Economy-wide Impact of Investment in Road Infrastructure in Ethiopia: A Recursive Dynamic CGE Approach

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Abstract

In this study an attempt has been made to examine economy wide impact of investment in road infrastructure using a recursive dynamic CGE model. The study used an updated version of the 2005/06 EDRI Social Accounting Matrix. Simulations with the CGE model confirm that with the increasing availability of road infrastructure, there is a positive growth on the macroeconomic and sectorial indicators (Real GDP, absorption, investment, private consumption, real export, and real import) though the magnitude of the effects is relatively small compared with the high investment costs and the changes vary among the different indicators. Similarly, the demand for labor, capital, land and livestock increases with increasing availability of road infrastructure. Income from livestock and land responds better compared to labor and capital as road investment increases. Welfare, measured as equivalent variation, increases on average and at the disaggregate level for all households. The rural poor benefited more from road investment in terms of earning better income and consumption. Road infrastructure affects the production sectors differently. Industrial sectors benefit, while agricultural sectors are relatively less favored.

Keywords: Road, infrastructure, CGE, Ethiopia

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1. Introduction

Investment in infrastructure in general, and in transport infrastructure in particular, is seen as a crucial prerequisite for sustainable economic development. This common belief is reflected in a strong emphasis on the part of all donors, especially those of multilateral aid. World Bank lending to Africa for these sectors amounted to US$3.3 billion in 2009, which is a doubling of infrastructure aid since 2006 (Hannah,2014).

The developing world, and especially the African continent, has a very poorly developed infrastructure, compared to middle- and high-income countries. On average, Sub-Saharan Africa has a road density of only approximately 200 meters of paved roads per km^2 compared to 1400 meters in high-income OECD countries (ibid).

Ethiopia is a land locked country where the major share of passenger and freight movement is by means of road transport and where the transport network is recognized as a major bottleneck.As the government of Ethiopia cognized the role played by road infrastructure in economic development and poverty reduction, the country has undergone rapid expansion in road infrastructure since 1997 as the result of the Road Sector Development Program (RSDP). Massive amount of capital has been invested by the government with the support of international donors for the provision of all-weather roads that improve regional connectivity (ERA, 2014).

Over the Seventeen years of the RSDP, physical works have been undertaken on a total of 110,163 kms of roads excluding routine maintenance work. The total budget for the planned works during this period amounted to ETB 160.3 billion (USD 11.1 billion). The total amount disbursed in the same period, is ETB 180.9 billion (USD 12.2billion).The Fourth Phase of RSDP which is part of GTP has been implemented since 2010/11. During the past four years of RSDP IV, a total of 69,421 kms physical work has been carried out, of which 10,970 kms by Federal roads, 19,355kms by regional roads and 39,096 kms woreda roads(ibid).

As a result of this, accessibility measured in terms of average distance from the road network and proportion of area farther than 5 kms from an all-weather road, shows substantial progress in expanding the road network. Specifically, due to the construction of new roads, the average distance from a road has been reduced from 21 kms in 1997 to 5.5 kms in 2014. The proportion of area farther than 5 kms from an all-weather road, which was 79% in 1997, has been reduced to 40.5% in 2014(ibid).

In addition the average Rural Access Index, RAI for the whole country is currently around 50%, a significant improvement when compared to the situation at the outset of the RSDP(13%) (ibid).

Despite significant improvements in road length, accessibility and quality of roads, few researches were conducted on the impacts of investments in road infrastructure on economic growth, household income and consumption.

The general gaps in the researches which were conducted so far were the inability to address the long term effect and the spillover effect of investing in road infrastructure. That is to mean that the researches were conducted following the partial equilibrium or econometric techniques that lack to address the interrelated effect (see Wondimu(2010),Lulit (2012), Worku(2011) and Dercon(2008)).In addition some of these studies were done for specific road sector development programs and/ or specific areas(Wondimu(2010),Lulit (2012),Dercon(2008 and ERA (2014)).

Generally the research conducted so far did not consider the issue of policy simulation which gives the option for policy makers how much and where to invest on the road infrastructure. In general partial equilibrium model does not provide good understanding of multiple linkages through which investment on infrastructure for road affects the economy and does not provide an adequate framework to outline the transmission mechanisms of the economy wide impact that we need to understand.

Therefore, this study aims to fill this gap by trying to address the limitations described above by using a recursive dynamic CGE Model which is believed to be best suited to assess the impact of investment on road infrastructure on different macroeconomic indicators and welfare effects.

Specifically it tries to analyze the impact of investment in road on:

- Macroeconomic indicators(real GDP, absorption, investment, private consumption, real export, real import),
- Sectorial growth effect(agricultural, industrial, service),
- Factor income(rural poor, rural non poor, urban poor, urban non-poor),
- Household income(rural poor, rural non poor, urban poor, urban non-poor),
- Household consumption expenditure(rural poor, rural non poor, urban poor, urban non-poor),
- In addition the study has an objective of identifying whether road investment is a pro- poor growth or not.

2. Literature Review

2.1 Theoretical literature

The theoretical bases of the impact of infrastructure in general and road infrastructure in particular on growth and other development outcomes are mostly to be found in growth theory.Infrastructure has always been considered as a prerequisite for growth. Different authors define infrastructure at different time from different perspectives. According to Emmanuel (1995), it is defined as “The foundation on which the factors of production interact to produce output and services”. Hirschman (1958) considered infrastructure as services without which primary, secondary and tertiary production activities cannot function.

