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CAUSAL LINKS AMONG SAVING, INVESTMENT AND GROWTH AND DETERMINANTS OF SAVING IN SUB-SAHARAN AFRICA: EVIDENCE FROM ETHIOPIA[1]

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Abstract

The relationship between saving, investment and GDP still remains an empirical issue. In their aspiration to catch up the rest of the world, developing countries provides a special place on this matter. This paper tried to investigate the main determinants of saving and the connection among saving, investment and GDP in the case of Ethiopia using a combination of time series models. The paper finds export, inflation and lag government expenditure to have a statistically significant short and long term impact on the saving rate. Growth of income has a positive effect on rate of saving and the impulse response function shows the relevance of the neoclassical growth model in explaining the relationship between the saving rate and growth of income albeit lack of statistically significant causality between saving and investment in either direction. Although they may not be conclusive, the results suggest a more conducive policy environment and measures to boost domestic saving so as to induce growth from inside.

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1. Introduction

The shortest path of development has still remained to be mysterious despite successes of some countries. Many countries in the developing world are still trying to search for the root that helps to traverse their population from living in abject state of life. Although it does not necessarily ensure all-embracing improvements in the life of every person, economic growth is a necessary condition for eradication of poverty at a country level. In turn, since economics started emerging as an independent discipline during the era of mercantilists and Adam smith, accumulation of wealth, (which is nothing but saving) has been identified as a key variable for growth. Saving, with the necessary enabling environment is easily converted into investment or capital and enables labour and other resources to be effectively mobilized for the growth of overall level of output in an economy.

The pioneer in terms of clearly establishing the link between saving and economic growth was Harrod (1939), who was later followed by Domar in (1946). The two pioneer development economists lent for the well-known Harrod and Domar Model. These two economists, Solow (1956) and Romer (1986) underscored the importance of saving as it translates itself into investment and stimulates economic growth. According to the neo-classical school led by Robert Solow, an increase in the saving rate brings about a shift in a steady state growth path although its effect is transitory because of diminishing marginal productivity of capital. The endogenous growth theorists argue that an increase in the rate of saving will have a sustained and permanent effect on economic growth because of increasing returns to scale. Regardless of differences in the weight attached to saving by different schools, the conventional view gives value for saving as a source of financing current investment or settling debts spent for past investments stemming either from foreign or domestic sources.

The policies and development activities of various countries have been influenced and guided by the approach advocated by the last generation development economists such as Harrod and Domar. The East Asian experience and the World Bank policy prescription has also been influenced by the same. However, the relationship between the saving rate and the level of income is somewhat complicated by the simultaneous operation of several factors. Thus, the relationship between saving and

investment, and thus, the relationship between saving and economic growth (through the medium of investment) has been an empirical issue.

In the traditional Keynesian theory, the relationship between the saving and the level of income indicates that saving rate increases with the level of economic development. The link between domestic saving rate and the investment is based on the hypothesis that capital does not freely move from one country to the other because of various imperfections. Economic agents and savers tend to invest their resources in domestic investment outlets and require premiums to cover the risk involved in making investment in other countries. This is generally the case provided that domestic investments opportunities are attractive, and resources are efficiently allocated for their most productive use.

Athukorala and Sen (2004) also argue against the perception of the globalization of capital that domestic investment is fundamentally determined by domestic saving and thus high rate of national saving is a crucial determinant of economic growth. There is cross-country evidence which supports the hypothesis that long-run growth rate of income is significantly determined by domestic investment rate and domestic saving rate (Levine and Renelt, 1992). Bacha (1990), DeGregorio (1992), Otani and Villanueva (1990) found a similar result. Loayza et. al. (2000) also find a strong and positive relationship between the national saving rate and the level of income of countries. If there is causality between the two, the policy implication is that domestic saving should be increased to finance domestic investment, finance imported capital goods and thereby achieve sustainable economic growth.

However, the relationship between income level and saving rate in poor countries might be influenced by considerations of subsistence consumption, which is more than inter-temporal consumption smoothing (Easterly, 1994 and Ogaki et.al., 1996). Saving rate and GDP may go in the same direction and this positive association may not necessarily indicate causality. There could be an omitted variable that commonly explains both saving and income. The empirical evidence suggests Granger-causality from economic growth rate to the saving rate instead of the vise versa (Attanasio, et.al, 2000; Rodrik, 2000). The same result has also been found by the studies of Jappelli and Pagano (1996), Gavin et al (1997), Sinha and Sinha (1998) and Saltz (1999).

Besides making an argument based on empirical evidence against the established view that saving is a necessary prerequisite for growth, Moore (2006) has come in open to provide a theoretical framework to show that saving cannot be a constraint for growth. As far as financial markets operate properly and there is a flow of capital across countries, it is not of a necessity to save for investment.

Even if the argument saving versus investment and economic growth has still been unsettled, the question of what determines saving is also a source of theoretical and empirical debate. The life cycle model (LCM), the permanent income hypotheses (PIH) and the relative income hypothesis (RIH) are widely used as a benchmark to organize the arguments about the consumption and saving behavior of households. The Life cycle model (LCM) assumes that economic agents make sequential decisions to achieve a coherent goal using the currently available information as best they can (Browning and Crossley, 2001). Utility maximizing agents postpone part of their current consumption and save it for consumption during retirement in a dynamic and uncertain environment. The PIH argues that consumption expenditure closely follows permanent income, instead of current income of economic agents as hypothesized by Keynesian economists. Modigliani (1986) in his RIH argues that the share of life time resources that households plan to devote to bequests is an increasing function of their life time resources relative to others in the same age cohort.

Basing their decisions on the underlying theory that suits the circumstances of their countries, governments strive to take policy measures that induce mobilization of saving. Propensity to save and thus the saving rate is relatively low in developing countries because of low level of income and the necessity to fulfill subsistence consumption before inter-temporal resource allocation, the relative dominance of necessities in the household budget and liquidity constraints. Interventions of governments in controlling interest rate and mobilization of loans and underdevelopment of financial institutions also contribute for low level of saving. Empirical evidence with regards to the role financial markets and interest rate in mobilizing savings has not been impressive in developing countries (Easterly, 1994; Ogaki et. al, 1996; Rebello, 1991) and this could partly be because of high distortions, which lead at times to negative real interest rate. One of the policy instruments to address this problem is financial liberalization. Financial liberalization tends to improve and nurture the functioning of financial markets and facilitates the flow of

capital across countries. It has become a common knowledge that owing to opening up of economies and increasing trend of globalization, the flow of capital across countries has increased over time. However, the mobility of capital is far from being perfect and supportive of sustainable development in all beneficiary countries.

For instance, Rodrik (2000) claims that countries that have successfully achieved fast and sustained economic growth are also those that increased and achieved high domestic saving rate and provided incentives for their citizens to engage in productive investment and growth promoting activities than otherwise. However, this has not been the case for counties such as Ethiopia, where a greater share of investment comes from foreign sources. The domestic saving rate in Ethiopia has been very low. During 1960-2004, the average domestic saving rate has been only 5.4 percent of GDP. The rate of saving as a share of GDP not only varied significantly among the three different policy regimes but also consistently declined: 14 percent during the period 1960/1- 1974/75, about 7% between 1975/76 and 1990/91 and about 4% between 1991/92 to 2004/5. The country has not been able to mobilize the required amount of saving, which causes for excessive dependence on foreign sources [Worku, 2004].

The main challenge is therefore to identify and explain the factors behind low level of saving for capital accumulation and establishing the link between saving and investment as well as the saving and growth in the context of Ethiopia. Having extensively discussing the theoretical and empirical literatures on saving, Abu (2004) estimated a saving function for Ethiopia and found that fiscal and monetary policy, the investment regime and external factors influence the behavior of economic agents and saving of the country. In addition to this effort, it is worthwhile to investigate the same with a different dimension with the use of different some sets of variables which have equality important influence on the saving rate of the country. This article tries to address these issues. The main objectives of the paper is therefore to (1) explore the main determinants of domestic saving, (2) assess the causality between saving and investment and (3) explore the response of economic growth to a change in saving rate with the intention of confirming or rejecting the validity of theory of the new classical growth by Robert Solow.

The remaining part of the paper is organized as follows. The next section discusses model specification, estimation procedures and the nature of the data set. The third

section deals with the discussion of results and the final section provides a brief concluding remarks.

2. Model specification and description of the nature of data

2.1. Model specification

On the basis of the above theoretical and empirical literature, the saving function to be estimated can be specified in general functional form as:

$$LGDS_t = f(LGDP_t, LGC_t, LX_t, LIM_t, LRIM, POPGR, r, INF, LUSFC) \quad \textbf{(1)}$$

where $LGDS_t$ is log of gross domestic saving. This variable captures both private and government saving because of the fact that the private sector economy in Ethiopia is very fragile and at low stage of development as the country was under a socialist oriented government over seventeen years. Despite the pressure from World Bank and IMF, privatization has not gone far and most privatized establishments became more inefficient after post privatization, thus the public sector has still owned many large enterprises [Worku, 2005].

The explanatory variables with signs expected from the regression coefficients are given as follows.

Explanatory variable (Abbreviated)	Descriptions	Expected sign
$LGDP_t$	Log values of Gross Domestic Product	+ (saving is a the proportion of income which is not consumed)
LGC_t	Government Consumption	- (An increase in government consumption is expected to reduce the amount of saving directly though reduction in government saving and fueling inflation and reducing purchasing power of money kept for consumption).

Explanatory variables continued.

LX_t	Log of export proceeds	+ (Export positively contributes to GDP and thus expects to positively affect the level of saving).
IM_t	Log of cost of imports	- or + (Imports are expenditures, which suppresses the net worth of the country, thus could reduce saving or high import as sign of spending on capital goods triggering development, implying the need for more saving).
$LRIM$	Log of remittance flow into the country	+ (Remittance contributes fairly high share in the GNP of the country, and thus it is possible that it could positively contribute positively to saving).
$POPGR$	Population growth rate	+ Or – (As the size of population increases, the number of people with capacity to save will increase in absolute size and may positively influence the size of domestic saving. On the other hand, high rate of population growth in the context of a typical developing country such as Ethiopia tend to imply that the dependency ratio tends to increase and thus tends to restrain the amount of saving.
r	Nominal interest rate	+ (Following the classical school, nominal interest rate as opportunity cost of capital is expected to have a positive impact on the level of saving.
INF	Inflation rate	- (An increase in inflation rate reduces real interest rate and thus, reduces saving as people tend to diversify risks by spending on real assets than depositing money in the bank).
$LUSFC$	Log of Final Consumption values of the United States of America	- (In line with the relative income hypothesis, the consumption level may tend to follow a similar trend and thus influence the level of saving.

2.2. Estimation procedures

Determination of a saving function based on country level data on time series requires following strict estimation procedures including stationarity test so as to have robust coefficients of parameters.

2.2.1. Unit root test

Macroeconomic variables are normally non-stationary and estimating results of non-stationary series could not provide robust estimates. Thus, unit root tests are done based on the common ways including graphical analysis, Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) on both the dependent and explanatory variables[3].

2.2.2. Engle Granger - Co-integration test

Once the test for unit root is performed and variables are found to be non-stationary, the next step is to make a bilateral co-integration test. A saving function will be

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[3] The common DF test is performed in accordance to the following steps. Assuming that $LGDS_t$ is generated as Autoregressive of Order 1 or AR (1) process of the form:

$$LGDS_t = \alpha_1 + \alpha_2 LGDS_{t-1} + u_t \qquad \textbf{(i)}$$

Dickey Fuller (DF) test requires estimating

$$\Delta LGDS_t = \beta_1 + \beta_2 LGDS_{t-1} + u_t \qquad \textbf{(ii)}$$

where $u_t \sim N(0,\sigma^2)$, $E(u_t u_{t-1}) = 0$ and $\beta_2 = (1-\alpha_2)$.

The test is carried out under the condition that:

$H_0 : \beta_2 = 0$, implying unit root, or $\alpha_2 = 1$,

$H_A : \beta_2 < 0$, implying stationary

ADF Test: Provided that $E(u_t u_{t-1}) \neq 0$, the augmented test to correct for this problem is done by adding differences of lag variables up to the optimal lag length, *k*.

$$\Delta LGDS_t = \beta_1 + \beta_2 LGDS_{t-1} + \sum_{i=1}^{k} \Delta LGDS_{t-1} + u_t \qquad \textbf{(iii)}$$

In this specification as well, the null and the alternative hypotheses are the same as the DF except in the case of ADF under $H_0 : \beta_2 = 0$, the coefficient follows a τ -statistic, which has its own critical values at different levels of degrees of freedom.

estimated based on single explanatory variable each. For instance, we have already estimated the co-integrating regression.

$$LGDS_t = \beta_1 + \beta_2 LGDP_t + u_t \quad \textbf{(2)}$$

The co-integration test is basically a test of the stationarity of the residuals that is derived from equation 4

$$u_t = LGDS_t - \beta_1 - \beta_2 LGDP_t \quad \textbf{(3)}$$

The error term captures the linear combination of the two variables and if it becomes stationary $I(0)$, we could say the two variables are integrated. Since, we do not have the values of the actual error terms; we use the residuals of the estimated results of equation 4.

$$\hat{\Delta} u_t = \alpha u_{t-1} + v_t \quad \textbf{(4)}$$

If all or some explanatory variables are co-integrated, the next step will be to estimate a multivariate saving function, *LGDS* as a dependent variable and all bilaterally co-integrated variables with the saving function as explanatory variables. In our case, as will be discussed in the following section, *LGDS, LGC, LX, LUSFC* and *LREM* are co-integrated with *LGDS*. Thus, the following function will be estimated and following the above procedure a unit root test will be made to test overall co-integration of the variables.

$$LGDS_t = \alpha + \beta_1 LGDP_t + \beta_2 LGC_t + \beta_3 LX_t + \beta_4 LIM_t + \beta_5 LUSFC_t + \beta_6 LREM_t + u_t \quad \textbf{(5)}$$

2.2.2. Error correction model

Once variables are found to be jointly integrated, the next step is to estimate the following error correction model.

$$\Delta DGDS_t = \beta_0 + \sum_{i=1}^{p} \alpha_{1i} DGDS_{t-i} + \sum_{i=1}^{p} \beta_{1i} DLGDP_{t-i} + \sum_{i=1}^{p} \beta_{2i} DLGC + \sum_{i=1}^{p} \beta_{3i} DLX + \sum_{i=1}^{p} \beta_{4i} DLIM +$$
$$\sum_{i=1}^{p} \beta_{5i} DLREM + \sum_{i=1}^{p} \beta_{6i} DLUSFC + POPGR + r + INF + \lambda_1 ECT_{t-1} + \varepsilon_t$$

where $ERT_{t-1} = \lambda_1 (GDS_{t-1} - \hat{\alpha}_1 - \hat{\beta}_1 LGDP_{t-1} - \hat{\beta}_2 LGC_{t-1} - \hat{\beta}_3 LX - \hat{\beta}_4 LIM - \hat{\beta}_5 LUSFC_{t-1} - \hat{\beta}_6 LREM)$ **(6)**

p, *i,* and *t* optimal lag length, lag length, and time respectively.

2.2.4. Granger causality test

The following VAR model will be employed to test the causality between saving and investment.

$$lGDS_t = \sum_{i=1}^{p} \alpha_i lINV_{t-i} + \sum_{i=1}^{p} lGDS_{t-i} + u_{1t} \quad \textbf{(7)}$$

$$lINV_t = \sum_{i=1}^{p} \alpha_i lGDS_{t-i} + \sum_{i=1}^{p} lINV_{t-i} + u_{2t} \quad \textbf{(8)}$$

After estimating restricted (leaving aside the lag variables of the independent variables in each equation) and unrestricted model (including all the dependent and explanatory variables), we construct the F-statistic of the following form:

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(T-k)} \quad \textbf{(9)}$$

where RSS_R and RSS_{UR} are sum of residuals of the restricted and unrestricted model, T is the number of observation (42 years), m is the number of lagged terms and k is the number of all estimated parameters.

2.2.5. Impulse response function

To test for the response of *LGDP* (or output growth, we will estimate a VAR model only considering *LGDS* and *LGDP* and their lags.

2.3. Nature and source of data

The source of data for this study is the World Bank (2007), World Development Indicators time series data, down loaded from the internet. The series has data for many socio economic variables. However, figures for most of these variables are missing for some of the years in the case of Ethiopia, thus limiting the number of key variables that are likely to have an impact on the dependent variables for this particular study. For instance, number of branches of commercial banks and bank density, wealth levels of households and similar other variables could directly or indirectly influence the level of saving and yet they are not considered in this particular study. This is one of the serious limitations of the study.

