0.927***	0.921***	0.706***
	(0.136)	(0.243)	(0.136)	(0.110)
Unemployment	0.615***	0.602***	0.615***	0.589***
	(0.086)	(0.162)	(0.087)	(0.081)
Head is single	0.342*	0.582**	0.346*	0.249
	(0.178)	(0.266)	(0.178)	(0.153)
Head is divorced	-0.053	0.048	-0.052	-0.053
	(0.133)	(0.219)	(0.133)	(0.121)
Head is widowed	0.008	-0.111	0.007	0.042
	(0.112)	(0.174)	(0.112)	(0.104)
Head is separated	0.142	0.165	0.146	0.136
	(0.283)	(0.430)	(0.284)	(0.252)
Head is polygamous	-0.090	-0.145	-0.090	-0.077
	(0.167)	(0.287)	(0.168)	(0.160)
Regional Fixed Effects	Yes	No	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.263	0.166		
sigma_e		1.171	1.171	
Rho		0.366	0.0216	
F	65.38***	13.67***		
Wald chi2			1237.8***	480.27***
Observations	1855	1855	1855	1855

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.
Source: Author's calculations.

There is an increase in life satisfaction and positive feelings with age. This result is in line with many recent studies who now support Campbell's (1981) contention that "the literary image of the crotchety old person, dissatisfied when everything, is not a very realistic picture of older people". The usual justification given is that older people are healthier and stay involved in more life domains than previous generations (for example, Xing and Huang, 2014). Therefore,

the result regarding age supports the optimistic suggestion that subjective well-being improves as people age.

The regression results also show that households with high dependency ratios report lower life satisfaction, lower positive feelings, and higher negative feelings. Being a member of a social association effects only positive feelings. Chronic health problems have a statistically significant effect only on negative feelings. Two justifications can be provided for this result from health-related literature. First, people appear to be remarkably effective in coping with health-related issues using cognitive strategies such as downward comparisons (Okun et al., 1984) that induce a positive image of their condition. If people can find ways of appraising their situations positively, the adverse impact of health problems on life satisfaction can be mitigated. Second, adaptation has been the most popular explanation for the weak association between incidental accidents and subjective well-being (Luhmann et al., 2012).

Another factor that significantly reduces an individual's subjective well-being is unemployment. Unemployment has a statistically significant negative effect on life satisfaction and positive feelings and a significant positive effect on negative feelings. This shows that unemployment is not simply an underutilization of resources and not simply a decision between choosing to stay employed (at a low wage) and becoming unemployed (with unemployment benefits). Rather, unemployed individuals experience psychological stress that goes beyond the reduction in financial losses.

Single and divorced people reported lower life satisfaction than those who were married. Being single relative to being married also had a direct effect on negative emotions. There is a cultural belief in society that women and men have essential qualities that are naturally complementary, and that findings one's 'other half' is needed to live a complete life. This result is congruent with literature (Barger et al., 2009) demonstrating that relationships have a significant impact on life satisfaction.

Table 4.5: Fixed effect estimation of multidimensional deprivation on subjective well-being for different household categories

Categories	Multidimensional Deprivation Predicting		
	Life Satisfaction	Positive Feelings	Negative Feelings
Entire sample	-0.842***	-0.648***	0.701***
	(0.263)	(0.200)	(0.251)
Residential area			
Urban	-0.678***	-0.716***	0.896***
	(0.209)	(0.288)	(0.265)
Rural	-0.783***	-0.047	0.414
	(0.243)	(0.333)	(0.413)
Sex			
Male	-0.695***	-0.330	0.363
	(0.214)	(0.246)	(0.327)
Female	-0.675**	-0.626**	0.863**
	(0.316)	(0.292)	(0.409)
Per adult consumption expenditure			
Bottom 50 percent	-0.531**	-0.537	0.899**
	(0.249)	(0.377)	(0.433)
Upper 50 percent	-0.775***	-1.225***	0.927**
	(0.261)	(0.315)	(0.442)

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. Only the coefficient of multidimensional deprivation is presented, even if other control variables are included in the regression analyses.
Source: Author's calculations.

4.1. Robustness checks

The premise of this study depends on the responses of household heads who are assumed to have the capacity to judge the whole household's subjective well-being status. If this assumption does not work, there might be a possibility that individual judgment with group judgment have been mixed. Therefore, a robustness check is done by including an observation if and only if the same individual from a household was surveyed in both the waves. This means, 163 observations which had a change of household heads between the survey periods, were dropped from the analysis. Columns 1,2, and 3 in Table 4.6 give the results of subjective well-being regressions using the fixed effects estimation. As can be observed in the table, multidimensional deprivation had a statistically significant effect on all aspects of subjective well-being with the expected signs.