Most infrastructure including road share common features in which they are mostly non-tradable, and are characterized by economies of scale (Emmanuel, 1995). They also influence consumption and production, though their influence on production is usually indirect through increasing total factor productivity, reducing costs, facilitating market transactions and promoting economies of scale.

The role played by the infrastructure to enhance growth has also been recognized long ago. According to Adam Smith, infrastructure is considered as a major conditioning factor for growth to occur through limiting the size of the market and hence the extent of division of labor. Although less visible, the role of road infrastructure has also been highlighted in subsequent growth theories. According to the Keynesian theory, the growth impact of infrastructure mainly comes through its effect on raising aggregate demand; and the productivity enhancing role of infrastructure is not much emphasized (Nourzad, 2000). Under neoclassical growth framework, transport infrastructure contributes to growth through facilitating the accumulation of factors of production, increasing the supply of productive inputs and raising resource allocation efficiency (Guild, 1998). In the context of endogenous growth theory, while growth is claimed to come through the accumulation of capital and knowledge, transport infrastructure contributes to growth indirectly by enabling firms to make an optimal choice of firm location, technology, scale of production, through expanding market size and increasing the incentive for innovation (Guild, 1998; Barro 1990).

Dissou et al, 2011 noted that investment on productive infrastructure is important in maintaining good economic performance. They also mentioned that Low level of investment on infrastructure is considered as partly responsible for poor growth performance in developing countries.

2.2. Empirical literature

Several studies have examined the impact of infrastructure investment in general and road infrastructure in particular on economic growth and/or poverty reduction. These studies confirm that road infrastructure can have a direct and an indirect effect on growth and/or reducing poverty.

Direct contribution is evidenced by studies undertaken by Barro (1990) in which he considers production function where aggregate output is produced by utilizing capital, labor and infrastructure as production inputs. Likewise Morrison and Schwartz (1996) argue that infrastructure provision improves the productivity of private firms and does contribute to output. The indirect channels reveal that beyond the direct inclusion of infrastructure in production function, there are also transmissions channels through which infrastructure can affect growth. Hanna (2014), considered road infrastructure as enhancing indirectly the productivity of workers through reduction in adjustment costs. In similar vein, infrastructure investments impacts through human development, as investments are made on improving health (Brenneman and Kerf ,2002). Different empirical studies in the past have produced diverse results based on the methodologies used and data employed.

Among the literatures which utilized CGE as a modeling approach, some are reviewed below.

Abhijit et al (2012)and Vaqar et al (2013) assess the impact of transportation infrastructure on economic growth in China and Pakistan respectively by using a dynamic CGE model and considering different financing scenarios. In the same modeling approaches but using different linking mechanism and focusing on road infrastructure, Jayant et al (2006) study the effect of rural road improvement in Lao PDR on poverty incidence using a general equilibrium modeling approaches. In similar way but after estimating the elasticity of trade and transport margin to road investment using econometric technique, Hannah (2014) also develops a modeling framework for analyzing the effects of improved road infrastructure on Zambian economy using CGE modeling approach. She first estimated the elaciticities of trade and transport margin to road density by using econometric technique. She considered 58 countries including 11 African countries to obtain the elacticities of trade and transport margin on road density. She took the trade and transport margin from the SAM of each country and used it as a crossectional data to estimate the coefficient. Accordingly, she obtained different elacticities (coefficients) ranging from 0.12 to 0.19 depending on the number of independent variables included in the regression equation. The elacticities (coefficients) also varies with the sectors

.After she obtained the elasticity of trade and transport margin to road density, she took 0.19 and 0.15 as an elasticity for agricultural sector and other sectors respectively (Hannah, 2014).

She also developed nested production function by considering the transport sector which is part of the overall production. Simulations with the CGE model confirm that with increasing availability of roads, the demand for labour and capital for transport declines. These factors move to the other sectors to produce a higher aggregate output. Welfare, measured as real consumption, increases on average and at the disaggregate level for all households.

Generally from the above few literatures, one can understand that there are different mechanisms to see the impact of infrastructure in general and road infrastructure in particular on the overall economy growth and/or poverty reduction. Some of them linked it directly in the production function (Abhijit et al (2012, Vaqar et al (2013)) and some of them linked it indirectly through transport cost (Jayant et al (2006) ; Hannah (2014)).All studies reviewed above indicated the positive impact of road infrastructure on growth, poverty reduction and welfare.

The impact of infrastructure in general and road infrastructure in particular can also be modeled using different econometric techniques including GMM, maximum likelihood, and full information maximum likelihood technique. Some of them are reviewed below.

Shenggen and Connie (2005) assess the impact of public infrastructure on growth and poverty reduction in China;Khandker et al. (2009)assess the impacts of two road projects in Bangladesh (RDP and RRMIMP) on a range of household outcomes paying particular attention to the contribution of roads. Khandker and Koolwal (2010) also examines the impact of rural roads using household level panel data from Bangladesh between 1997and 2005.Mu and van de Walle (2007) also investigate the impact of a rural road rehabilitation project funded by the World Bank and implemented in Vietnam between 1997 and 2001.Balisacan and Pernia (2002) also indicated the importance of complementarities between public investments in infrastructure and human capital using provincial level data for the Philippines from the 1980s and 1990s.Renkow et al (2004) estimated how transaction costs and market participation is responsive to rural infrastructure in Kenya. Fan and Zhang (2008) and Fan et al. (2002) provides evidence on the importance of the market access channel in alleviating poverty in poor countries like Uganda and Tanzania respectively.

At the local level in Ethiopia, some of the studies carried out including that of Worku (2011), Lulit (2012), Wondimu(2010) and Dercon et al. (2009) show in general that road infrastructure investment has a significant impact on output growth,,poverty reduction and welfare.