The rate of inflation *(INF)* is approximated by consumer price index as it directly influences the amount of expenditure of consumption expenditure of households. Banks facilitate mobilization of saving through the medium of interest rate and deposit rate is used to capture the opportunity cost of capital (*r*). Export proceeds of goods and services *(LX)* and cost of imported goods (consumption, intermediate inputs and capital goods) (*LIM)* is used to capture expenditure on imports. Government consumption or expenditure does not include capital goods and military hard wares. As explained above, an increase in government consumption is likely to have a negative effect on saving. All values are used in terms of US dollars for purposes of avoiding heterogeneity of currencies while considering final consumption expenditure of USA. Gross Domestic Product *(LGDP)* and remittance (RIM) are treated in their common usage in the literature. The series covers a period of 42 years (1962 to 2004).

3. Empirical results

3.1. Pre-estimation analysis of the nature of the series

3.1.1. Stationarity test

The first step is to examine the trend of variables over the study period to have a clue about the presence of a systematic trend. Because of the relative income hypothesis of Duesenberry (1949), consumption habits of developing countries could be influenced by the consumption pattern of industrialized countries. Globalization further facilitates the trend of cultural transfer. Unlike most other countries, Ethiopia has never been colonized and thus do not have a special attachment to any particular developed country. Nonetheless, in order to test for the relevance of demonstration effects in affecting consumption expenditure of countries transcending across countries, the consumption expenditure of the US is taken to represent the consumption pattern of the developed world as it is a giant economy in the globe. Figure 1 indicates that the trend of consumption of Ethiopia (LC) is slightly upward trending (with irregularities) while the consumption of USA (LUSFC) shows a smooth upward trend with a lower linear slop.

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The saving of Ethiopia (LDGS) and USA (LUSDS) as displayed in Figure 2 in the Appendix also reflects a similar trend as consumption of the two respective countries. Whereas the USA consumption and saving functions give a hint that the two variables could be non-stationary, the saving data for Ethiopia obscure the nature of the series. From the two figures, one may not be able to deduce that the USA consumption could influence consumption and thus saving rate of Ethiopia. This will be examined later in the empirical estimates.

Figures 3, 4 and 7 (in the Appendix), provide a hint that Investment (LINV), domestic saving (LGDS), import (LIM), export (LX) and remittance are likely to be non-stationary. On the other hand, Figure 5 and Figure 6 (in the Appendix) do not provide sufficient evidence on whether or not Gross Domestic Product (LGDP), Population Growth Rate (POPGR), Nominal Interest Rate (r) and Inflation (INF) are stationary. The summary of graphical representation of variables in levels (before differenced) is displayed in Figure 8 below.

A more concrete test of stationarity of variables is conducted using Dickey Fuller (DF) and Augmented Dickey-Fuller (ADF) and summary of the result is given Table 1 below.

Table 1: Dickey –Fuller and Augmented Dickey Fuller test results[4]

Variable	DF	ADF		Decision Rule
		Computed	Optimal Lag Length+	
LGDP	-1.8964	-1.802	4	Non-Stationary
LINV	-2.8737	-2.2225	4	Non-Stationary
LIM	-1.7762	-1.95	4	Non-Stationary
LX	-2.9623	-2.4458	4	Non-Stationary
LGC	-2.191	-2.1930	4	Non-Stationary
R	-0.91974	-1.4678	4	Non-Stationary
LREM	-3.2178	-2.1854	4	Non-Stationary
LUSFC	-0.49275	-0.43001	4	Non-Stationary
LGDS	-2.4423	-2.1820	4	Non-Stationary
POPGR	-6.4037**	-3.0628	4	Non-Stationary
INF	-3.100	-3.058	4	Non-Stationary

Source: Own calculations.

[4] Critical Values: DF at 5% = -3.514, DF at 1% = -4.178. ADF at 5% = -3.525 and 1% = -4.202. + Based on the minimum values of AIC and SC.

The H_0 for Dickey Fuller is unit root and result indicated that except the population growth rate (POPGR), null hypothesis is not rejected for all other variables, implying that all variables are non-stationary. The ADF result also confirmed that all variables are non-stationary[5].

Provided that the plots show most of these variables to move upward over time, differencing, including the trend variable and a constant term will likely to change the non-stationary series into a stationary one. The summary of results of the Dickey Fuller and Augmented Dickey Fuller test on first difference is displayed in Table 2 below.

Table 2: Results of Dickey–Fuller and Augmented Dickey Fuller test on first difference[6]

Variable	DF	ADF		Decision Rule
		Computed Values	Optimal Lag Length+	
DLGDP	-4.9850**	-3.7823*	2	Stationary
DLINV	-8.8722**	-4.1612*	4	Stationary
DLIM	-8.5529**	-8.5899**	1	Stationary
DLX	-9.3520**	-3.788*	4	Stationary
DLC	-5.2784**	-3.7845*	3	Stationary
Dr	-4.4491**	-3.750*	3	Stationary
DLREM	-6.6273**	-4.007	3	Stationary
DLUSFC	-17.850**	-4.3996**	3	Stationary
DLGDS	-9.6473**	-5.4808**	4	Stationary
DPOPGR	-10.728**	-4.5909**	4	Stationary
DINF	-9.0178**	-4.432**	4	Stationary

Source: Own calculations.

It could be learnt from Table 2, all variables became stationary after first difference, although at different lag length and level of significance. Figure 9 shows a summary of trends of first difference variables. These trends reflect he non-existence of a systematic moment away from the mean values, revealing the stationary of variables.

[5] The summary of graphical representation of variable in levels (before differenced) is displayed in Figure 8 in the Appendix

[6] Critical Values: DF at 5% = -3.519, DF at 1% = -4.19. ADF four lag: at 5% = - 3.532, at 1 % = 4.2161 ADF three lag: at 5% = - 3.528; at 1 % = 4.209; ADF two lag: at 5% = - 3.522; at 1 % = 4.196 and ADF one lag: at 5% = - 3.516; at 1 % = 4.184. + Based on the minimum values of AIC and SC.

The test for stationarity for investment variable (DLIV) is done together with the explanatory variables of the saving function to understand its behaviour as we will test for causality between saving and investment in the later stage.

3.1.2. Co-integration test

Provided that the variables are non-stationary at levels, the next step is to test for co-integration at two different levels. First, a bivariate regression of the saving variable (LGDS) on each of the explanatory variables is made for Engle – Granger and Augmented Engle Granger test for co-integration on the basis of the error term.

The Engle – Granger Causality test indicated that except interest rate (r), inflation rate (INF) and population growth parameter (POPGR), residuals of all bivariate estimates of saving (LGDS) on all other explanatory variables are co-integrated of order 1. The next step is to estimate a multivariate model on saving (LGDS) on all variables co-integrated with saving.

Table 3: Test Results of the Engle – Granger Co-integration Test[7]

Residuals Saved from $GDS = F(.)$	DF	ADF		Decision Rule
		Computed values	Optimal Lag Length+	
LGDP	-4.1871**	-3.6459*	2	Co-integrated
LIM	-8.5529**	-4.1404*	4	Co-integrated
LX	-4.936**	-3.6515*	4	Co-integrated
LGC	-4.1210*	-3.9770*	3	Co-integrated
R	-3.743*	-3.743*	0	Not-cointegrated
LREM	-4.3904**	-3.7975	3	Co-integrated
LUSFC	-4.3993**	-3.5654*	3	Co-integrated
POPGR	-4.9247**	-4.9247**	0	Not-cointegrated
INF	-4.5233**	-4.5233**	0	Not-cointegrated
Residual from multivariate regression	-4.9346**	-4.159**	4	Co-integrated

Source: Own calculations.

[7] Critical Values for DF: at 5% = -3.514, at 1% = -4.178; ADF: Lag 4: 5% = -3.525; 1% = -4.202; ADF: Lag 3: 5% = -3.522; 1% = -4.196; ADF: Lag 2: 5% = -3.519; 1% = -4.19; + Based on the minimum values of AIC and SC.

The ADF test on the residual of multivariate co-integrating equation indicated that individually co-integrated variables with the saving function are jointly co-integrated[8].

Before we estimate the final error correction model, the correlation matrix of independent or predetermined variables is estimated as shown below in Table 4.

Table 4: Correlation Matrix of Independent Variables

	REM	INF	LGC	LGDS	LUSFC	LIM	LX	POPGR
REM	1.0000	0.060936	0.18038	0.049008	0.0066465	0.030069	-0.0488	-0.0068
INF	0.060936	1.0000	0.53272	0.032368	0.14581	0.17669	0.055952	0.14572
LGC	0.18038	0.53272	1.0000	0.54048	0.59131	0.64347	0.44772	0.16066
LGDS	0.049008	0.032368	0.54048	1.0000	0.77618	0.80285	0.70278	0.29401
LUSFC	0.0066465	0.14581	0.59131	0.77618	1.0000	0.98059	0.88760	0.016970
LIM	0.030069	0.17669	0.64347	0.80285	0.98059	1.0000	0.89553	0.059704
LX	-0.0488	0.055952	0.44772	0.70278	0.88760	0.89553	1.0000	-0.10656
POPGR	-0.0068	0.14572	0.16066	0.29401	0.016970	0.059704	-0.10656	1.0000

Source: Own computations.

3.2. Error correction model

Most explanatory variables are found to be co-integrated of order 1. Estimating difference equation of the saving variable (DLGDS) on differences of other variables would give a robust estimate in econometric sense, but it could only show the short run or the transitory effect of these variables on saving. Economic policy decision requires marginal and total effects of predetermined and exogenous variables on the dependent or target variable. Thus, the error correction model (ECM) is estimated to capture both transitory and long run effects. The error correction term is captured from the first lag of the residuals of the multivariate equation. Apparently, we could observe from Figure 11 of the Appendix that the residual of the multivariate co-integrating equation is stationary oscillating its zero mean value. The over parameterization model for estimating the error correction model (8) captures first

[8] The trend of co-integrated variables is displayed in Figure 10 below.

differences of co-integrated variables, the non-nonintegrated variables at levels and the error correction term.

After a series of iteration, the parsimonious estimated ECM with the major diagnostic test statistics result is summarized in Table 5 below.

Table 5: Error correction model results

Variable	Coefficient	Std. Error	T-value	Prob.
Constant	-0.0125	0.039625	3.17	0.0
DGDP	0.10581	0.0538	2.1	0.03
DLGC-1	-0.46688	0.2035	-2.29	0.029
DLX	0. 0124	0.02048	2.02	0.024
DLIM	0.346976	0.2751	1.26	0.216
DLRM	0.0818217	0.0557	1.48	0.149
DLUSFC	-5.02955	3.303	-1.52	0.138
POPGR	0.15999	0.10628	1.505	0.154
R	0.0096	0.13728	1.43	0.155
INF	-0.0530674	0.007328	-3.15	0.001
INF-2	-0.0155380	0.008273	-1.88	0.07
ECT-1	-0.716116	0.2858	-2.51	0.019

Sigma = 0.40893 RSS = 3.01002492 R^2 = 0.792061, F (30, 12) = 298 [0.009]. Log likelihood = -4.24527 DW = 2.21 No of Observation = 42. ARCH - χ^2 (1) = 0.05. Reset - χ^2 (1) = 0.061.

Source: Own Calculations.

After a series of experimental estimation, the parsimonious equation estimates reveal six significant coefficients among eleven parameters (excluding the intercept term). On the basis of F – test, R^2 and the other tests, the model is statistically significant to describe the short and long run relationships. The stability of the model is also confirmed through the use of Chow Test. The power of the model to predict the actual values of the LGDS is also tested using graphical analysis. Both results are displayed in Figure 12 and 13 in the Appendix. The $ECT-1$ is the error correction term demonstrating the long run relationship of variables with the error term and it

appeared with statistically significant coefficient and expected usual sign. It shows the process of the long term adjustment towards equilibrium once saving diverges from equilibrium.

The result confirms the importance of *GDP* or economic growth in the saving processes. The level of current income positively and significantly influences the behavior of aggregate saving rate. This result supports the absolute income hypothesis in that the level of income is an important determinant of the capacity of a country to save. However, the aggregate nature of the data does not allow the effect of distribution of income on saving or the level of saving rates for different income categories. Lag government consumption (LGC-1) has significant and negative impact on the level of current saving.

The estimates on the population growth are not statistically significant. This is in line with our expectation that population growth has a mixed effect on saving. The higher the rate of growth of population, the larger the number of people joining the active age group with the capacity to save, which tends to boost the level of saving. However, because of lopsided population structure towards the dependent age group, the increasing rate of population may even lead to a more than proportionately increase in consumption and thus reduction in saving. The insignificant coefficient for the demographic variable *(POPGR)* is an indication of the inability of either of the two effects to outweigh the other. Neither the attempt to change the rate of population growth with proportion of the people in the active age of group (15 to 64 years) changes the result.

The coefficient for nominal interest rate *(r)* is positive as expected but found to be insignificant. This does not however lead to a conclusion that interest rate does not have a role to mobilize saving. The rate of interest has been set by the government and revisions have been made less frequently. Thus, the administratively set rate does not necessarily reflect the market clearing rate. Particularly before 1992, government was directly involved in credit rationing and this policy clearly used to distort the financial market in terms of mobilizing savings. Since 1991/92, the incumbent government has provided more opening to the financial market and yet the upper and lower bounds of interest rates are still set by the National Bank of Ethiopia. This has greatly limited the role of financial markets to link up the demand for loanable funds

with the supply (Authukorala and Worku, 2006). For this reason, interest rate in Ethiopia does not reflect the opportunity cost of current consumption relative to future consumption and thus does not provide adequate guide on the basis of which economic agents adjust their decisions.

Because of the need to capture the effect of the change in real interest rate, inflation rate *(INF)* was incorporated in the saving function with the nominal interest rate. As it is expected, current inflation rate (*INF)* has a significant negative impact on saving. This is contrary to the hypothesis and of the result of Athukorala and Sen (2004) that 'when faced with inflation, consumers attempt to maintain a target real wealth relative to income by reducing consumption'. The empirical result rather suggests that in a country where a largest segment of the population live in amidst of poverty, as risk averse economic agent, consumers tend to utilize their income in the current period before it looses its value in the coming future. Inflation in this context is a tax on saving.

Although migration into the developed world has a damaging economic effect as it is mainly in the form of a brain drain, remittance has now become a significant source of income into the developing world including Ethiopia. According to the World Bank (2006), remittance has exceeded US$ 233 billion worldwide by 2005. [Brown, 1994] indicated that migrants' savings and investment abroad may represent a substantial or even the major part of their overall transfers. World Bank (2006) attributed this remittance to an increase in altruistic payments of migrants to their families abroad. Sinning (2007) indicated that savings in the home country is one of the motives for remittance. In this study, *LRM* has shown a positive and yet insignificant value. This might tends to shade light about the positive impact of remittance on saving. However, because of the macro nature of the data, it is difficult to capture the saving behavior of individuals, who benefit out of remittance.

Export proceeds (LX) have shown a positive and statistically significant impact on saving as it positively influences the trade balance and thus the capacity of the country to save. On the other side, coefficient for the imports (LIM) is not statistically significant although shows a theoretically unanticipated positive association with saving. It could be because of the fact that in the Ethiopian case, imports normally exceed over and above export revenues and they are largely financed by foreign loan

and aid. Thus, import revenue may not have a short or a transitory direct effect on savings.

The theory of the relative income hypothesis suggesting that demonstration effect has an impact on consumption pattern of households and this effect transcends across boundaries is not backed by empirical evidence in the case of Ethiopia. Despite the fact that the level of US consumption is found to be negatively associated with the Ethiopian domestic saving, it is not found to be statistically significant. This could be because of various reasons. There is a huge variation in the living standards of the people of two countries. Owing to Ethiopia's unique historical background of being out of cultural domination of any country, associating its consumption pattern and expenditure on a specific country on the basis of the relative income hypothesis may not give sound evidence.

3.3. Granger causality between saving and investment

Granger causality test has been undertaken to confirm whether the long-established view of development economists suggesting that saving is a necessary requisite for investment and of growth or the recent theoretical literature arguing that saving is never a constraint on investment. The result is indicated in Table 6 below.

Table 6: Pair-wise Granger causality test: Saving and investment (1962-2004)[9]

Null Hypothesis	Observation	Optimal lag length for the test*	Computed F-Statistic	Decision Rule
Investment does not Granger cause saving	42	6	1. 4923**	Accepted
Saving does not Granger cause Investment	42	6	1.2300	Accepted

Source: Own calculations.