The other robustness check relates to the appropriateness of treating subjective well-being as having a cardinal or ordinal nature. Ferrer-I-Carbonell and Frijters (2004) show that the assumption of cardinality or ordinality does not matter for subjective well-being. However, in principle, as the number of categories decline the bias of assuming cardinality may become large. Consequently, the bias for affective measures which have fewer categories might be still

substantial, while the bias for the life satisfaction measure may be negligible. Thus, this paper estimated fixed effects ordered logit models using the 'Blow up and Cluster' (BUC) model proposed by Dickerson et al. (2014). Columns 4, 5, and 6 in Table 4.6 give the results and the coefficients of multidimensional deprivation have the same signs and significance levels as the basic fixed effects estimates.

Table 4.6: Robustness checks with respect to individual responses and fixed effect ordered logit

	Individual response			Fixed effect ordered logit (BUC)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Life Satis.	Neg. Feeling	Pos. Feeling	Life Satis.	Neg. Feeling	Pos. Feeling
Multidimensional dep.	-0.775***	0.597**	-0.507**	-0.895***	0.748***	-0.695***
	(0.282)	(0.299)	(0.225)	(0.263)	(0.251)	(0.199)
Log expenditure	0.293***	-0.142**	0.062	0.620***	-0.196*	0.225
	(0.070)	(0.068)	(0.044)	(0.189)	(0.113)	(0.195)
Relative income	-0.009	0.058	-0.023	0.107	0.298	0.265
	(0.136)	(0.174)	(0.134)	(0.389)	(0.259)	(0.382)
Age	0.111***	0.027	0.032**	0.234***	0.020	0.168***
	(0.022)	(0.022)	(0.014)	(0.048)	(0.033)	(0.050)
Age squared	-0.001***	-0.000**	-0.000*	-0.002***	-0.001*	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dependency Ratio	-0.003***	0.005***	-0.007***	-0.004***	0.008***	-0.018***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Social Association	-0.040	0.191	0.995***	0.274	0.261	0.974***
	(0.124)	(0.139)	(0.107)	(0.263)	(0.208)	(0.264)
Health problems	0.209	0.940***	-0.325	0.369	0.995***	-0.955
	(0.243)	(0.259)	(0.203)	(0.487)	(0.480)	(0.688)
Unemployment	-0.322	0.645***	-0.355*	-0.622	0.991***	-0.619***
	(0.208)	(0.210)	(0.182)	(0.381)	(0.321)	(0.211)
Single	-0.342	0.654*	-0.204	-0.034	0.992***	0.007
	(0.356)	(0.335)	(0.203)	(0.520)	(0.459)	(0.506)
Divorced	-0.544**	0.183	0.053	-0.805**	0.079	0.267
	(0.225)	(0.295)	(0.234)	(0.360)	(0.353)	(0.469)
Widowed	-0.015	-0.157	0.100	0.220	-0.112	-0.394
	(0.242)	(0.264)	(0.226)	(0.419)	(0.287)	(0.513)
Separated	-0.535	0.775	-0.466*	-2.120	0.172	-0.665
	(0.514)	(0.401)	(0.271)	(1.260)	(0.619)	(1.049)
Polygamous	-0.055	-0.117	0.212	-0.289	0.028	-0.827
	(0.311)	(0.333)	(0.286)	(0.748)	(0.396)	(0.868)
2016.year	0.482***	-0.076	0.063	1.158***	-0.135	-0.227
	(0.086)	(0.112)	(0.073)	(0.209)	(0.160)	(0.222)
R^2	0.318	0.160	0.380	0.489	0.207	0.577
N	1692	1692	1692	2232	2414	1,746

Note: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** and $p < 0.01$.
Source: Author's calculations.

5. Conclusion

The history of human being abounds with inquiries about the pursuit of pleasure. The notion that satisfaction dictates what households believe in and what they will challenge is as old as the field of economics. Several researchers and thinkers argue on the importance of achieving a desirable life and rising above mere existence. Assessing the direct report of well-being can be a way of measuring society's quality of life. Previous studies on subjective well-being depend on income/consumption measures for representing people's socioeconomic conditions. However, socioeconomic conditions cannot simply be measured by a lack of monetary resources but need a more comprehensive concept of capability and functioning that are essential for reaching a minimum standard of well-being. Thus, this paper included the recently introduced indices of multidimensional deprivation while studying subjective well-being.

The paper used two wave of panel data from 2012 and 2016 collected by Ethiopian Roads Authority in analyzing the effects of multidimensional deprivation on subjective well-being. Life satisfaction was used to capture the cognitive aspects of well-being, while positive feelings and negative feelings were used to capture the affective aspects. The average person in the sample, had lower level of life satisfaction when compared to the neutral value of '5' in a '10' point scale. The average feeling was slightly above neutral in the balance between positive and negative emotions, with infrequently experienced negative feelings and frequently felt positive feelings. Having these, the paper presumed that, for the sample household's, multidimensional deprivation resulted in lower levels of subjective well-being.