In general both the econometric and the CGE modelling approach of the literature indicates that road infrastructure investment has positive effects on economic growth, welfare and poverty reduction. Few of them also indicated that investment in road infrastructure alone does not give the targeted growth of economy, reduce poverty and positive welfare effect. To bring such growth, it has to be coupled with human capital (Balisacan and Pernia (2002)).

In Ethiopian case all the research conducted on the impact of road infrastructure on different macro and micro issues were done following different econometric techniques at country level, regional level or specific road projects. In all cases, under their scope the response of road investment is positive to all macro and micro indicators (Work (2011), Lulit (2012), Wondimu (2010) and Dercon et al. (2009).

Generally this study tries to fill the existing gaps in terms of identifying the macro impact, sectoral impact and welfare impact brought by road infrastructure investment at national level using CGE modeling approach. The study also utilizes the trade and transportation margin as a channel to realize the impact of road infrastructure investment.

3. Data and methodology

3.1 Source of data

To capture the economic wide impact of investment in road, the study has employed a dynamic CGE (which is developed by IFPRI). This study utilized an updated version of 2005/06 SAM which represents the Ethiopian economy by activities, factors (capital, land and different types of labor) and commodities and institutions (households, government and the Rest of the World), including an aggregate savings-investment account (EDRI,2009).The source of this data is EDRI. In addition to this, data from Ethiopian roads authority is also employed in the study.

3.2 The Social Accounting Matrix

A social accounting matrix (SAM) is a comprehensive, economy wide data framework, typically representing the economy of a nation.More technically,a SAM is a square matrix in which each account is represented by an arrow and a column. Each cell shows the payment from the account of its column to the account of its row. Thus, the incomes of an account appear along its row and its expenditures along its column. The underlying principle of double-entry accounting requires that, for each account in the SAM, total revenue (row total) equals total expenditure (column total) (Lofgren et al., 2002).

With regard to the structure of SAM, the standard SAM basically has four major accounts. These are activities, commodities, institutions, factors of production and saving-investment accounts. In addition to these accounts, SAM may have extra accounts like taxes, total margins (ibid).

This study utilized the 2005/06 SAM but updated in 2009 by IFPRI in order to adjust the data so as to match it with the economic performance during 2009 that is disaggregated into 113 activities (with 77 agricultural activities by agro ecological zones, AEZs), 64 commodities, 16 factors (by AEZs except capital), and 13 institutions including 12 households. The SAM also has different taxes, saving-investment, inventory, and rest of the world accounts to show the interaction of different economic agents. It integrates regionally disaggregated agricultural production and income generation for the four main agro-ecological zones of Ethiopia (Humid, high land cereals, drought prone and pastoralist zones)(EDRI, 2009).

3.3 Overview of Standard Computable General Equilibrium Model

A CGE model is generally appropriate in the study where an economy wide impact of a given policy is analyzed. The model explains all of the payments recorded in the SAM of Ethiopian economy. It follows the SAM disaggregation of factors, activities, commodities, and institutions. It is written as a set of simultaneous equations, many of which are nonlinear. The equations define the behavior of the different actors. There is no objective function. In part, this behavior follows simple rules captured by fixed coefficients. For detail of the model see Lofgren et.al, 2002.

The model is appropriate because it can allow multi-sectoral modelling which makes it well suited and it can also be used to model changes for which there is no past experience. In addition it provides a consistent framework to assess the linkages and tradeoffs among different policy packages and help to pass better-informed policy prescriptions (Robinson, 2002).

In this study, we make use of the recursive dynamic CGE model developed by International Food Policy Research (IFPRI) Institute (see Lofgren et al., 2002). A recursive dynamic CGE model is based on the assumption that the behavior of agents is based on adaptive expectations, where agents make decisions on the basis of their past experience of the economy.

The recursive nature of this model implies that the model is solved one period at a time which allows to separate the within period component or the static part from the between or dynamic component of the model. The model is calibrated with the Social Accounting Matrix, which provides initial values for variables and parameters in the model.

3.4 Econometric model for transport and trade cost

Translating the theoretical framework into a suitable CGE model requires information on how much reduction in transport costs will result from an increase in the quantity of roads. In order to link the road infrastructure investment to the overall economic variables, trade and transport margin are suitable channel. In this case an econometric model is required to link trade and transport margin with road infrastructure and other determinants. This actually requires identifying these factors.

There are few literatures that identified determinants of trade and transport margin (TTM). From these literatures the following factors are identified. These include: road network density (RD), GDP per capita (GDPP), population density (PD), degree of urbanization (DU), climate conditions (temperature index (TI) and the yearly precipitation (PR)), fraction of land dedicated to agricultural (FL). Almost all literature uses a cross sectional data across countries to identify the relationship. But one can also estimate the model following the time series data available depending on the quality of the data.