The econometric result in this particular study reveals that investment does not Granger cause saving and saving does not Granger cause investment. This might be because of the fact that in the Ethiopian case, the role of domestic saving in financing

[9] Critical F (28,6): at 1% = 4.02; at 5% = 2.92.

investment is extremely limited. This is clearly observed from the external trade balance as well as the saving-investment gap of the country. This result seems to go in line with Moore (2006) hypothesis that 'Saving is never a constraint on investment'. Nonetheless, this conclusion does not necessarily imply that countries may not need to save in order to develop their economies.

Depending heavily on foreign sources for investment is likely to impose high debt burden and policy interference by lending or foreign capital source countries. In addition to foreign loan and aid, the other source of external finance is FDI. The economic impact FDI on sustainable development of countries has remained to be controversial because of the various motives [Athukorala and Worku, 2003] and asymmetric information and moral hazard issues. Thus, promoting domestic saving is not only a more reliable source of sustainable development as it reduces dependence on foreign sources but also boosts the level of investment of the country, which has still remained very low.

3.4. Impulse response function: Growth of GDP versus saving

The results of the vector autoregressive (VAR) model for saving and GDP in Table 7 indicates that past growth rate of real per capita income has a strong and robust prediction power on current saving rate performance.

Table 7: VAR Estimation Results on Saving and GDP Growth for 1962-2004

Variables	LGDS (Saving)	LGDP (GDP)
saving(-1)	0.5881***	0.0551
	(0.1703)	(0.3766)
saving (-2)	0.3417**	0.0238
	(0.16339)	(0.3613)
Growth(-1)	0.1646**	0.1939
	(0.07439)	(0.1645)
Growth (-2)	0.0021	-0.507***
	(0.0779)	(0.1722)

Note: The numbers in parenthesis are standard errors for the corresponding coefficients. *,**,*** refer to significance levels at 10, 5 and 1 percent, respectively.

However, GDP growth rate does not seem to be strongly predictable by past domestic saving performance. The weak, short-run dynamic relationship between past saving rate and current growth performance, albeit positive, might suggest weaknesses in allocation of saving to their most productive uses that can sustain and attract further saving efforts. The short term relation, however, should not be interpreted as if saving rate does not also have long term effect. A country still finances part of its investment from external borrowing and grants, this may not however continue in the long term since the economy would reach unsustainable level of external indebtedness. Rather failure to improve the saving rate might continue to negatively affect the domestic capacity of capital formation and thus sustainable development of the economy[10].

The empirical result suggests that an increase in the saving rate is likely to boost the level of GDP and thus creates disequilibrium for a while. Adjustment for the shock could take up to a period of 20 years. The implication is that a one shot increase in the saving rate could positively contribute for the growth the economy and yet may not bring about a sustained increase in the pace of growth of the economy. A continuous improvement in the level of growth needs continuous rise in the saving rate, which may not be easy. Thus, in addition to improving the saving rate, it is also worthwhile to invest on human capital and technical progress to bring about a consistent rise in the rate of growth of the economy because of their effect in shifting the production frontier of the country and help to alleviate the problem of diminishing returns to capital possibly emanating from investing on the prevailing technology through increasing saving.

4. Conclusion

The article tried to identify the main determinants of domestic saving in Ethiopia. GDP growth, previous government consumption level, export and inflation have a statistically significant impact on saving. The error correction term is also found to be statistically significant indicating the existence of a long run relationship between these explanatory variables and the saving parameter. Remittance, interest rate and the US consumption level are found to be statistically insignificant but with the

[10] The graphical representation of the impulse response function establishing the relationship between *LGDS* and *LGDP*[10] is shown in Figure 14 of the Appendix.

expected sign of causality. The Granger causality test indicates that saving does not cause investment neither does investment cause saving. This is because of the heavy reliance of the country for investment. The vector auto-regressive model indicates that there is a positive short and long-run effect of saving on growth, which is not yet significant. Income growth has been seen to have statistically significant positive impact on saving. The impulse response function reveals the relevance of the Solow growth model to explain the relationship between saving rate and growth of GDP in the Ethiopian context.

The empirical result suggests the need for revisiting the policy environment to induce growth from inside. Barriers of financial markets including setting interest rate by government bodies might need to be looked into. The public should be encouraged to participate in the saving schemes of their choice and invest on various areas of the economy. Government should also need to look into the possible crowding out effect of excessive public expenditure and continue its move towards promoting exports. Although remittances are not found statistically significant impacts on saving, their importance on reducing foreign dependence should not be under looked. The country has many people in the Diaspora. Besides the remitting meager resources to the country, Ethiopians abroad need to be fully engaged into the country's development endeavors through mobilization of their savings. For this to come by, it requires investigating possible hurdles that might have constrained investment flows from this source in terms of policy, bureaucratic inefficiency, lack of investment promotion activities or other areas of concern and accordingly making the necessary measures to create a more accommodative and enabling environment.

References

Abu Girma Moges. 2004. On the Determinants of Domestic Saving in Ethiopia. Paper prepared for the Second International Conference on the Ethiopian Economy. Ethiopian Economic Association, June 3-5, 2004.

Athukorala, Prema Chandra and Sen Kunal. 2004. Determinant of Private Saving in India, *World Development*, Elsevier Ltd., Vol. 32, No. 3, PP. 491 – 503.

Athukorala, Prema Chandra and Worku Gebeyehu. 2006. Trade Performance and Manufacturing Performance in Ethiopia, in *Trade, Growth and Inequality in the Era of Globalization*, eds. Kishore Sharma and Oliver Morrissey, Rutledge Taylor and Francis Group, London.

Athukorala, Prema Chandra and Worku Gebeyehu. 2003. Foreign Direct Investment and Trade: Diagnostic Trade Integration Study, Addis Ababa, Unpublished.

Attanasio, Ozario, Lucio Picci and Antonello Scorcu. 2000. Saving, Growth and Investment: A Macroeconomic Analysis using a Panel of Countries, *The Review of Economics and Statistics,* 82(2): 182-211.

Bacha, E. L. 1990. A Three – Gap Model of Foreign Transfers and the GDP Growth Rate in Developing Countries, *Journal of Development Economics*, Vol. 32, PP. 279 – 96.

Brown, R. P. C. 1994. Migrants' Remittances, Savings and Investment in the South Pacific, *International Labor Review*, 133(3): 347{367.

Browning, Martin and Thomas Crossley. 2001. The Life Cycle Model of Consumption and Saving, *Journal of Economic Perspectives,* 15:3, pp 3-22.

DeGregorio J. 1992. Economic Growth in Latin America, *Journal of Development Economics*, Vol. 39, PP. 59 - 84.

Domer, E. D. 1946. Capital Expansion, Rate of Growth and Employment', *Econometrica*, Vol. 14, PP 1057 – 72.

Duesenberry, J. 1949. *Income, Saving and the Theory of Consumer Behaviour,* Cambridge: Harvard University Press.

Easterly, William. 1994. Economic Stagnation, Fixed Factors, and Policy Thresholds, *Journal of Monetary Economics,* 33: 525-557.

Gavin, M. R. Hausmann and E. Talvi. 1997. *Saving Behaviour in Latin America: Overview and Policy Issues*, in R. Hausmann and Reisen R. (eds). Promoting Savings in Latin America, OECD and Inter – America Development Bank, Paris.

Gujarati, D. 2003. *Basic Econometrics*, 3rd Edition, Mc Graw-Hill, New York.

Jappelli, T. and M. Pagano. 1996. The Determinant of Saving: Lessons from Italy, Paper Presented at the Inter – America Development Bank Conference on Determinants of Domestic Saving in Latin America, Bogota, Colombia.

Levine, Ross and David Renelt. 1992. A Sensitivity Analysis of Cross-Country Growth Regressions, *American Economic Review*, 82: 942-963.

Harrod, R. 1939. An Essay in Dynamic Theory, *Economic Journal*, Vol. 49, PP. 14-33.

Loayza, Norman; Klaus Schmidt-Hebble; and Luis Serven. 2000. What Drives Private Saving around the World? *The Review of Economics and Statistics*, 82(2): 165-181.

Modigliani, Franco. 1986. Life Cycle, Individual Thrift and the Wealth of Nations, *The American Economic Review*, 17(3): 297-313.

Moore, Basil. 2006. Saving is never a Constraint on Investment, *South African Journal of Economics*, Vol.74: 1.

Ogaki, Masao, Jonathan Ostry and C.M. Reinhart. 1996. Saving Behavior in Low - and Middle- Income Countries: A Comparison, *IMF Staff Papers*, 43(1): 38-71.

Otani, I and D. Villanueva. 1990. Long term Growth in Developing Countries and Its Determinants: An Empirical Analysis, *World Development*, Vol. 18, PP. 90 – 98.

Paul R. 1986. Increasing Returns and Long Run Growth, *Journal of Political Economy'*, (October 1986), 1002 – 37.

Rebello, Sergio. 1991. Long-Run Policy Analysis and Long-Run Growth, *Journal of Political Economy ,*99: 500-521.

Rodrik, Dani. 2000. Saving Transitions, *The World Bank Economic Review,* 14(3): *481-507.*

Romer, Paul M. 1986. Increasing Returns and Long Run Growth. *Journal of Political Economy*, 99: 500-521.

Saltz, I. S. 1999. An Examination of the Causal Relationship between Savings and Growth in the Third World, *Journal of Economics and Finance*, Vol. 23, PP. 90 – 83.

Sinha, D. 1991 and T. Sinha. 1998. Cart before the Horse? The Saving – Growth Nexus in Mexico, *Economic Letters*, Vol. 61, PP. 43 - 47.

Sinning, Mathias. 2007. *Determinants of Savings and Remittances Empirical Evidence from Immigrants to Germany*, RWI Essen and IZA Bonn

Solow, R. 1967. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70 (February 1956, 65 – 94).

Worku Gebeyehu. 2005. Has Privatization Promoted Efficiency in Ethiopia? A Comparative Analysis of Privatized Industries vis-à-vis State Owned and Other Private Industrial Establishments. *Ethiopian Journal of Economics*, Vol. IX, Number 2, Addis Ababa.

Worku Gebeyehu. 2004. FDI in Ethiopia: Size, Nature and Performance, EEA/Ethiopian Economic Policy Research Institute, *Working Paper* No.2/2004, Addis Ababa.

World Bank. 2006. Global Development Finance 2006: The Development Potential of Surging Capital Flows, World Bank.