The fixed effects estimation's results suggest that multidimensional deprivation had a significant effect on the respondents' subjective well-being. Exhibiting the largest marginal effects, respondents who were deprived in basic needs reported lower satisfaction with life. This result show that reducing multidimensional deprivation is very important for improving satisfaction with life, which is a reflective judgment of people's lives compared to what they want their lives to be. Reducing multidimensional deprivation is also related to improving positive feelings and reducing negative feelings.

Therefore, subjective well-being is not an accidental by-product of arbitrary mental construct as personality-trait and comparison theorists claimed it to be, rather a functional bio-psychological compass that draws on objective circumstances. The satisfaction of basic needs,

such as sufficient food, proper nutrition, education, sanitation, and shelter are found to have strong influence on subjective well-being, which is in support of the need-based theory. Interestingly, the same trend was observed for people at different position of income group. This suggests that households at all levels of income need to continue fostering activities that facilitate the satisfaction of basic needs. Moreover, policy makers should give more emphasis on improving multidimensional capability, which has robust and replicable effects on all components of subjective well-being and can thus be a pervasive force in the country's development.

Real per adult consumption expenditure has a substantial influence on life satisfaction and a relatively lower influence on positive and negative feelings. Since the study used consumption expenditure which captures households' permanent income, the result is an indication that permanent income is associated with stable changes in subjective well-being which are captured through life satisfaction. Whereas previous analyses of the link between income and subjective well-being, suggest a prima facie case for relative income playing a dominant role, this paper finds that it is only absolute conditions that matter to subjective well-being.

In addition, dependency ratio and unemployment seem to affect all the three domains of subjective well-being. Social associations are related to positive feelings and critical health problems with negative feelings. The fact that household dependency, unemployment, health problems, and social associations predict subjective well-being after controlling for consumption and multidimensional deprivation, imply that measuring subjective well-being can provide a greater voice to quality of life by capturing factors beyond economic variables. Moreover, the finding that consumption, health problems, and social associations have different effects on different components of subjective well-being, imply that different aspects of subjective well-being call for different policy approach. This underlines that researchers and policy makers should be clear about which aspects of subjective well-being they want to address.

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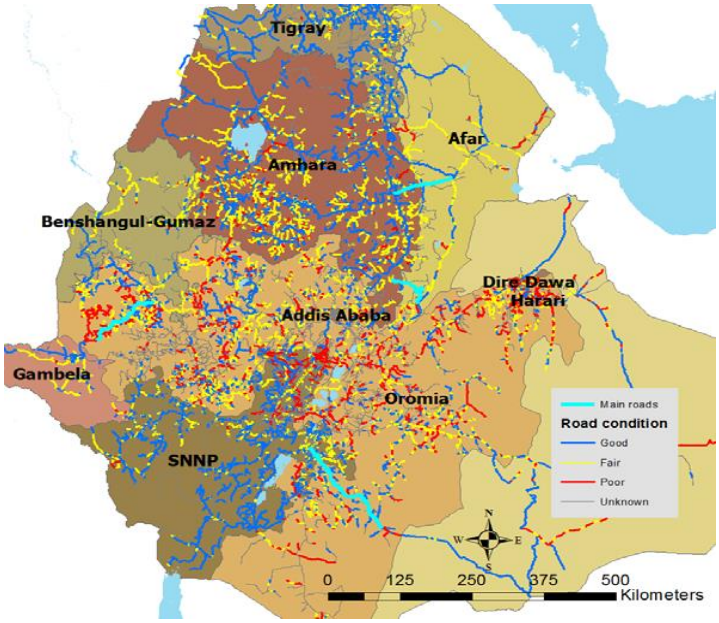
Appendix A4

Graph A4.1: Road Networks in Ethiopia



Source: The World Bank (2016).

Table A4.1: Indicators of multidimensional deprivation

Dimension	Indicator	Deprived
Education		
	Schooling	If no household member has completed 6 years of schooling
	Attendance	If any school aged child (7-18 years) in the household is not attending school in the academic year of study
Health		
	Medicine	If the household has no adequate access to medicines
	Food	If there was a time when the household did not have enough food to eat within a year
Standard of Living		
	Energy	If the household has no electricity
	Water	If the household does not have access to safe drinking water
	Sanitation	The household's sanitation facility is not improved, or it is shared with other households
	Flooring	If flooring is made of earth, sand, or dung
	Cooking fuel	If wood, charcoal, or dung is used
	Assets	If the household does not own more than one radio, television, or mobile phone

Note: Nested weights in parentheses.
Source: Alkire and Santos (2014).