Based on the identified factors the following model can be constructed:

Using time series data

$$\boldsymbol{TTM}_t = \beta_0 + \beta_1 \boldsymbol{RD}_t + \beta_2 GDPP_t + \beta_3 PD_t + \beta_4 DU_t + \beta_5 TI_t + \beta_6 PR_t + \beta_7 FL_t + \epsilon_t \text{..eq (4.17)}$$

Or in logarithmic form

$$ln\boldsymbol{TTM}_t = \alpha_0 + \alpha_1 ln\boldsymbol{RD}_t + \alpha_2 lnGDPP_t + \alpha_3 lnPD_t + \alpha_4 lnDU_t + \alpha_5 lnTI_t + \alpha_6 lnPR_t + \alpha_7 lnFL_t + \mu_t \text{ ....equation (1)}$$

Using crossectional data across the countries

$$TTM_i = \gamma_0 + \gamma_1 RD_i + \gamma_2 GDPP_i + \gamma_3 PD_i + \gamma_4 DU_i + \gamma_5 TI_i + \gamma_6 PR_i + \gamma_7 FL_i + \epsilon_i \text{... (eq4.19)}$$

Or in logarithmic form

$$lnTTM_i = \theta_0 + \theta_1 lnRD_i + \theta_2 lnGDPP_i + \theta_3 lnPD_i + \theta_4 lnDU_i + \theta_5 lnTI_i + \theta_6 lnPR_i + \theta_7 lnFL_i + \mu_i \quad \text{……………………equation (2)}$$

Where TTM are the dependent variables and the remaining are the independent variables described above .Theoretically road density measured as the length of roads in km per km^2 has an inverse relationship with transport and trade margin as transport is easier and different locations are linked more directly. In addition, this effect is expected to be stronger in agricultural sectors as agricultural production is typically located in remote regions.

3.5 Linking strategy

Any domestically produced goods are either be consumed at home or supplied to the domestic market or exported abroad as is assumed in the IFPRI model. If it is marketed, it has to be combined with trade and transport margin. The choice between *home consumption* and *marketed production* is determined by a constant elasticity of transformation (CET) function (Hanna, 2014). Home consumption is only possible in agricultural sectors and basic manufacturing (i.e. food processing). Domestic goods are imperfect substitutes for foreign goods. Domestically produced goods are combined with imported supply in a Constant Elasticity of Substitution (CES) function to form the Armington aggregate which is sold on domestic markets. Domestically produced goods may also be exported, but production of exports differs from production for local markets. This is implemented using a CET function (Lofgren et.al, 2002).

The strategy to link the road density to the CGE models is as follows: First, we should translate the average percentage change of road density to transport and trade margin. That is to mean keeping other variables constant. What is the effect of a certain percentage change of road density to the transport and trade margin? This will be obtained (calibrated) from (Hanna, 2014) result. After getting the percentage change of the trade and transport margin as a result of a certain percentage change in road density (different scenarios can be considered), a shock will be done using the calibrated result in the CGE model through the trade and transport margin equation in the IFPRI model.

4. Simulation and result

4.1 Calibration

The CGE model is calibrated to a base-year dataset in order to provide a benchmark structure of the economy.

Since there is no time series data on trade and transport margin in Ethiopia (except a one year data on the SAM), an estimated road infrastructure-elasticity of the trade and transport by Hannah (2014) was taken. The CGE model has been calibrated in such a way that the trade and transport margin in the agricultural sectors has an elasticity of 0.19 with respect to road density. For other sectors an elasticity of 0.15 has been assumed (Hannah (2014), Teravaninthorn and Raballand (2009)).

4.2 Simulation

In order to give a general idea of the size of the simulated shocks:

a) Performance of road infrastructure in different periods will be considered
b) Projections about the road infrastructure requirements of developing countries should be taken into account.

In relation to the road infrastructure requirement of the developing countries, one might consider the work by Fay &Yepes (2003) as cited by Hanna (2014) that Sub-Saharan African countries should on average invest 5.5% of their GDP per year into infrastructure where approximately 20% of these investments should be spent on roads. This is the same as increasing the road density between 60 and 200% not taking into account increases in the quality through maintenance. For this reason one can demonstrate a wide range of shocks, keeping in mind that 5% is far below the requirements and 200% might be above the optimal investment.

The simulations are therefore intended to show economic wide impacts at different points and test whether there are decreasing returns at some point.

Based on the above assumptions, the following scenarios are considered to evaluate the overall impact of road infrastructure on the economy.

Simulation 0: This is the base case scenario and serves as a reference in the absence of any policy shock .Thus, the result of the base line simulation is used as the benchmark value so as to compare the values of different variables after the policy shocks.

Simulation 1: In this scenario, the average annual road density growth during the Plan for Accelerated and Sustained Development to End Poverty PASDEP (2005-2010) is considered. During this period the road density grew by 6%.Taking the elasticity of trade and transport margin by Hannah (2014), it is the same as reducing the trade and transport margin by 1.02%. Hence a1.14% reduction in transport and trade margin is considered in this scenario.

Simulation 2: In this scenario, the average annual road density growth required to achieve a lower middle income level by 2025(road density of 260km/1000km^2) is considered. During this period the road density is required to grow by 10%.Using the same elasticity, it is similar to reducing the trade and transport margin by 1.7%. Hence a1.7% reduction in transport and trade margin is considered in this scenario.

Simulation 3: In this scenario, the average annual road density growth during the GTP period is considered. During this period the road density grew by 20%.Taking the same elasticity of trade and transport margin, it is the same as reducing the trade and transport margin by 3.4%. Hence a3.4% reduction in transport and trade margin is considered in this scenario.

Simulation 4: In this scenario, the average annual road density grows by 30% or similarly the trade and transport margin reduces by 5.09%

Simulation 5: In this scenario, the average annual road density grows by 40% or similarly the trade and transport margin reduces by 6.78%

Simulation 6: In this scenario, the average annual road density grows by 50% or similarly the trade and transport margin reduces by 8.48%.