APPENDIX

Figure 1: Trend of Ethiopian and US consumption

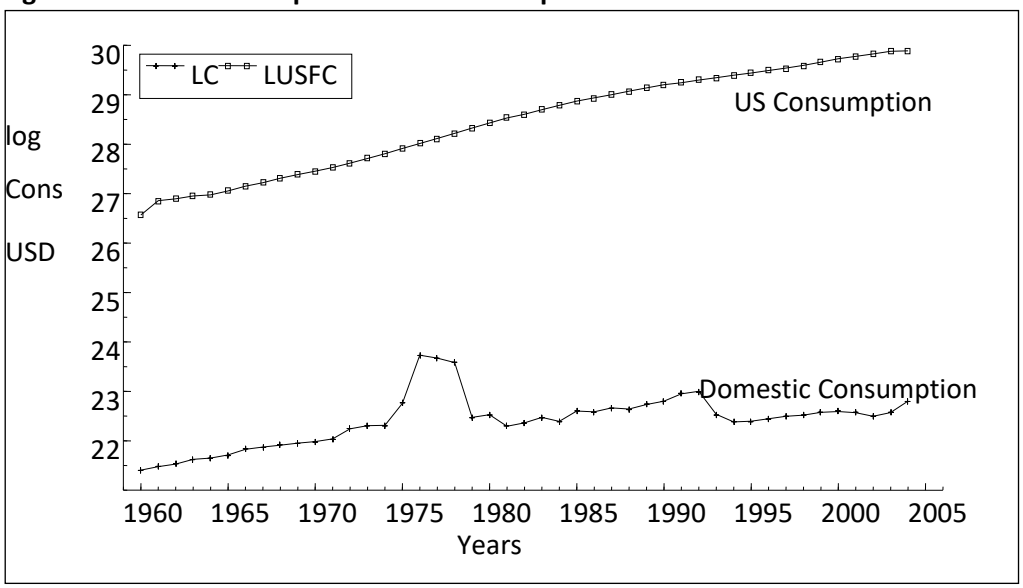


Figure 2: Trend of Ethiopian and US saving

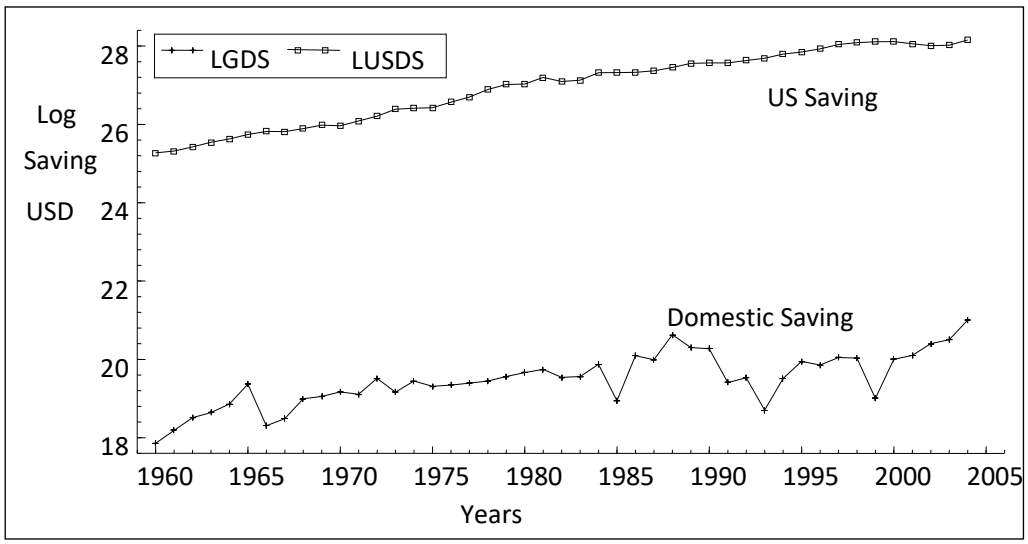


Figure 3: Trend of investment and saving

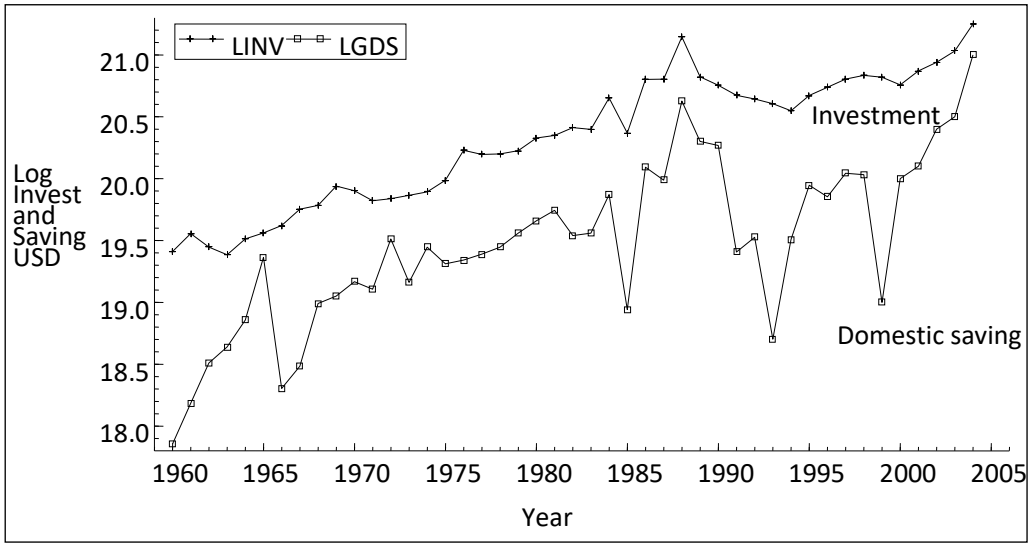


Figure 4: Trend of imports and exports

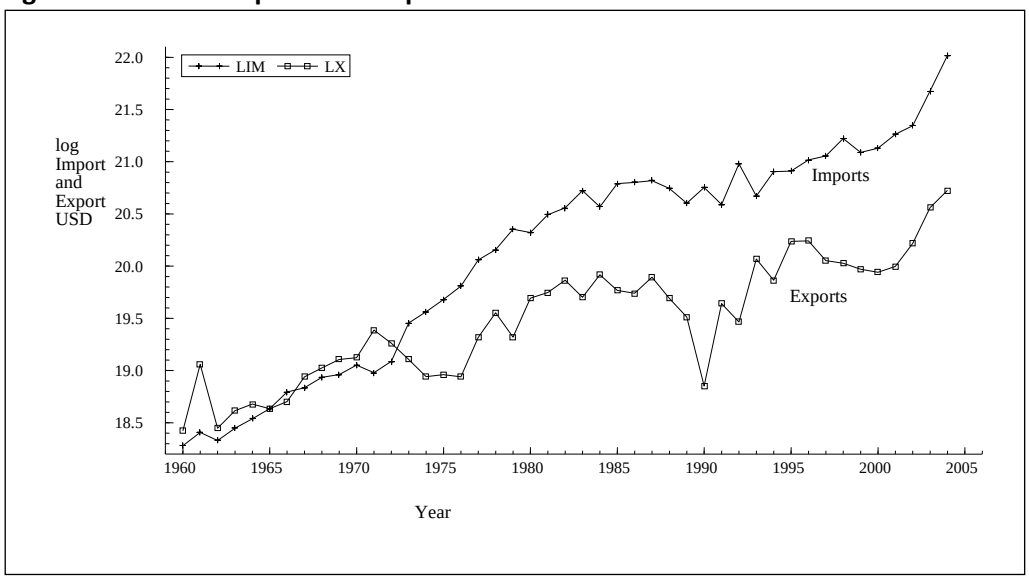


Figure 5: Trend of GDP and population growth rate

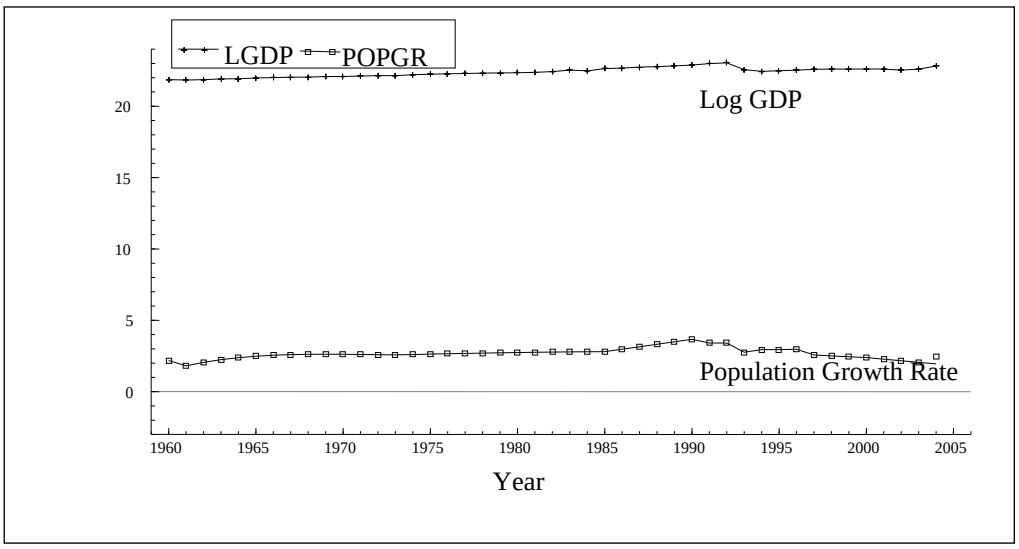


Figure 6: Trend of interest and inflation

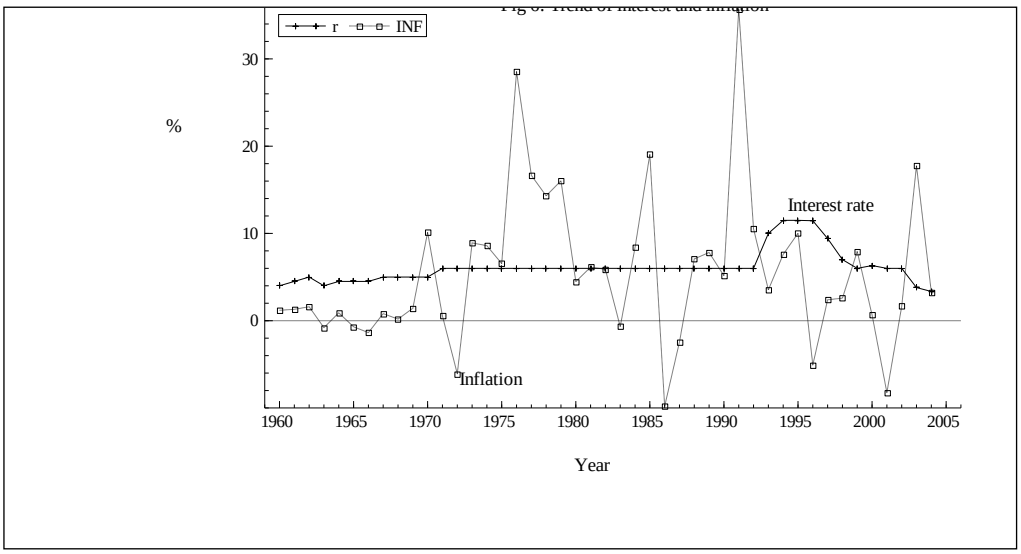


Figure 7: Trend of remittance

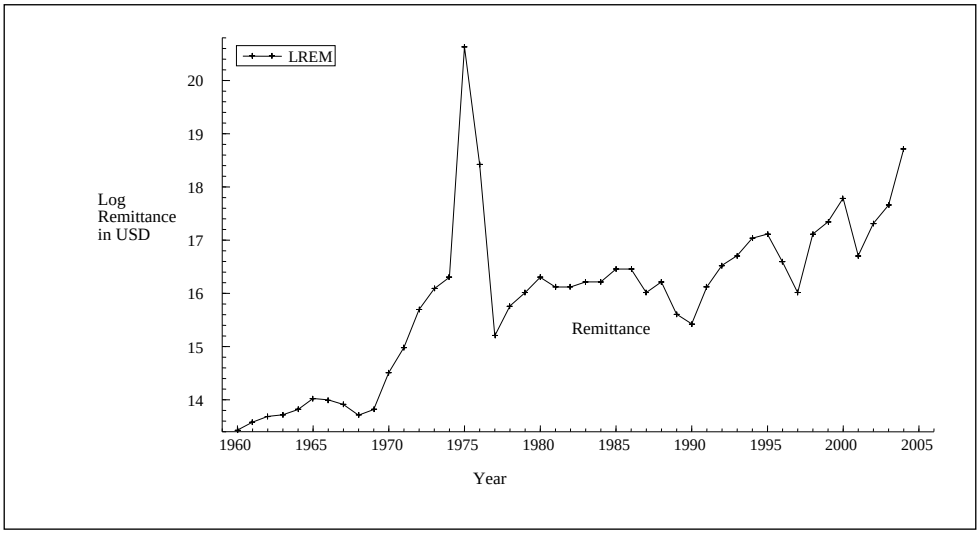


Figure 8: Trends of variable in levels (1960 – 2004)

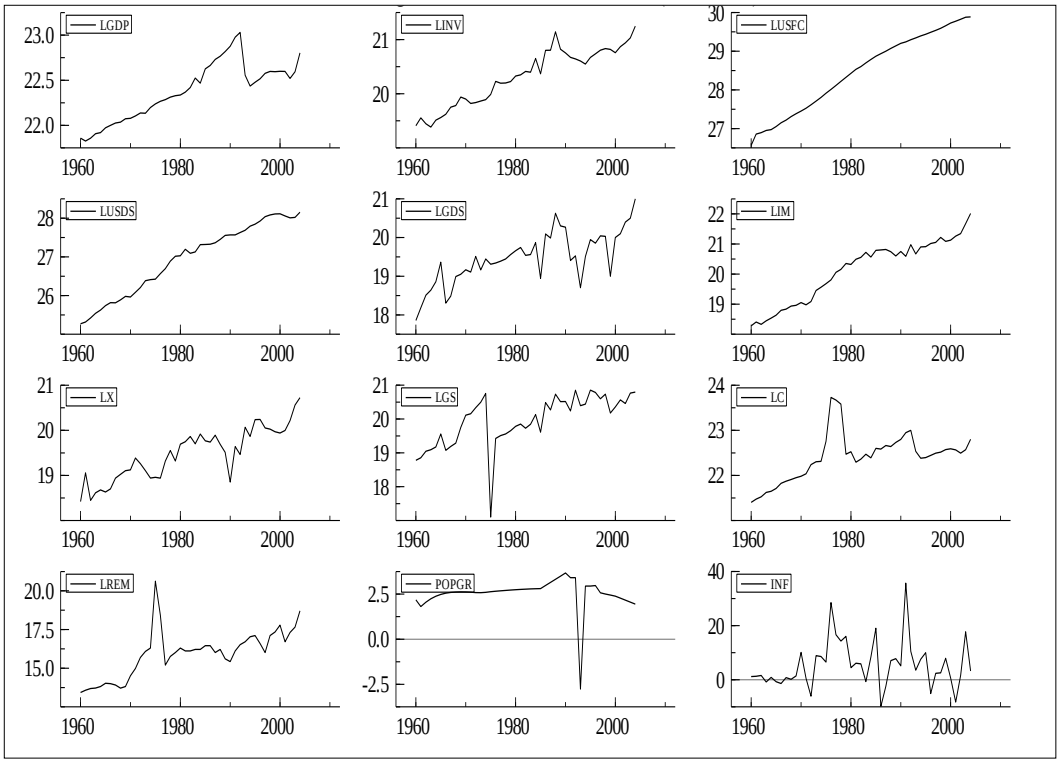


Figure 9: Trends of variables in their first difference

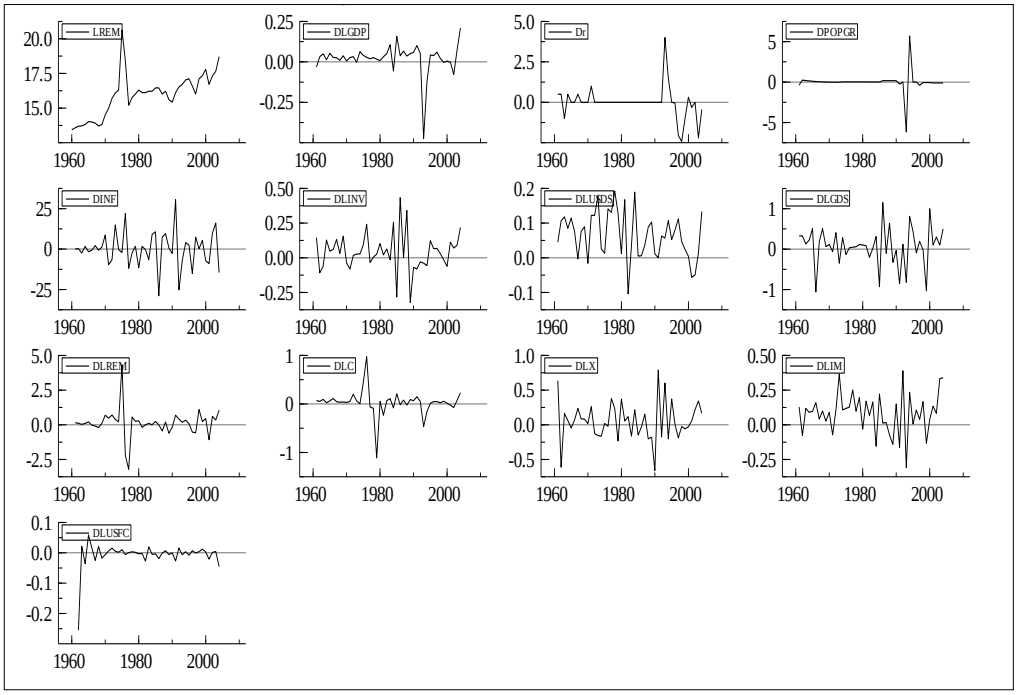


Figure 10: Trend of cointegrating variables

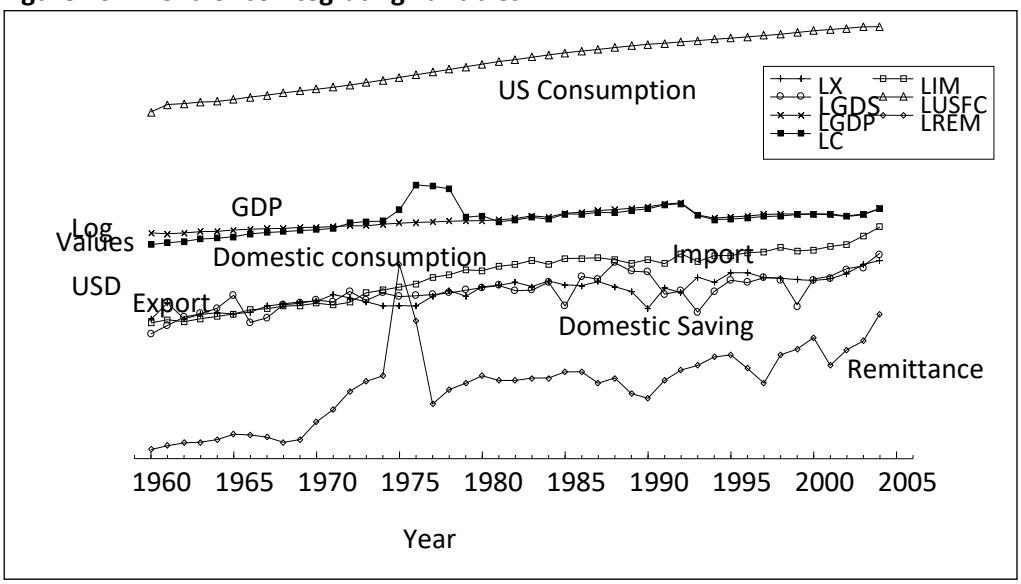


Figure 11: Error Correction Term from the Cointegrating Equation

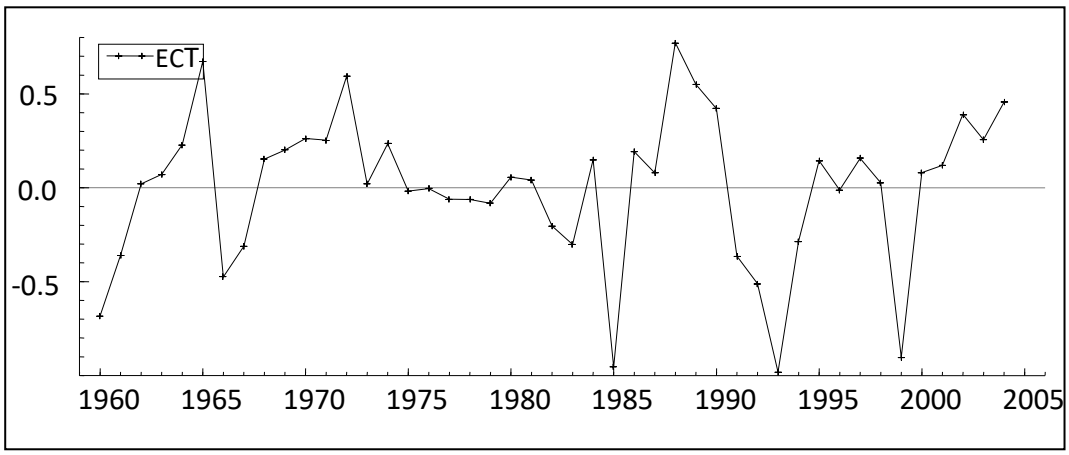


Figure 12: Parameter Stability and Chaw Test

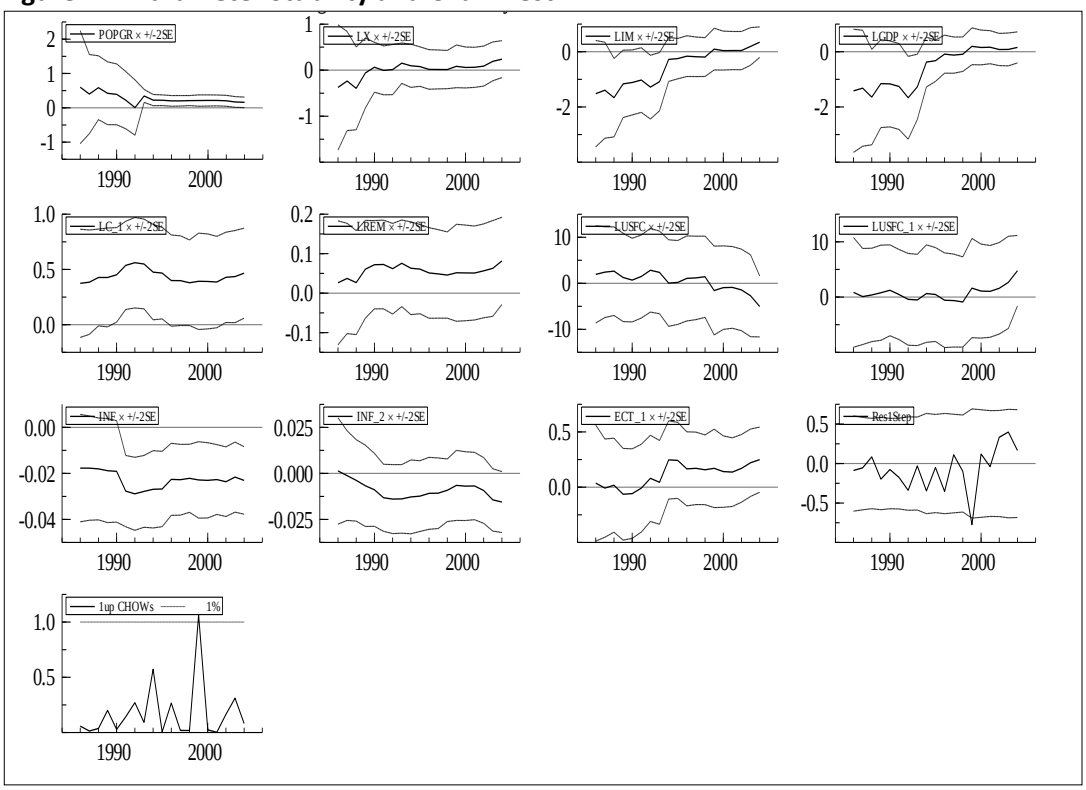


Figure 13: Actual versus fitted residuals

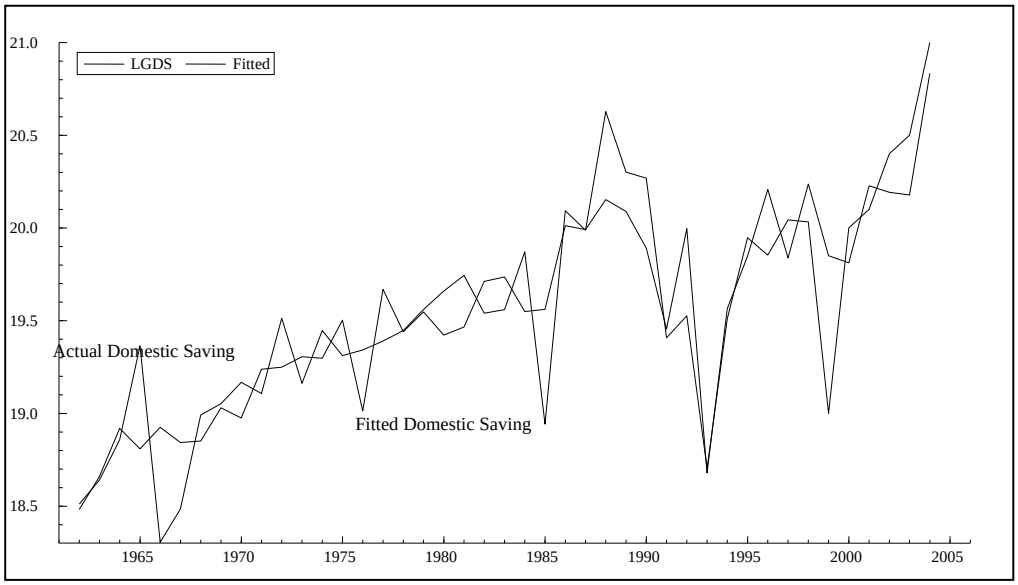


Figure 14: Impulse response function GDP (Growth) caused by change in saving rate

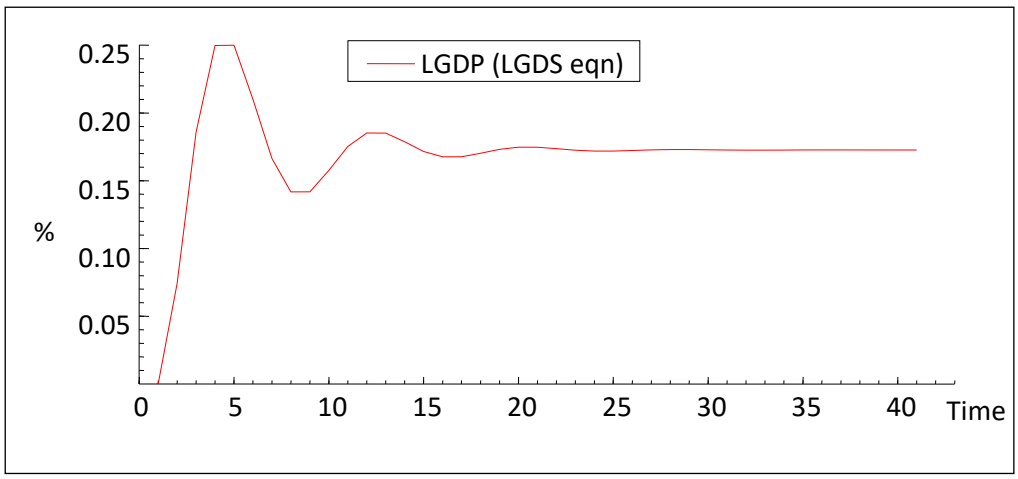
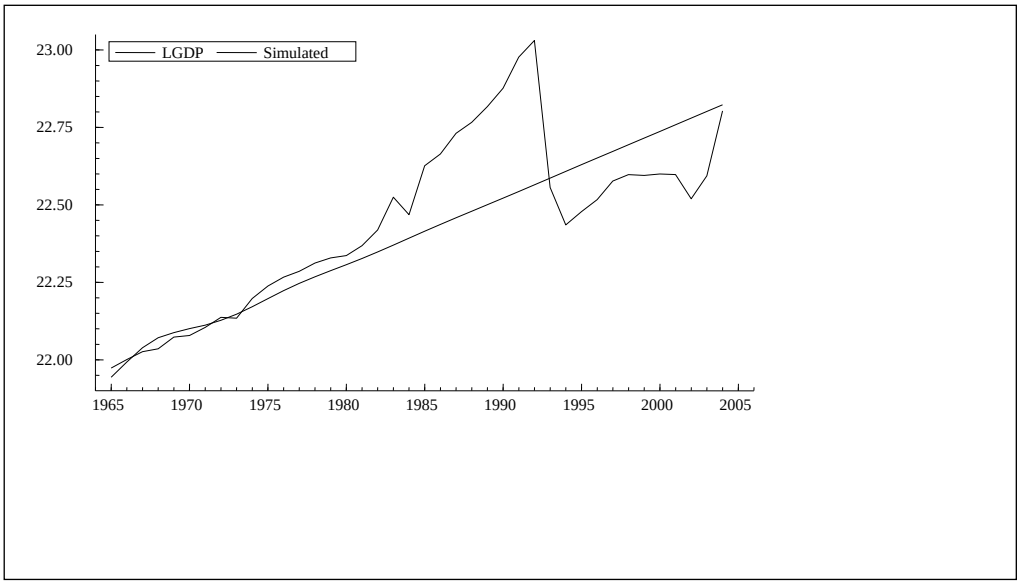


Figure 15: Actual GDP versus simulated GDP



URBANIZATION AND FERTILITY RATES IN ETHIOPIA[1]

Fanaye Tadesse[2] and Derek Headey[2]

Abstract

Fertility rates are important determinants of both overall population growth and demographic transitions from high to low age dependency ratios, which in turn have important consequences for economic growth, poverty reduction, and improved health and nutrition outcomes. Ethiopia currently has one of the highest fertility rates in the world, although there are marked differences between rural and urban fertility rates. This paper explores the drivers of rural and urban fertility rates, including systematic tests of differences in key determinants. This further allows us to project fertility rates into the future based on alternative urbanization, economic growth, and education scenarios. Finally, we link these alternative projections with existing estimates of the benefits of fertility reductions on economic growth, nutrition, and poverty reduction

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[1] The final version of this article was submitted in September 2011.

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1. Introduction

Demographic changes have long been recognized as a critical component of economic development, although there is considerable debate about whether population helps or hinders development, and whether governments can substantially alter population growth rates. With regard to the first of these debates, Malthusian arguments that population growth induces food supply constraints have been viewed with skepticism by most economists, given the possibility of population-induced technological change in both agriculture (Boserup 1965) and industry (Henderson 2010), with the latter capable of financing food imports. More recently, David Bloom and colleagues (Bloom et al. 2007; Bloom and Williamson 1998) have argued that the change in age structures matters more than population growth per se, with the transition from low to high age dependency ratios inducing higher savings rates and greater investments in education. In successful Asian countries, this demographic "window of opportunity"—chiefly induced by lower fertility rates—explains 25–40% of the region's miraculous economic growth. High population growth has also been associated with increased poverty (Eastwood and Lipton 2004) and increased malnutrition (Headey 2011). However, what is not clear is the extent to which direct population policies substantially influence fertility rates. Economists view fertility rates as a demand-led factor heavily influenced by income levels, livelihoods, and education factors. Efforts to directly influence fertility rates (through contraception family planning or more draconian measures) may therefore be less important than these indirect factors. Indeed, even in the Chinese context, the effectiveness of the country's one-child policy is heavily debated among demographers.[3]

In Ethiopia these debates are highly relevant. Although the country is undergoing rapid economic growth (albeit from a low base), Ethiopia has a long history of Malthusian population dynamics (Pankhurst 1985). In the middle ages, rapid population growth and the resultant deforestation of the population dense highland areas contributed to the collapse of the agricultural bases of several early empires,

[3] For example, Hasketh, Lu, and Xing (2005) observe: "The policy itself is probably only partially responsible for the reduction in the total fertility rate. The most dramatic decrease in the rate actually occurred before the policy was imposed. Between 1970 and 1979, the largely voluntary "late, long, few" policy, which called for later childbearing, greater spacing between children, and fewer children, had already resulted in a halving of the total fertility rate, from 5.9 to 2.9. After the one-child policy was introduced, there was a more gradual fall in the rate until 1995, and it has more or less stabilized at approximately 1.7 since then."

which eventually led to its downfall. In more recent times Ethiopia has sadly become notorious for some of the worse famines of the 20th century. And although there are large tracts of largely uninhabited land in the lowland peripheries of Ethiopia, the population-dense highlands face shrinking farm sizes and major problems of deforestation and soil degradation (Ringheim, Teller, and Sines 2009; Yusuf et al. 2005). These problems are clearly related to population growth rates that are too high relative to the local resource base and to traditional farming practices. Indeed, the total population is estimated to be growing at 2.6 percent per year, chiefly as a result of high fertility in rural areas (CSA 2008). Moreover, Demographic Health Survey (2010) data suggest that Ethiopia not only has one of the largest fertility rates in the world (at 5.4 children in 2005), the country also has the largest rural-urban fertility differential in the world: in 2005 an average rural woman can be expected to give birth to 6 children in her lifetime, relative to just 2.4 children in urban areas.

The federal government of Ethiopia clearly recognizes the importance of reducing fertility rates. A National Population Policy was initiated in 1993 when the current government took power, with the general objective of harmonizing the relationship between population dynamics and other factors that affect the country's development. The specific objectives of the policy include raising the contraceptive prevalence rate among married women from 4 percent in 1990 to 44 percent by 2015, raising the age of marriage from 15 to 18 years, and reducing the total fertility rate from 7.1 children in 1990 to 4 children in 2015. However, the most recent DHS data show achieving these targets is a remote possibility. For example, in 2005 only 15 percent of married women used either a traditional or a modern method of contraception. And despite a significant decline in mortality rates (from 217 to 123 deaths per 1000 live births between the late 1980s and 2004) the decline in fertility rates has been gradual, declining to 5.4 children in 2005 (CSA 2005).

Given the critical welfare consequences of reducing the fertility rate, this study explores the determinants of fertility rates in Ethiopia. However, unlike most previous studies (reviewed in Section 2) we systematically disaggregate explanations of fertility rates in rural and urban areas. This is important precisely because Ethiopia has unusually large rural-urban fertility differentials, but also because Ethiopia is currently one of the most under-urbanized countries in the world, and is therefore predicted to urbanize rapidly in coming years. Our approach also allows us to rigorously test

whether rural and urban fertility have different determinants using the 2005 Ethiopian Demographic and Health Survey (described in Section 3). Specifically, the econometric tests reported in Section 4 allow us to explore whether the determinants of rural and urban fertility rates are different, whether these determinants have statistically different magnitudes, and whether the rural-urban fertility differential is explained by observed factors (such as rural-urban education or wealth differences) or unobserved factors (such as the impact of urban living on attitudes). Given the various interactions between urbanization and fertility differentials—as well as economic growth and education—a second objective of this paper is to project fertility rates into the future, based on alternative urbanization and development scenarios (Section 5). This in turn allows us to re-estimate alternative age dependency paths for Ethiopia, which have consequences for important welfare objectives, such as economic growth and poverty reduction. Section 6 concludes by reviewing our main results and their implications for Ethiopia's development strategies.

2. A review of existing theories and evidence

As we noted above, the relationship between fertility and economic development has captured the interests of many economists and is still a controversial subject. In this section we aim to briefly overview economic theories of fertility, and theories of the impact of fertility rates on economic growth. The former is clearly relevant for the specification of our fertility regressions (Section 4), while the latter is pertinent for our projections of the impact of fertility on economic growth and poverty reduction.

In terms of the underlying socioeconomic determinants of fertility (as opposed to the proximate health-related determinants), economic theories of fertility have long focused rigorously separate supply and demand factors, with cultural preference (related to religion, for example) treated as exogenous. Economic theories also tended to emphasize demand side factors, as opposed to supply side constraints, such as access to contraceptives. For example, Becker (1960) introduced a number of important economic concepts that led to the construction of demand side theories. One important notion is that children possess both consumption good characteristics (i.e. they yield utility or happiness to their parents) and investment good

characteristics (e.g. they can provide security for parents in their old age, and provide labor and income for the household, such as farm labor or remittances).

A second notion is that of quality and quantity tradeoffs, which posits a likely substitution from quantity to quality as family income increases (Becker and Lewis 1973). A third notion is that of opportunity costs. In other words, while children yield benefits, they also come with both explicit costs (feeding, education, and so on) and implicit costs (such as the time required for rearing children, which could be applied to other activities). This implies that parental demand for children is very much a function of a variety of individual and social livelihood factors, such as location, occupation, land-labor ratios, costs and returns to education, female wages, and the development of formal social security systems. In addition to these economic factors, infant mortality rates are another demand-side factor deemed to be positively related to fertility rates, since a greater likelihood of infant death requires a family to have more births in order to reach its desired number of children. In some cultures there are also gender preferences that may lead parents to have larger numbers of children in the hope of satisfying a threshold demand for male children. It has also been noted that religious factors may influence the demand for children. For example, Muslim populations tend to have higher fertility rates than non-Muslim populations (both within and between countries), although this effect may relate more to slower transitions (Westoff and Frejka 2007).

A wide range of studies have attempted to test these theories with both cross-country and household level data. One stylized fact consistent with the demand-side view of fertility decisions is that individual's desired number of children often closely matches their actualized number of children, at least in an approximate fashion. Infant mortality rates and fertility rates are also very closely correlated both across countries and within them (Ben-Porath 1976; Benefot and Schultz 1996; Murthi, Guio, and Drèze 1995). Some research has found a negative correlation between family size and child quality that supports the Becker and Lewis (1973) theory (Rosenzweig and Wolpin 1980; Li, Zhang, and Yi 2005). Incomes also have a pervasively positive effect on fertility, especially over the longer run, but there are gender nuances at work, especially in the short run (Schultz 1997). In cases where the husband's income increases fertility rates may increase as the family has an increased ability to support more children (Freedman and Thornton 1982). On the other hand, an increase in the

wife's earning from her participation in the labor force is shown to have a negative substitution effect by making childbearing a costly activity for the household (McNown 2003; Engelhardt, Tomas, and Alexia 2004; Foster & Rosenzweig 2006).

Similarly, more women's education tends to reduce fertility (Jain 1981; Chaudhury 1986; Axinn 1993; Bledsoe and Cohen 1993), partly through female labor force participation and higher wages (i.e. higher opportunity costs), and partly through supply side factors such as increased knowledge of contraception, and a later age of first marriage. However, the level of education that can affect fertility decisions is still not clear. In most studies it seems only secondary and tertiary education is found to significantly affect fertility, but some studies have found some significant negative impact even with primary level education (Dzekedzeke and Nyangu 1994; Garenne 2008). On the other hand, Jain (1981) found that a small amount of education in least literate societies might initially increase fertility at the early stage of development due to a positive income effect.