4.3 Results and discussion

Here, the detailed results of the simulation and their interpretation are presented. The analysis is done in line with the objective. That is to mean attempt was made to see the effect of investment in road infrastructure (increase in road density or reduce in transaction cost) on major issues like its impacts on macroeconomic indicators (real GDP, absorption, investment, private consumption, real export, real import), sectorial growth effect (agriculture, industry, service), private consumption expenditure (rural poor, rural non poor, urban poor, urban non-poor), and factor income.

4.3.1 Impact of road investment on macroeconomic variables

Table 1 shows the summary of the results focusing on real GDP at factor cost (GDPFC2), fixed investment (FIXINV), private consumption (PRVCON) and absorption.

In all simulations, the macroeconomic variables have shown positive changes. In simulation 1, real GDP at factor cost reveals a 0.02% increase from base line simulation. In simulation 2, real GDP at factor cost reveals a 0.03% increase from base line simulation and in simulation 3, real GDP at factor cost reveals a 0.05% increase from base line simulation. The above results indicate the third simulation perform better compared to others.

For robustness test, three other scenarios are considered: simulation 4, simulation 5 and simulation 6.The result generally indicates that GDP at factor cost has a positive change though the magnitude is small. It grows by 10.72%, 10.75% and 10.77% respectively.

The growth pattern in general indicates that the improvement in road network which ultimately has an effect on reducing the transaction cost has a little effect on the economy unless the economy is also derived by other factors.

Private consumption also increases by 0.12%, 0.19% and 0.39% in simulation 1, simulation 2 and simulation 3, respectively, as compared to base line simulation. Similarly, real investment increases by 0.13%, 0.22% and 0.45%, respectively, in simulation1, simulation2 and simulation3 respectively.

Absorption, which is the total demand for all final marketed goods and services by all economic agents resident in an economy, regardless of the origin of the goods and services themselves, indicates that there is a 0.11%, 0.19% and 0.37 % increase in scenario 1, in scenario 2 and scenario 3 as compared to the base line scenario. The increase in the absorption as the road length increase is theoretically accepted as it relates to environment in which the road creates in terms of availing goods and services at a relatively lower price. Increasing the road network in terms of quality and quantity reduces transaction cost.

Gross fixed investment which is defined as total business spending on fixed assets, such as factories, machinery, equipment, dwellings, and inventories of raw materials, positively influenced by the size in road density. Among all the macro variables, gross fixed investment shows a relatively better increment in all scenarios.

Private consumption increased by 0.12% and 0.19% and 0.39% in scenario 1, scenario 2 and scenario 3 respectively.

Table 1: Impact of road investment on macroeconomic variables (average % change per year)

Variables	**Initial**	**Sim0**	**Sim1**	**Sim2**	**Sim3**	**Sim4**	**Sim5**	**Sim6**
ABSORP	457.7369	10.14	10.25	10.33	10.51	10.72	10.89	11.05
PRVCON	338.6106	9.2	9.32	9.39	9.59	9.80	9.98	10.14
FIXINV	85.4902	12.45	12.58	12.67	12.90	13.15	13.35	13.54

GDPFC2	354.9523	10.64	10.66	10.67	10.69	10.72	10.75	10.77

Source: *Simulation results*

4.3.2. Impact of road investment on trade balance

Table 2 presents result for trade balance. Real export increases by 0.16% in simulation1 compared to base line simulation, while it increases by 0.26% and 0.53% in simulation 2 and simulation 3 as compared to the base line simulation.

Similarly, real import increases by 0.08%, 0.14% and 0.27%, respectively, in simulation 1, simulation 2, simulation3 as compared to the base line simulation.

Simulation 4,5 and 6 indicates that both real export and import shows improvements as the road length expands (the transaction cost reduces).

Table 2: Impact of road investment on export and import (average % change per year)

Variables	**Initial**	**Sim0**	**Sim1**	**Sim2**	**Sim3**	**Sim4**	**Sim5**	**Sim6**
Export	52.14	12.39	12.55	12.65	12.92	16.12	16.92	17.17
Import	-126.51	10.64	10.72	10.78	10.91	9.71	10.13	10.26

Source: *Simulation results*

4.3 .3. Sectoral impact of investment on road infrastructure

As the different sectors have differing transport intensities, a shock in transport costs will have substantially various effects on the different sectors.

Table 3 indicates that agricultural sector grows by 0.03%, 0.05% and 0.09 % in simulation1, simulation 2 and simulation 3, respectively, compared to the base line scenario. The industrial sector grows by 0.19%, 0.32% and 0.65 %, respectively, in simulation,1 simulation 2 and simulation 3 as compared to the base line scenario. The service sector also grows by 0.05%, 0.09% and 0.17% under simulation 1, simulation 2 and simulation 3 respectively as compared to the base line scenario. The remaining scenario (4, 5 and 6) also depicts the same growth pattern.

The result indicates investment in road infrastructure contributes more for the industrial sector than the other sectors. The next sector benefited from road infrastructure is the agricultural sector followed by the service sector.

Table 3: Sectoral impact of investment on road (average % change per year)

Variables	**Initial**	**Sim0**	**Sim1**	**Sim2**	**Sim3**	**Sim4**	**Sim5**	**Sim6**
Agriculture	174.26	7.20	7.23	7.25	7.29	7.38	7.44	7.51
Industry	36.20	13.90	14.09	14.22	14.55	15.09	15.52	16.14
Service	144.50	13.40	13.45	13.51	13.58	13.68	13.82	14.01

Source: *own computation from simulation results*

4.3.4. Impact of road investment on factor income

In relation to returns to factors of production, the results from the CGE model are provided in Table 4. Aggregate factor income has improved in all simulations. The increase in factors income is because of increase in output of activities in all the sectors (industry, service and agriculture). However, the higher growth rate in aggregate factor income is obtained in simulation 6 compared to other simulations. The average growth rate of aggregate returns rises from 10.59% in simulation 1 to 12.54% in simulation 6. It has grown by 0.18%, 0.3%, 0.56%, 0.94%, 1.12% and 1.4%, respectively, for simulation 1, 2, 3, 4, 5 and 6 compared to the baseline simulation. Therefore, returns to all factors of production increase as the road density increases.