In terms of the effect of urbanization on fertility, it has long since been established that urban fertility rates are pervasively lower than rural fertility rates, especially in poor countries (Kuznets 1974). The urban fertility in Sub-Saharan Africa is on average almost 30 percent lower than the rural fertility (Shapiro and Tambashe 2000; Dudley and Pillet 1998). Table 1 shows the most recent rural and urban fertility rates based on Demographic Health Surveys conducted in the last 5 years (DHS 2010). The table shows that while urban fertility rates are lower than rural rates everywhere, the differential in Ethiopia (at 3.6 children) is much larger than the African average (2.0 children), and is indeed the highest of any country surveyed by the DHS.

Table 1: Rural and urban fertility differentials in Ethiopia in relative terms

	Rural	Urban	Difference	Number of countries
Ethiopia	6.0	2.4	-3.6	
Africa	6.1	4.1	-2.0	23
Asia	3.3	2.5	-0.8	8
Central Asia & MENA	2.6	2.2	-0.4	9
Latin America	3.7	2.4	-1.3	10

Source: DHS (2010).
Note: MENA: Middle East and North Africa

What is less clear, however, is how exactly urban living reduced fertility rates. There are obviously some expected channels. As a stylized fact, mean incomes are pervasively higher in urban areas (even when adjusted for smaller household size), women tend to engage more in wage labor, paternal and maternal education levels are higher, infant mortality rates are lower, and there is generally better access to contraceptives in urban areas. Moreover, while there is always a rural-urban differential in fertility, urban fertility rates still vary both across countries and within countries. For instance, in the case of Addis Ababa, the nation's capital, the total fertility rate (TFR) dropped from 3.3 to 1.9 between 1990 and 2000, which is even below the population replacement rate. However, the contraceptive prevalence rate was only 34 percent in Addis Ababa in 2000, such that the drop in the TFR occurred in the absence of any considerable family planning initiatives (Sibanda et al. 2003). Hence there are many puzzles still unanswered with respect to the precise channels through which urbanization influences fertility trends.

Existing work has illuminated these questions somewhat. Kirk and Pillet's (1998) study of fertility trends in sub-Saharan Africa found a widening rural-urban fertility differential at early stages of fertility declines (this is also evident in Table 1), and that this differential was not satisfactorily explained by other rural-urban differences, such as household wealth or female education. This was in contrast to Asian countries where the rural-urban fertility differentials were smaller and more easily explained by differences in education, wealth, and other factors. Hence in the African context in general, and in Ethiopia in particular, further research is still needed to explain these much wider rural-urban fertility differentials.

However, previous work in Ethiopia has not examined this issue in any comprehensive fashion. Several studies that have been done on fertility under the Ethiopian context employ the Bongaarts framework to identify the proximate determinants of fertility such as contraceptives, postpartum insusceptibility, sterility, abortion, and marriage (Hailemariam and Zewoldi 1994; Population Studies and Training Center 2003; Sibanda et al. 2003; World Bank 2007; and of course the main descriptive results of the 2000 and 2005 DHS surveys (Central Statistical Agency [Ethiopia] and ORC Macro 2001, 2006). Others focus on segments of the population to look into the fertility determinants. For instance, Alemayehu et al. (2010) look into determinants of adolescent fertility in Ethiopia and a study by Gurmu and Mace (2008) focuses on the link between fertility and poverty in Addis Ababa.

A 2007 World Bank report is also comprehensive in using both DHS data to explore both proximate and underlying determinants of fertility, and an economy-wide macroeconomic simulation model (a computable general equilibrium model) to look into the impact of demographic change on economic outcomes such as consumption growth and savings. That analysis showed that two of the proximate determinants of fertility in Ethiopia are the age at marriage and first birth, and the extremely low use of contraceptives. Both age at marriage and contraceptive use were found to be much lower in rural areas, albeit with regional variation. To underlying determinants the study ran both aggregate and rural and urban regressions on the 2000 Ethiopian Demographic Health Survey (EDHS) with disaggregations by age groups. However, no systematic tests were conducted, nor was there any investigation of why urbanization seemed to reduce fertility, although it did note an association between urban living and secondary education. Finally, in terms of macroeconomic modeling the study indicated that fertility will most likely continue to reduce quite quickly if the government achieves its education targets, and that this fertility reduction will produce a so called “demographic dividend” in the form of faster growth in per capita consumption.

Although the World Bank study and others have made impressive contributions to this literature, to our knowledge there exists no comprehensive study that separately looks into the social and economic causes of fertility in rural and urban Ethiopia, particularly with regard to explaining why the rural-urban fertility differential is so unusually large. Hence, in this study we try to more systematically test for rural urban

differences in fertility determinants through a range of econometric tests described in the next section.

3. Data and estimation

3.1. Data

The data used for this study is EDHS (Ethiopian Demographic and Health Survey) of 2005. The EDHS is a nationally representative survey of 14,070 women between the ages of 15 and 49 and 6,033 men with ages between 15 and 59. This survey is conducted in Ethiopia as part of the worldwide Demographic and Health Surveys (DHS) project (CSA 2005). The survey contains information on the population and health situation of the country. Some of the topics covered include family planning, fertility levels and determinants, fertility preferences, child and maternal mortality, child health, nutrition, and knowledge of HIV/AIDS. Table 2 provides a list of the variables used in this study (some of which are constructed by the authors), including definitions and measurement issues.

The sample for the survey was designed to provide representative estimates for the variables of interest for Ethiopia as whole, urban and rural areas as separate domains, and 11 geographic areas with 9 regions and 2 city administrations (CSA 2005). The sample selection was done in two stages with 250 clusters (145 urban and 395 rural) selected from the list of enumeration areas[4] (EAs) from the 1994 population and housing census sample frame. The sample was also drawn from the 1994 Census frame. However, CSA (2005) indicates that there could be some bias in the representativeness of the regional estimates of Somali and Afar regions since the census frame excluded some part of these regions which were predominantly nomadic. Since the selected 540 EAs are not distributed proportionally by region according to the census population, the sample was weighted to produce national estimates. On the second stage of sample selection the households were randomly selected from each previously selected cluster.

[4] Enumeration areas are formed by subdividing each *woreda* into convenient areas and are either total urban or rural.

In addition to the DHS, Geographic Information Systems (GIS) estimates of travel times to nearest cities were merged with the DHS data based on the coordinates of the surveyed clusters. The purpose of adding this variable is to have information on the effects of isolation on fertility rates, and also because the rural-urban divide is somewhat arbitrary in locations where rural people have good access to cities (e.g. peri-urban areas). Information on how travel times are estimated can be sourced in Schmidt and Mekamu (2009).

Table 2: Variable description and measurement issues

Variable name	Definition	Measurement Issues
Dependent variables		
Children-ever-born	Number of children-ever-born by a woman	
Desired children	Number of children a woman desires to have in her life time	
Explanatory variables		
Women's age		
Age	Age of woman in years	
Age2	Square of age of woman in years	
Woman's Education		
No education	Woman has not attended any education	
Primary	Attended primary education	These variables are only a measure of quantity and do not measure quality of education. Also, the variable relate to attendance not completion.
Secondary	Attended secondary education	
Higher	Attended higher education	
Husband's education		
No education	Husband has not attended any education	
Primary	Attended primary education	
Secondary	Attended secondary education	
Higher	Attended higher education	
Religion		
Muslim	Dummy to indicate whether the woman is a Muslim	
Christian	Dummy to indicate whether the woman is a Christian	
Other religion	Dummy to indicate whether the woman has other religion	

Continued from Table 2		
*Economic status**		
1st wealth quintile	Dummy=1 if household's wealth status is poorest quintile	
2nd wealth quintile	Dummy=1 if household's wealth status is poor quintile	
3rd wealth quintile	Dummy=1 if household's wealth status is middle quintile	
4th wealth quintile	Dummy=1 if household's wealth status is rich quintile	
5th wealth quintile	Dummy=1 if household's wealth status is richest quintile	
Land ownership		
Ln land	Log of land size in hectares	
Ln land2	Log of land size in hectares squared	
Women's occupation		
Not working	Woman doesn't participate in any work outside of her home	Women who have no labor force participation outside of their homes for the past 12 months are the omitted category
Professional	Participates in professional work outside of her home	
Clerical and sales	Participates in clerical and sales work outside of her home	
Agriculture	Participates in agricultural work outside of her home	
Others	Participates in other works outside of her home	
Location		
Distance to health center	Travel time (minutes) to the nearest health center	Uses the DHS GPS points
Urban	Dummy=1 is residence is urban	
Listens to radio	Dummy=1 if woman listens to the radio frequently	
Contraceptive knowledge	Percentage of people living in the village who know about contraceptives	
Child mortality		
Child mortality*	Number of children born alive but died before age five	Treated as endogenous variable.*

Notes: * child mortality is treated as endogenous variables because fertility decisions could also cause mortality outcomes within the household. We therefore use cluster level averages of child mortality rates to proxy for expected child mortality.

3.2. Estimation

Following other empirical studies on fertility, the number of children born by a woman is used as the measure of fertility (Winklemann and Zimmermann 1994; Schultz and Zeng 1995), but also the desired number of children. The former might be regarded as a revealed preference (controlling for age), while the latter is a stated preference. In such economic contexts where the dependent variable of interest is a nonnegative integer or count, the response variable is discrete (unlike the classical regression model), where the distribution places probability mass at nonnegative integer values only (Wooldridge 2002). Given this discrete and non-negative nature of our dependent variable, the OLS model is inappropriate and count data models are therefore used for estimation.

Following the work of Smith, Ruel, and Ndiaye (2004) on child malnutrition in rural and urban areas (also using DHS), a regression equation that includes an urban dummy variable (1 if urban and 0 otherwise) and the interaction of all the independent variables with the urban dummy variable is estimated to see whether the effects of the socioeconomic determinants differ across urban and rural households. Afterwards, separate regression equations are run for urban and rural areas and a seemingly unrelated estimation is obtained along with the Chow-test for coefficient differences among urban and rural areas. These estimations are done for both the number of children-ever-born by a woman and the desired number of children.

The national level regression equation is given by:

$$y_i = \alpha + \sum_{k=1}^{k} \beta_k X_{ik} + \sum_{n=1}^{n} \beta_n (X_{in} * u_i) + \varepsilon_i$$

where the β_s are the parameters to be estimated, the X_s are the explanatory variables and the expression ($X_{in} * u_i$) are interactions of the explanatory variables with the urban dummy. The interaction variable obviously tests whether the effects of the explanatory variables on fertility differ by location. However, we also separately estimate urban and rural equations and conduct Chow tests to check for parameter differences among these groups.

Another complication is that the DHS does not have information on consumption or income variables. Instead, the DHS measures a wealth index constructed from the information on asset holdings using principal component analysis. While this wealth index has been shown to be a good proxy for economic status—such as strong correlations with education and other non-material welfare indicators (Filmer and Pritchett 2001) - it does have some limitations. The wealth index has not been shown to be a systematically close proxy for consumption expenditure in all countries. This is not a bad thing per se (consumption is also measured with error and is not conceptually the same as wealth), but it means we have to be careful with interpretation.

Another consideration in the estimation is the possible endogeneity of child mortality in the household. Since household fertility and mortality rates are likely to respond to the same determinants (such as access to health services), we use the average child mortality in the cluster, excluding the household in consideration, as a proxy for the infant mortality risk that an individual household faces. The use of this variable also helps to capture the expected child mortality that a household faces since the formation of such expectations are more likely to be influenced by what happens within the neighborhood. We note that this type of approach has been previously used in the development literature, particularly the literature on migration (Trang and Purnamasari 2011).

4. Results

4.1. Descriptive statistics

We begin our analysis with some basic descriptive statistics on the number of children born and the desired number of children. Both variables are disaggregated by age brackets. In the case of the number of children the reasons are obvious (older women have had more time to have more children), but even for desired number of children the answers to these questions may be influenced by the number of children already born, and hence by maternal age. Turning to the results, Table 3 shows that at any age level there is statistically significant difference between rural and urban levels of both actual children-ever-born and desired numbers, with rural fertility indicators invariably exceed urban levels. For example, for women in their 30s there is a huge difference between rural and urban levels in number of children-ever-born (2.33 to

2.74 more children per rural woman, compared to urban woman). In general there is less variation between rural and urban women in desired number of children across age brackets, although the differences are still big (generally, rural women desire 1 to 1.6 more children than urban women). It is also interesting to note that at older ages the actual number of children-ever-born tends to be higher than the stated preference for number of children. This suggests that either women have insufficient decision-making power, insufficient access to contraceptives, or that—because of infant mortality rates and other health risks—households systematically overshoot their desired number of children.

In the bottom of Table 3 we also disaggregate by education. While these numbers are not net of age, they still may be insightful regarding possible interactions between education and location. We find significant rural–urban fertility differences for women with no education, and particularly large differences for women with primary education only. However, for secondary and tertiary education no clear differences emerge.

Table 3: Average number of children born and desired number of children by age category, education and place of residence

	Number of children-ever-born			Desired number of children		
	Rural	Urban	Difference	Rural	Urban	Difference
Age						
15-19	0.21	0.07	0.14***	3.46	2.79	0.67***
20-24	1.35	0.53	0.82***	4.41	3.18	1.23***
25-29	3.15	1.4	1.75***	4.91	3.57	1.34***
30-34	4.82	2.49	2.33***	5.4	3.84	1.56***
35-39	6.19	3.45	2.74***	5.41	4.38	1.03***
40-44	6.99	4.59	2.4***	5.7	4.32	1.38***
45-49	7.54	5.64	1.9***	5.99	4.39	1.6***
Education						
None	4.09	3.12	0.97***	5.15	4.16	0.99***
Primary	3.95	1.72	2.23***	5.06	3.56	1.5**
Secondary	0.92	1	-0.08	3.32	3.28	0.04
Higher	0.44	1.34	-0.9	3.69	3.3	0.39

Source: Authors' calculations from EDHS (2005).
Note: ** significant at 5 percent; *** significant at 1 percent.

In Table 4 we disaggregate the results by regions. Although we have not controlled for age, the age structure of women is fairly similar across regions, with the exception of Addis Ababa. In all regions we again see larger fertility indicators in rural areas. The levels are statistically different in all regions with the exception of the children-ever-born variable for the Somali region (where representativeness may explain the statistically weak result) and for the desired number of children in Addis Ababa. It is also interesting to note that the differences appear to vary across regions, and that there are fertility differences across urban areas, and across rural areas. For example, Addis Ababa appears to have lower fertility rates than urban areas of other regions, and previous studies have suggested that total fertility rates in Addis Ababa are even below replacement levels. Although it is not straightforward to explain this result, Addis is by far the largest city in Ethiopia, with a population of at least 3 million, which is around 6 times the next biggest city, Dire Dawa. Women in Addis also desire less children (3.28 children) than women in other urban centers such as Dire Dawa (4.6 children), while urban women in the Somali region desire 6.6 children.

Table 4: Children born and desired number of children by region and across rural and urban areas

	Children-ever-born			Desired number of children		
	Rural	Urban	Difference	Rural	Urban	Difference
Tigray	3.36	1.66	1.7***	4.93	3.91	1.02***
Afar	3.67	1.55	2.12***	8.9	3.84	5.06***
Amhara	3.48	1.76	1.72***	4.25	3.21	1.04***
Oromiya	3.57	1.76	1.81***	4.44	3.12	1.32***
Somali	3.83	2.8	1.03	10.55	6.64	3.91***
Ben-Gumz	3.47	1.82	1.65***	5.2	3.31	1.89***
SNNP	3.4	2.44	0.96***	4.76	3.92	0.84***
Gambela	2.94	2.32	0.62***	4.92	3.71	1.21***
Harari	3.56	1.31	2.25***	6.25	3.53	2.72***
Addis Ababa	2.39	1.21	1.18***	4.19	3.28	0.91
Dire Dawa	3.88	1.75	2.13***	7.2	4.59	2.61***

Source: Authors' calculations from EDHS (2005).
Note: ** significant at 5 percent; *** significant at 1 percent.

Apart from location determinants, it is obviously of interest to look at other possible sources of fertility differences. In Table 5 we list our explanatory variables by rural and urban levels, with p-values for differences. Clearly, urban populations have substantially greater wealth, female education, health services, access to contraceptives, and women marry at a slightly older age. Rural areas obviously own more land, but apart from that obvious exception they are clearly socioeconomically disadvantaged.

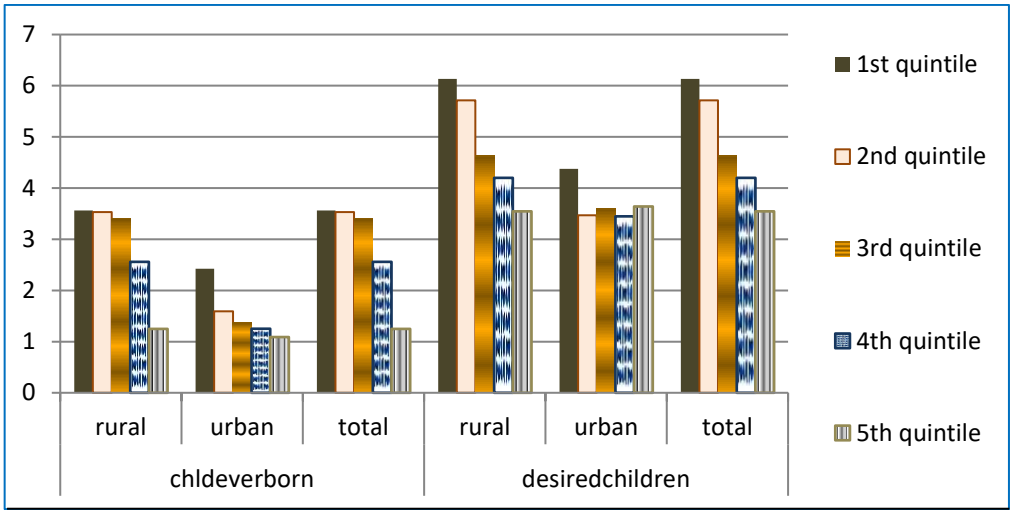
Table 5: Mean of variables by rural and urban areas (mean difference significant at 5 percent for all variables).

	Rural	Urban	Difference
Mother - Age (years)	28.4	26.8	1.6
Mother - No education	75%	25%	50%
Mother - Primary education	22%	25%	-3%
Mother - Secondary education	3%	44%	-41%
Mother - Higher education	0%	7%	-7%
Christian	66%	86%	-21%
Other religion	3%	0%	2%
Child mortality	56%	18%	38%
Mother - Listens to radio	34%	80%	-45%
Land owned (hectares)	2.2	0.2	2
Mother - Not working	67%	56%	11%
Mother - Professional occupation	0%	6%	-6%
Mother - Clerical/sales occupation	8%	27%	-19%
Mother - Agriculture occupation	3%	1%	2%
Mother - Other occupations	3%	10%	-7%
Husband - no education	70%	23%	47%
Husband - primary education	2%	35%	-33%
Husband - secondary education	0%	29%	-28%
Husband - higher education	1%	11%	-10%
Travel time to health center (hrs)	1.3	0.5	0.8

Source: Authors' calculations from EDHS (2005).

In Figure 1 we disaggregate rural and urban fertility outcomes and preferences by wealth quintiles. There are some interesting patterns. With regard to actual number of children the poorest women have higher number of children than those in the richest quintiles. This pattern seems to be consistent for both urban and rural areas. At the national level the number of children ever born seems to be showing a slight decline going from the first to the second quintile. A rather sharp decline is especially observed for those in the richest quintiles. As for desired number of children, the wealth gradient in urban areas is quite flat, but there is a big difference between the poor quintile and the rich quintile. At the national level the gradient is quite steep and linear: moving from one quintile to the next—from poorer to richer—reduces the number of desired children on average by one child.

Figure 1. Average number of children and desired number of children by economic status and place of residence

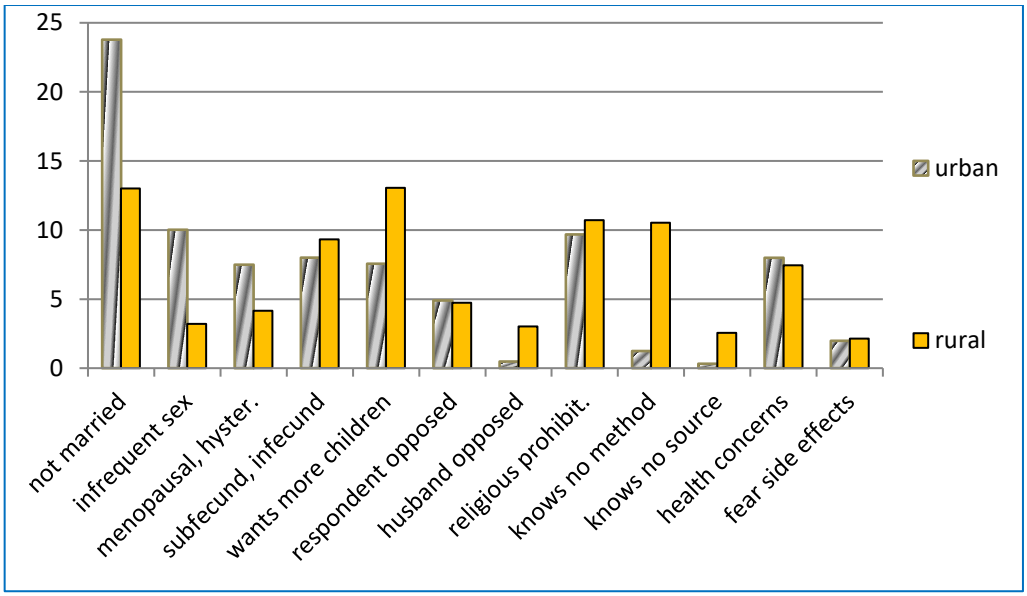


Source: Authors' calculations from EDHS (2005).
Note: 1st quintile is poorest quintile

There is a generally a low contraceptive use among women with only 18 percent of women using any method. The majority of these women using contraceptives are living in urban areas. Close to 37 percent of urban dwellers use traditional or modern contraceptive methods while only 15 percent of women in rural areas use contraceptive methods. In Figure 2 we look at the reasons for not using contraceptives across rural and urban areas. Netting out not being married, the main differences are

as follows. First, rural women are frequently ignorant of contraceptive methods (over 10% relative to just over 1% of urban women). A second reason is the desire to have more children (consistent with Table 5). And finally, small differences include not knowing any source and opposition on the part of the husband. Interestingly, religious prohibition is a significant factor in both rural and urban areas, as is lack of fecundity and health concerns (although it is not clear what those concerns are).

Figure 2: Reasons for not using contraceptives by place of residence



Source: Authors' calculations from EDHS (2005).

4.2. Regression results

Table 6 reports the results for the national level regression. The results are reported both for the number of children born and desired number of children; and for both dependent variables we disaggregate into the ever-married group and the whole sample. Following Garrett and Ruel (1999) all the explanatory variables are interacted with the urban dummy to see whether the socioeconomic variables have different impacts across urban and rural households. Interactions that are not significant were dropped and are therefore not reported in the results in Table 6.

Turning the signs and magnitudes of the coefficients, the regressions show fairly consistent results across dependent variables, although there are some exceptions. Age consistently has a positive but non-linear effect that is stronger for children-born relative to the desired number of children (as expected). The positive effect of age on desired fertility may suggest that younger Ethiopia women desire fewer children, but since this indicator could be biased by the number of children already born to a woman, we are hesitant to make strong inferences.

Table 6: National level regression results

	Children born	Desired number of children
Age (years)	0.91***	0.18***
Age squared	-0.01***	-0.01***
Woman - primary education	-0.04	-0.37***
Woman - Secondary education	-0.70***	-0.47***
Woman - Higher education	-0.91***	-0.76**
Husband - primary education	0.15***	-0.06
Husband - Secondary education	0.13	0.04
Husband - Higher education	0.08	-0.52
Christian	-0.06	-0.64***
Other religion	-0.09	-0.23
Child mortality	0.58***	0.75***
Listens to radio	-0.02	-0.14
2nd wealth quintile	0.09	-0.05
3rd wealth quintile	-0.01	-0.08
4th wealth quintile	0.02	0.03
5th wealth quintile	0.18	-0.32
land owned (hectares)	0.26***	-0.18
land, squared	-0.03	0.09*
Professional occupation	-0.62***	-0.10
Clerical/sales occupation	-0.25***	0.12
Agriculture occupation	-0.28***	-0.39***
Other occupations	-0.16	-0.10
Travel time to health center (hrs)	0.02	-0.05
contraceptive knowledge (village level)	0.13	-1.55
Urban	-0.46**	-2.88***
land*urban	0.01	0.09
land, squared*urban	0.21	0.38
Travel time to health center*urban	0.07	0.22*
Child mortality*urban	2.19***	-2.30***
Christian*urban	-0.23	-5.86**
Other religion*urban	-1.55**	-2.26***
Regions		
Oromia	0.32***	-0.62***
Afar	-0.02	1.4***
Amhara	-0.07	-0.82***
Somali	0.19	2.14***
Benishangul-Gumuz	0.10	-0.82***
SNNP	0.26***	-0.61***
Gambela	-0.38***	-0.84***
Harari	-0.18	-0.08
Addis Ababa	-0.24*	-0.26
Dire Dawa	-0.09	0.80***
Prob>chi2	0	0
Number of observations	9419	8332

Sources: Authors estimates from EDHS data.
Notes: reported coefficients are marginal effects.
Asterisks indicate significance a 1 percent (***), 5 percent (**) and 10 percent (*). All variables are dummy variables unless the measurement unit is indicated in parentheses.

Of considerably more policy relevance is that primary education has no effect on desired or actual fertility, but secondary and tertiary education have quite sizeable effects. Relative to no education, secondary education reduces actual or desired number of children by 0.7 children, while tertiary education has very large effects on actual number of children (reducing the number by more than two children in the ever-married sample) but quite modest effects on desired number of children. Husband's education seems to have little effect on fertility. Female occupation has moderately large effects (and may, of course, be correlated with education), with the largest impact for professional occupation (which reduces observed fertility by around 0.62 children). Impacts of other occupations relative to not working at all are more modest (around 0.28 children fewer).

Table 7 reports the regression results and test for parameter stability across urban and rural areas for children born by a woman and desired number of children as a measure of fertility. According to the results from the regression with children born as a dependent variable, it is found that fertility is positively related with age while the negative sign pertaining to the variable age squared implies a quadratic relationship between age and fertility behavior to reflect the biological factors that may limit the fertility of women as they grow older. This finding is consistent with the CSA report (2005) which indicates that fertility is low among adolescents and increases to a peak of 241 births per 1,000 among women of age 25–29 and declines thereafter. Although the relationship between age and the dependent variable is positive and the quadratic relationship is the same for rural and urban areas, the test for parameter stability suggests a difference in urban and rural areas in the strength of association between age and fertility with high association witnessed in the rural areas.

Education has entered the model in level form, rather than by year of schooling. The reference category for analyzing the results is the variable 'no education'. Accordingly, for the two measures of fertility women's education is a significant determinant for both rural and urban areas. The test for parameter difference suggests structural differences across urban and rural areas in the association between education and number of children born by women. The weak relationship between primary education and fertility is also an observation worth noting. The regression results

suggest that only education above the primary level plays a significant role in reducing fertility.

This finding is in line with the argument of Bledsoe and Cohen (1993) which indicates that throughout the world, formal schooling for women is the single most consistent variable correlated with their low fertility. Women with no formal education are also less empowered to make their own decisions in their households. Fertility decisions may not always necessarily be the choice of the woman and could be imposed by the husband or other family members. Though the woman may not want to have additional number of children, the fact that she is dependent on her husband and other family members for her welfare forces her to adhere to their fertility choices. Hence, education, by increasing the status of women in a society, empowers women to make their own choices and decisions regarding their lives and matters in their households including fertility. Those women with education and their own source of income tend to be independent in making their own choices and are less likely to be influenced by others with regards to their fertility choices.

Looking at religious differences, compared to the omitted variable, which is whether the woman is Muslim or not, Christians and those with other religion are less likely to have more children. This is especially the case in the urban areas while these variables are not significant for the rural Ethiopia. The parameter stability test suggests significance difference in the coefficients across the place of residence. The fact that Muslim families tend to have more children (and desire more children) than other religions seems broadly consistent with the cross-country literature, which either shows higher fertility rates or slow reductions in fertility in Muslim populations (controlling for other factors).

With regards to village child mortality (a proxy for maternal expectations of mortality), the number of children who were born alive but died before the age of five affects fertility decisions for both urban and rural areas across the sample groups. The coefficient difference is also found to be significantly different across urban and rural areas. In the presence of expected child mortality the number of children a woman is likely to have is expected to be higher. For fear of ending up with lower number of children than desired due to child mortality, it is more likely that women with higher

expected child mortality will have higher number of children to cope with possible loss.

The relationship between economic status and the number of children born by a woman is not found to be significant in both urban and rural areas, while women's participation in jobs outside of their homes is negatively related in both urban and rural areas. The fact that women are engaged in income generating activities makes the opportunity cost of childrearing activities very high. Allocating a majority of time at the household could be viewed as a costly activity to the mother leading to a decision to limit her fertility. The parameter stability test shows no significant difference between the coefficients among the rural and urban areas. Moreover, the type of occupations for which the relationship is significant varies across urban and rural areas. Women engaged in clerical and sales occupations appear to have lower number of children than those who are not employed, and this holds for both rural and urban areas. Professional women are also likely to have lower number of children than those who are not working, all other variables constant, but this relationship is only significant in the urban areas. This is perhaps not very surprising since the proportion of women in professional occupations is generally low in rural areas. On the other hand, in the rural areas women engaged in work in agriculture outside of their home also have lower number of children than those who are not engaged in any work outside their home, while the relationship is insignificant for those in the urban areas.

Distance to the nearest health center and husband's education are not found to be significant in affecting fertility in both the urban and rural areas. The result with regard to husband's education is not particularly unusual in the literature. The fact that travel time to health centers has no effect on fertility rates is interesting in that it calls for further investigation whether availability of contraceptives actually has limited effect on fertility decisions assuming all health centers provide family planning services, or whether family planning services do not exist or are not provided sufficiently in the health centers.

We also observe relatively similar impacts with the desired number of children as the dependent variable. The direction of relationship between desired number of children and age, education, religion, and labor force participation (particularly the case of

agriculture for the rural areas) is similar as those observed in the case of actual children-ever-born by women. However, economic status does not seem to significantly affect the desired number of children in either urban or rural areas. Moreover, differences in coefficients across rural and urban areas are only observed for religion and occupation variables, while there is no statistically significant difference for the other variables.

One significant difference is that the marginal impact of "listens to radio frequently" is now significant in rural areas (but not in urban areas), and is predicted to reduce the desired number of children by 0.17. So while travel time to health centers has no impact on desired number of children in rural areas, the availability of radios does have some impact, even after controlling for asset ownership in general. Moreover, contraceptive knowledge proxied by the number of people in the village who have information about contraceptive use is found to significantly affect desired number of children.