Table 4: Impact of road investment on factor income (Average % change).

Variables	**Initial**	**share**	**Sim0**	**Sim1**	**Sim2**	**Sim3**	**Sim4**	**Sim5**	**Sim6**
Labor	174.0084	49.02	9.42	9.60	9.72	10.02	10.36	10.62	10.86
Capital	110.3244	31.08	9.59	9.80	9.95	10.30	10.71	11.02	11.31
Land	39.76201	11.20	11.17	11.47	11.68	12.19	12.76	13.22	13.63
Livestock	30.85749	8.69	12.17	12.44	12.62	13.07	13.58	13.98	14.35
Average		100.00	10.59	10.83	10.99	11.39	11.85	12.21	12.54

Source: *Simulation results*

It appears that households that possess a large number of farm animals, larger land size and better land quality and better human and fiscal capital benefit more from road infrastructure. Among the factors of production, the return of land grows at the fastest rate. Income from land grows by 0.3%, 0.5%, 1%, 1.5%, 2% and 2.5% for simulation 1, 2, 3, 4, 5 and 6 compared to the baseline simulation. The reason could be as the road density increases, productivity of land would increase. The effect of roads on income is larger in a situation where poor farm households use fertilizer as fertilizer raises the return to land (Wondimu, 2012).

The poor benefit from road infrastructure boosts the overall factor productivity and the return to assets possessed by this group of the household(Wondimu,2012).Factor income on the average has increased by 0.18%, 0.30%, 0.60%,0.94%,1.2% and 1.44% in simulation 1, 2, 3,4 ,5 and 6 compared to base line simulation.

4.3.5 Impact of road investment on households income and expenditure

Road projects interventions improve income by altering farm gate price ratios and subsequently influencing micro level production, resource allocation and marketing decisions. Apart from the condition of road access, the effectiveness of markets and the institutions that support them will be critical in determining producer responses to the incentives created by road improvements (Wondimu, 2012).

4.3.5.1 Impact of road investment on household Income

The primary sources of income for households are factor payments generated during production. They also receive transfers from other institutions like government, other domestic institutions and the rest of the world. One can analyze the impact of investment in road on household income using Table 5.

Table 5 below indicates that as the road network increases, aggregate household income has registered positive growth. It grows by 9.5%, 9.76%, 9.56%, 10.31%, 10.59% and 10.80% in simulations 1, 2, 3, 4, 5 and 6 respectively as compared to the baseline scenario.

Table 5 also indicates that household income increased by 0.14%, 0.24%, 0.48%, 0.73%, 0.97%% and 1.16% respectively for simulation 1, 2,3,4,5 and 6 as compared to the base line scenario.

One can also show that the impact of this investment on poor and non-poor households by aggregating income of households in different agro ecological zones through dividing urban and rural areas (see table 6). In general the investment in road will result in increase in real incomes of all households groups irrespective of where they live and wealth status (see table 5). Improvement in road access enhances income through reducing transaction and transport cost, enhancing competition, expanding market opportunities and improving spatial prices for goods and factors (Wondimu, 2012). Through the price mechanisms, it subsequently influences various micro level decisions, namely what to produce (the choice of the cropping pattern), how to produce (input use pattern in general and adoption of new techniques in particular), how much to produce, how much to sell and where to sell. These decisions in turn, through their effect on static and dynamic efficiency, ultimately influence the level of income farm households can generate from their fixed resources (ibid).

Table 5: Impact of investment in road on household income (average % change per year)

Household	**Initial (in billion Birr)**	**share**	**Sim0**	**Sim1**	**Sim2**	**Sim3**	**Sim4**	**Sim5**	**Sim6**
Rural poor	73.93	19.75	9.88	10.09	10.24	10.59	10.86	11.40	11.66
Rural non-poor	261.08	69.74	9.64	9.80	9.90	10.16	10.46	10.70	10.90
Urban poor	3.83	1.02	8.8	8.91	8.98	9.17	9.40	9.50	9.70
Urban non-poor	35.54	9.49	7.65	7.74	7.80	7.95	8.15	8.25	8.35
Total	374.38	100	9.5	9.65	9.76	10.03	10.31	10.59	10.80

Source: *Simulation results*

Identifying the role of roads in poverty reduction and pro-poor growth is critical for policy makers and transport strategist in developing countries. Assessing whether road infrastructures facilitate pro-poor growth or whether the non-poor benefiting more from road projects is critical.

As can be seen in table 6 households who are categorized in the humid poor are very responsive as the road density increases (transaction cost reduces) as compared to the remaining group. In this group the household income increases as road density increases by 0.31%, 0.52% and 0.9% in simulation 1, simulation2 and simulation 3 compared to the base line simulation. Secondly, the highland cereal poor and drought prone poor groups have benefited from road investment. In these groups household income increases as road density increases by 0.23%, 0.38% and 0.75% in simulation 1, simulation2 and simulation 3 as compared to the base line simulation.

In general, in all simulation and household groups the poor are more benefited as compared to the non poor which indicates that investment in road is pro-poor.

Table 6: Impact of investment in road on household income by agro ecological zones (average % change per year)

Household	Initial (billion birr)	Share	Sim0	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Highland cereal poor	29.5	7.88	9.89	10.12	10.27	10.64	11.09	11.39	11.69
Highland cereal non poor	109.9	29.37	9.78	9.97	10.10	10.41	10.78	11.08	11.28
Humid poor	15.7	4.2	10.33	10.64	10.85	11.36	11.23	12.83	13.13
Humid non poor	42.8	11.44	10.07	10.22	10.32	10.57	10.87	11.07	11.27
Drought prone poor	18	4.81	9.85	10.08	10.23	10.60	11.05	11.35	11.65
Drought prone non poor	41	10.96	9.83	10.01	10.12	10.41	10.73	11.03	11.23
Pastoral poor	3.8	1.02	9.98	10.19	10.33	10.68	11.08	11.38	11.68
Pastoral non poor	19.5	5.21	9.89	10.06	10.17	10.46	10.79	10.99	11.29
Farming poor	6.9	1.84	9.36	9.46	9.53	9.69	9.86	10.06	10.16
Non farming non poor	47.8	12.77	8.61	8.71	8.78	8.94	9.11	9.31	9.41
Urban poor	3.8	1.02	8.8	8.91	8.98	9.17	9.4	9.5	9.7
Urban non poor	35.5	9.49	7.65	7.74	7.80	7.95	8.15	8.25	8.35
	374.2	100	9.50	9.67	9.79	10.07	10.35	10.69	10.90

Source: *Simulation results*

4.3.5.2. Impact of road investment on household consumption expenditure

Consumption by households basically depends on observable household characteristics such as age, sex and household size. In addition, consumption can be affected by household's own capital or wealth and other unobservable heterogeneous characteristics of the households. However, provision of public facilities such as roads is important to facilitate production and consumption processes (Wondimu, 2010).

Household consumption grows by 9.16%, 9.25%, 9.48%, 9.71%, 9.97%, and 10.16% in simulation 1, 2,3,4,5 and 6, respectively as compared to the baseline simulation. It grows by 0.13%, 0.23%, 0.46%, 0.68%, 0.94% and 1.13% respectively as compared to the base line simulation. The consumption pattern in rural poor is a bit better than the other household group. Similarly the consumption pattern for rural area is better than the urban area. This might be associated with saving culture and access to roads in the rural areas compared to the urban areas. In general, household consumption raises more with investment in road infrastructure.

The simulation result also indicates that increases in road density or reduction in transport and trade margin benefit more the poor rural and urban household. The poor household benefits 0.04%,0.08% 0.14%, 0.07% ,0.38% and 0.4% higher than the non-poor household in simulation 1,2,3,4,5 and 6 respectively. The result is similar to Wondimu (2012) where the poor rural household benefited from growth in road density. But the response to a unit change in road growth is big as compared to the result of this study. Wondimu (2012) found that a 1% increase in road density increases consumption growth by 13 percent which is significant at 1% significance level. Both studies suggest that road has significant effect on rural households' consumption growth.

Table 7: Impact of investment in road on household consumption (Average % change per year)

household	Initial (in billion Birr)	Share	Sim0	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Rural poor	70.18	20.73	9.62	9.79	9.91	10.20	10.37	10.88	11.08
Rural non poor	237.97	70.28	9.17	9.30	9.39	9.62	9.87	10.07	10.26
Urban poor	3.43	1.01	8.24	8.32	8.38	8.51	8.67	8.79	8.90
Urban non poor	27.04	7.98	6.31	6.39	6.44	6.57	6.72	6.84	6.94
Total	338.61	100	8.59	9.16	9.25	9.48	9.71	9.97	10.15

Source: *Simulation results*

Table 8: Impact of investment in road on household consumption by agro ecological zones (Average % change per year)

Households	INITIAL	Share	Sim0	Sim1	Sim2	Sim3	Sim4	Sim5	Sim6
Highland cereal poor	28.0287	8.28	9.63	9.80	9.92	10.21	10.53	10.80	11.04
Highland cereal non poor	101.6645	30.02	9.39	9.56	9.67	9.95	10.26	10.51	10.75
Humid poor	14.88678	4.40	10.08	10.35	10.54	10.99	10.76	12.38	12.57
Humid non poor	39.57851	11.69	9.67	9.79	9.86	10.06	10.27	10.45	10.62
Drought prone poor	17.13067	5.06	9.6	9.79	9.92	10.25	10.61	10.90	11.17
Drought prone non poor	37.93422	11.20	9.43	9.60	9.71	9.98	10.29	10.54	10.77
Pastoral poor	3.593093	1.06	9.73	9.88	9.99	10.24	10.53	10.76	10.98
Pastoral non poor	18.0667	5.34	9.49	9.62	9.71	9.94	10.19	10.39	10.58
Farming poor	6.541493	1.93	9.07	9.14	9.19	9.31	9.44	9.55	9.65
Non farming non poor	40.72477	12.03	7.89	7.98	8.04	8.19	8.36	8.49	8.61
Urban poor	3.425521	1.01	8.24	8.32	8.38	8.51	8.67	8.79	8.90
Urban non poor	27.03559	7.98	6.31	6.39	6.44	6.57	6.72	6.84	6.94

Source: *Simulation results*

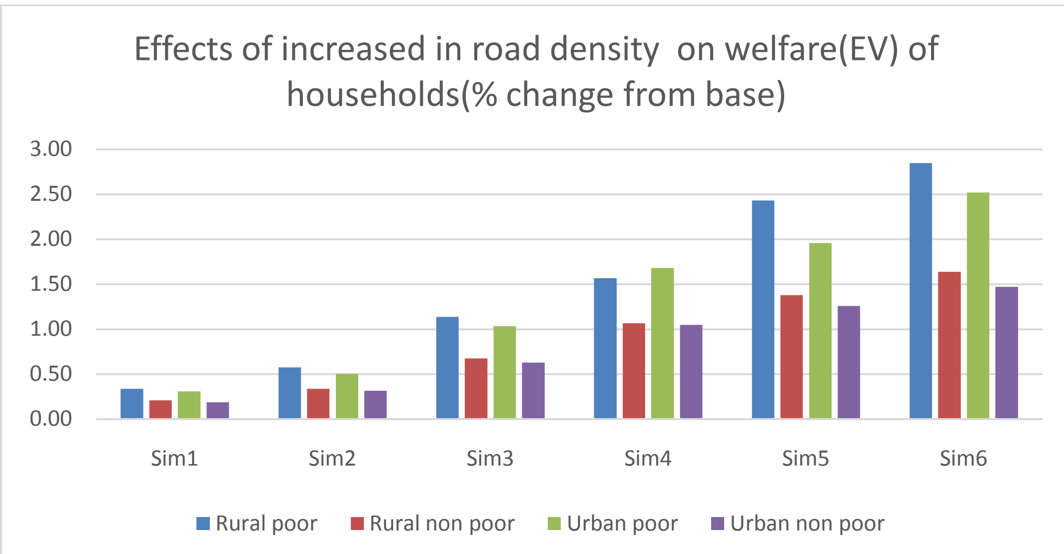
Overall, the effects of even a 100% increase in road infrastructure are fairly small compared to the rather large effects found in some of the results from the production-function literature. This is because Ethiopia has such a low level of road infrastructure that even doubling it leaves the country with an insufficient network.

3.3.6 Welfare Effects

Equivalent variation (EV) measures the change in utility due to the change in prices by using the current prices as the base price and asks what income change is needed at the current price that corresponds to the anticipated change in terms of its impact on utility (Varian, 1992).

EV is widely used as welfare indicator in the literature for CGE models. The major reason behind this is that EV measures the income change at current prices and keeps price fixed at status-quo for different policies, which makes it suitable to compare more than one proposed policy change. Positive EV would imply that there is a welfare gain due to the policy shock while negative EV would imply that there is welfare (utility) loss.

In all the six scenarios, one can see positive EVs for the increases in road density indicating welfare improvements. The EVs showed the highest increase for all household groups during the high case scenario (SIM6) by 2.8% (rural poor), 1.64% (rural non-poor), 2.52% (urban poor) and 1.47% (urban non-poor). The welfare of rural households improved larger than that of the urban counterparts with poor households being relatively well-off in both areas.



Source: *Simulation results*

5. Conclusion and policy implications

5.1. Conclusion

In this study attempt was made to examine economy wide impact of investment in road infrastructure using a recursive dynamic CGE model. The study used an updated version of the 2005/06 EDRI Social Accounting Matrix. Six simulations were done to evaluate economy wide impact of investment in road infrastructure.

Simulations with the CGE model confirm that with increasing availability of road infrastructure, there is a positive growth in the macroeconomic indicators (Real GDP, absorption, investment, private consumption, real export, and real import) though the magnitude of the effects is relatively small compared with the high investment costs and the changes varies among the different indicators. This is partly because the initial road density is so low that even doubling the availability leaves a country with a highly insufficient network. Similarly, the demand for labor, capital, land and livestock increases with increasing availability of road infrastructure. Income from livestock and land responds better compared to labor and capital as road investment increases. Welfare, measured as equivalent variation (EV), increases on average and at the disaggregate level for all households. In this case the poor benefited more from road investment in terms of earning better income and consumption. This indicates that road infrastructure investment is a pro poor growth. Road infrastructure affects the production sectors differently. In particular, the industrial sectors benefit while agricultural sectors are relatively less favored.

In general, road infrastructure investment programmes are an instrument to support the development of a country, as increased road infrastructure has positive effects on economic growth and welfare.

5.2. Implications

This study has some useful implications for policy and future research in relation to investment in road infrastructure.

- Expanding road infrastructure for each agro-zone according to their comparative advantage will provide important inputs for policy making.
- Currently, Ethiopia has reached at the road density of 90.5 km per thousand square km which falls far behind the average road density of lower middle income countries which is about 260 km/1000 sq.km. Therefore, it needs further attention by the government and international donors to enhance the road infrastructure in the country. In this case the RSDP is well performing and required to continue at the same rate or beyond the economy growth.
- Continuing with the road infrastructure development during the PASDEP period has less effect on the overall economic performance and welfare effect compared with the road infrastructure development during the GTP period. Continuing the road infrastructure development growth during GTP period helps to attain the road density requirement of the middle income countries as early as possible.
- As the result showed the land, Livestock holding and human & capital base of a household significantly influence its capacity to benefit from road

investment. Therefore, raising the human capital base and access to other productive resources, such as education and health services, will be necessary for road infrastructure to raise household income in general and the income of the poor in particular.

- For the economy of Ethiopia to be transformed from agricultural to Industrial, the integration of efficient market will be critical. In this case it requires all markets in any regions to be interconnected so that there will be a backward and forward linkage between agricultural and industrial sectors. This implies that the government of Ethiopia should continue its effort in road development.
- While expanding road access is essential, it is not, however, a complete solution as such kind of intervention should be accompanied by other policy and institutional measures to obtain the benefits obtained through investing on road infrastructure.

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