Table 7: Estimation of children born and desired number of children by place of residence

	Children born			Desired children		
	Urban	Rural	Significance of parameter difference	Urban	Rural	Significance of parameter difference
Age (years)	0.51***	0.98***	***	0.21***	0.17***	
Age squared	-0.01***	-0.01***	***	-0.01**	-0.01***	
Woman - Primary education	-0.06	-0.03		-0.39	-0.35***	
Woman - Secondary education	-0.39**	-0.74***	*	-0.25	-0.69***	**
Woman - Higher education	-0.44**	-2.28***	*	-0.72**	-0.58	
husband- Primary education	0.35**	0.14**		-0.15	-0.08	
husband- Secondary education	-0.07	0.11		0.20	0.05	
husband- Higher education	0.04	0.17		0.43	-0.64	
Christian	-0.40**	-0.04	***	-1.49***	-0.58***	
Other religion	-1.39***	-0.08	*	-1.99***	-0.17	***
Child mortality	1.80***	0.58***	**	0.93	0.77***	
Listens to radio	0.17	-0.04		0.32	-0.17*	
2nd wealth quintile	-0.04	0.13		-0.63**	0.05	
3rd wealth quintile	-0.01	0.03		-0.41	0.01	
4th wealth quintile	0.25	0.04		-0.39	0.15	
5th wealth quintile	0.19	0.73		-0.55	-1.08	
Log of land owned (hectares)	0.28	-0.02		0.00	-0.01	
Log of land, squared	-0.03	0.09***		0.17	0.05	
Professional occupation	-0.44**	-0.57		-0.05	0.52	
Clerical/sales occupation	-0.32***	-0.21*		0.00	0.17	
Agriculture occupation	-0.06	-0.30	**	2.84	-0.42***	**
Other occupations	0.04	-0.30**		-0.07	-0.16	
Contraceptive knowledge (village	0.44	0.14		0.08	-1.43***	
Travel time to health center (hrs)	0.05	0.02		0.13	-0.05*	
Oromia	-0.14	0.36***	**	-1.17***	-0.50***	
Afar	-0.86***	0.03	***	-0.87***	2.16***	***
Amhara	-0.31*	-0.05	***	-1.01***	-0.81***	***
Somali	-0.03	0.23		-0.05	2.78***	***
Benishangul-gumuz	-0.16	0.13	**	-1.52***	-0.67***	**
SNNP	0.36*	0.24***		-0.49**	-0.59***	
Gambela	-0.39**	-0.47***		-0.85***	-0.85***	
Harari	-0.57***	0.27**	***	-0.74***	0.63	
Addis Ababa	-0.40***	-0.01		-0.53***	-0.74	
Dire Dawa	-0.57***	0.30*	***	0.05	1.02***	***
Prob>chi2	0.0000	0.0000		0.0000	0.0000	
Number of observations	2,157	7,262		1,994	6,338	

Note: reported coefficients are marginal effects
Asterisks indicate significance a 1 percent (***), 5 percent (**) and 10 percent (*)

5. Implications: Why fertility rates matter and how fertility reductions can be achieved

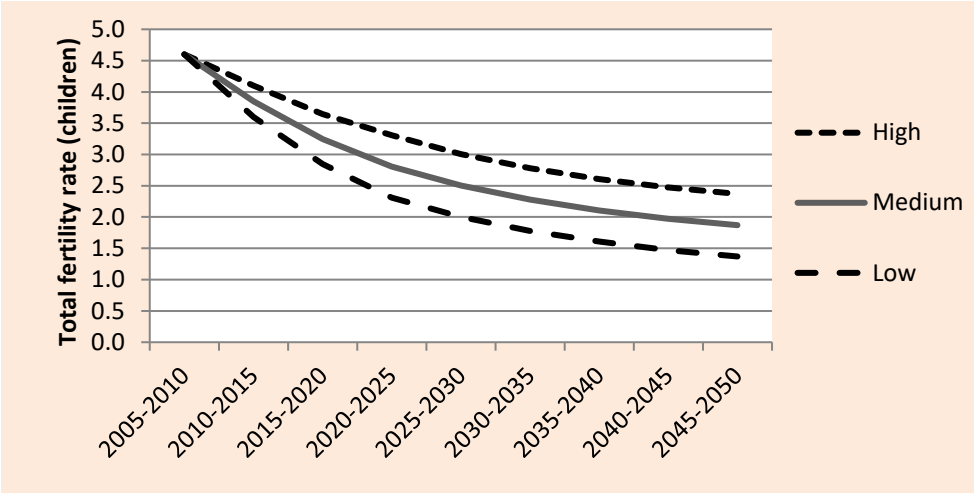
In the introduction to this paper we made allusion to some of the important benefits of reducing fertility relatively quickly, especially in a country like Ethiopia. In this concluding section we reflect on our findings regarding the causes of fertility rates, and examine the possible consequences of different fertility rates for Ethiopia's economic future based on new demographic projections from the United Nation's population division, and existing research on the impact of age dependency rates on saving rates and economic growth.

5.1. Fertility trends influence the demographic window: when it opens and how far it opens

To give some idea of the expected impact of getting more women into secondary education, we combine the results in Table 6 with the UN's 2010 population revision forecasts of future demographic trends in Ethiopia based on alternative fertility scenarios (UN 2011). These new UN projections are a significant improvement on previous projections because of an improved Bayesian forecast model that incorporates a broader set of both country-specific and cross-country information on fertility rates (Raftery et al. 2009). Another advantage of this model is that the only variation to the entire demographic model is variations in fertility rates, which in turn influence overall population growth and age dependency rates. Figure 3 shows the new alternative fertility predictions based on high, low, and medium variants, while Figure 4 shows the impact of these alternative fertility paths on age dependency ratios. The alternative fertility paths are purposively set such that by 2020–2025 there is 0.5 child difference between the medium variant and the high and low variants (and hence a 1 child difference between high and low variants). Figure 4 shows that these fertility differences, though seemingly modest, have a sizeable difference on age dependency ratios. By 2025 the spread of age dependency ratios reaches its maximum (+/-7 percentage points between medium and high/low variants), and this is maintained until around the year 2060 when the age dependency ratios reach their minima. In other words, the speed at which fertility rates fall determines the size of Ethiopia's demographic window.

What about the predicted impacts of reduced fertility rates and age dependency ratios on economic growth? Long standing theories predict that as the ratio of working age adults to dependents increases, savings and investment increases (Coale and Hoover 1958), and human capital accumulation expands as parents opt for quality over quantity (Becker and Lewis 1973). Cross-country regression analysis has also showed that growth in the share of the working age population makes a substantial impact on economic growth, but also that this dividend is increasing in institutional quality (Bloom et al. 2007). The idea underlying this institutional nexus is fairly simple. A growing working age share has tremendous potential to increase savings, human capital, and innovation, but only if the right policies and institutions are in place. The "right" policies and institutions would generally include a business environment that is conducive to higher savings and investment—such as secure property rights, a well developed financial sector, and labor market regulations that encourage job creation—as well as public investment policies that enhance skills and competitiveness.

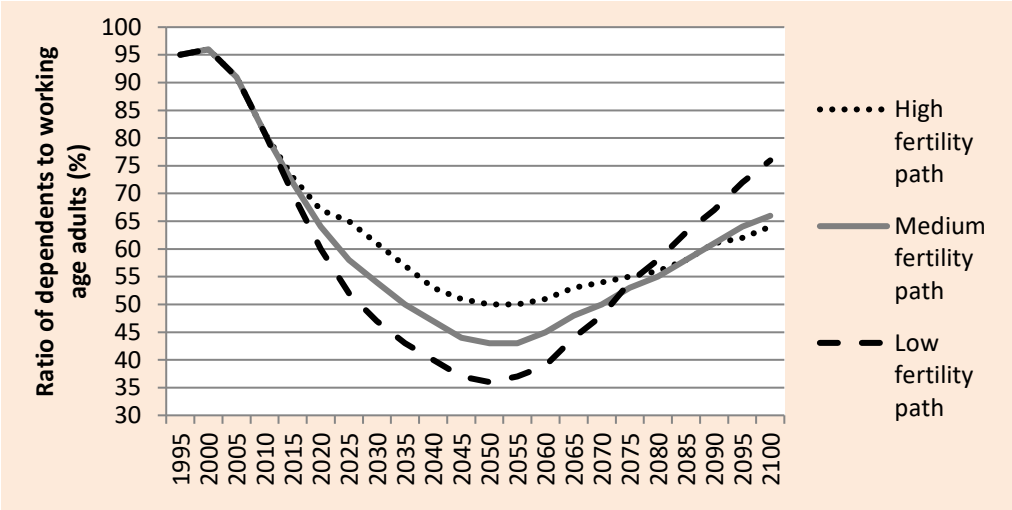
Figure 3: Alternative fertility predictions for 2010 to 2050



Source: 2010 Revision of *World Population Prospects* (UN 2010).

Notes: The total fertility rate is the average number of children a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as children per woman.

Figure 4. The projected impact of alternative fertility paths on age dependency ratios



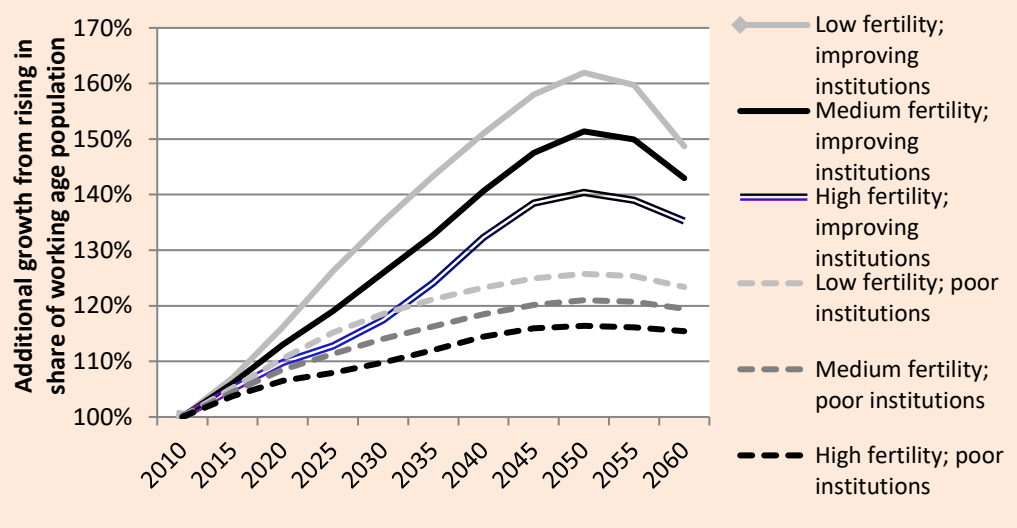
Source: 2010 Revision of *World Population Prospects* (UN 2010).

Using the cross-country regression estimates of Bloom et al. (2007) we can get some sense of the expected impact of alternative fertility paths on economic growth, conditional upon institutions. Specifically, we estimate the "demographic dividend" of each alternative fertility path under two scenarios: constant low institutional quality path (20%), and a consistently improving path (2 percentage points every five years). Figure 5 shows the growth impacts that result from the rising working age population shares from 2010 to 2060, which in turn are a function of the alternative fertility paths. These predicted growth impacts are additional to whatever baseline growth rates are obtained by Ethiopia over this period, so we are only presenting an additional growth impact, not a prediction of Ethiopia's overall growth rate. Also note that because the working age population share rises until 2050 and then start to decline thereafter, the growth dividend does the same (in other words, a declining working age population share becomes a drag on economic growth after 2050).

Bearing these nuances in mind, the main message in Figure 5 is that the demographic dividend of lower fertility rates is substantial, but only when institutional quality also improves. For example, in the low fertility scenarios income per capita in 2050 would only be 25% higher than in 2010 if institutional quality stayed low, whereas it would be around 60% if institutional quality doubled between 2010 and 2050. Moreover, the growth differential between the low and high fertility scenarios is substantial even

if institutions improve in both cases. In the low fertility–improving institutions scenario incomes in 2050 would be 60% higher than in 2010, whereas they would be only 40% in the high fertility–improving institutions scenario. So conditional upon institutional and policy improvements, it is clear that reducing fertility rates has important economic benefits.

Figure 5: Ethiopia's demographic dividend as a function of institutional quality



Source: Author's calculations based on UN (2010) fertility variants and econometric results from Bloom et al. (2007).

Notes: Under the "poor institutions scenario" Ethiopia's institutional quality stays constant at the sub-Saharan average (20%). Under the "improving institutions scenario" institutional quality improves by 1 percentage point every five years from 2010 onwards.

The aforementioned World Bank (2007) study also shows that lower fertility rates have sizeable economic benefits using a more sophisticated general equilibrium model. They show that a low fertility–low mortality path results in more rapid growth in per capita consumption (3.1% per annum) than in a higher fertility–higher mortality path (2.8% per annum). Numerically their more sophisticated model yields results that are actually quite similar to those observed in Figure 5,[15] although one potential weakness of their model is that it does not incorporate institutional quality.

[15] For example in their low fertility scenario per capita consumption grows by 16.5% from 2005 to 2030, whereas in our low fertility scenario per capita income grows 18.5% between 2010 and 2030.

5.2. The best way to reduce fertility rates appears to be via secondary education, particularly for rural women

Our results clearly show that a number of direct and indirect policy related factors can substantially influence fertility rates. Perhaps foremost among the factors at work is female education. Controlling for all other factors and relative to no education, some secondary education reduces fertility rates by 0.63–0.81 children, while some tertiary education reduces fertility rates by 1.51–2.07 children (see Table 6). The World Bank (2007) study also finds similarly large effects of secondary education using the 2000 DHS. Like us they also show that secondary and tertiary education levels in Ethiopia are currently so low that there are potentially huge demographic gains to be reached by getting more girls into secondary and tertiary institutions. In the 2005 DHS, just 11.9% of women aged 15-49 had secondary or tertiary education, but this masks a huge rural-urban divide: 51% of urban women had some secondary education against 3.5% of rural women.

Given that rural fertility rates are much higher than urban rates and that we uncover evidence suggesting that secondary education reduces fertility in rural areas more so than in urban areas (see Table 6), the most "fertility-effective" education strategy would therefore be to target secondary education investments towards rural areas. However, cost considerations are also important. In general, providing secondary education in rural areas is more expensive than in urban areas (especially after controlling for quality), and social and economic constraints could also inhibit female enrollment in rural areas (e.g. gender attitudes, on-farm labor requirements, weak transport infrastructure). In the medium term it will probably be more cost-effective to concentrate education infrastructure in population dense rural areas where the relative returns to female education—and hence potential enrollment—are higher. It also true that facilitating more rapid urbanization could make a positive contribution to fertility reduction, especially migration out of isolated areas where infrastructure investments are less cost-effective.

The emphasis on secondary education and gender equity in enrollment is also emphasized by the government of Ethiopia in its 5-year growth and transformation plan (GTP). The plan aims to raise secondary school gross enrollment from 38 percent in 2010 to 75 percent in 2015. However, while the government has the goal of gender

parity for primary school enrollment, no such goal exists for secondary school enrollment, and there are no explicit rural and urban targets either. Another constraint is that education is almost certainly underfunded. Table 8 shows trends in the share of federal government expenditures allocated to education and defense in eight African countries. Despite rapid increases in enrollment rates in the 2000s (and hence the need for rising expenditure), Ethiopia's education budget share remains one of the lowest in Africa (9.2%), with only Nigeria (7.6%) maintaining a lower level. In the other six countries the education budget grabs 15 to 28% of the total budget. The result of increased enrollment with such a modest education budget is obviously relatively low quality, which has been confirmed by very low literacy scores.

Table 8: Trends in federal government budget allocations 2000-2007

Country	Agriculture	Education	Health	Trans/ Comm	Social	Defense	Other
Ethiopia	9.4	9.2	1.9	4.4	9.9	18.3	46.8
Ghana	0.5	15.1	4.7	1.2	0.0	2.1	76.3
Kenya	4.3	27.7	6.0	5.6	5.6	7.8	43.1
Malawi	5.0	18.2	12.2	4.1	7.0	2.6	50.9
Mozambique	5.1	20.1	12.9	15.4	N.A.	N.A.	46.2
Nigeria	2.9	7.6	4.6	2.4	2.5	6.2	73.8
Uganda	3.9	18.7	10.7	9.6	2.9	10.0	44.1
Zambia	10.8	16.6	7.9	1.0	0.4	12.4	50.9

Source: Authors' calculations from IFPRI (2011) data.

5.3. Some persistent knowledge gaps

While our results do not shed much evidence on the role that contraceptive availability and family planning plays, existing evidence suggests that contraceptive demand exceeds supply and that family planning services are effective and seemingly quite cost-effective (World Bank 2007). In some of our results we find that access to a radio (and hence radio messages on family planning) also had some positive effect on reducing fertility. We await the new Ethiopia Demographic Health Survey (forthcoming in 2011) to see what the progress has been made on contraceptive use, and what impact other family planning interventions, including the relatively new health extension worker (HEW) program, are having on fertility rates.

In addition to these knowledge gaps we must acknowledge that while some of our regressions appear to satisfactorily explain the large urban effect on fertility rates (i.e. in terms of parameter heterogeneity of explanatory variables), there are still some persistent puzzles regarding Ethiopia's fertility rates. In particular, there is still substantial regional variation, with Addis Ababa's fertility rates seemingly much lower than other urban centers.

References

Alemayehu,T., J. Haider and D. Habte. 2010. Determinants of Adolescent Fertility in Ethiopia. *Ethiopian Journal of Health Development* 24(1):30-38

Axinn, W. G. 1993. The Effects of Children's Schooling on Fertility Limitation. *Population Studies* 47 (3): 481-493.

Becker, G. S., and H. G. Lewis. 1973. On the Interaction between the Quantity and Quality of Children. *Journal of Political Economy* 81 (2): S279-S288.

Becker, G. S. 1960. *An Economic Analysis of Fertility*. Bureau of Economic Research. Demographic and Economic Changes in Developed Countries. Princeton, N.J.: Princeton University Press.

Benefot, K., and P. Shultz. 1996. Fertility and child Mortality in Cote D'Ivoire and Ghana. *World Bank Economic Review* 1 (1): 123-158.

Ben-Porath, Y. 1976. Fertility Response to child Mortality: Micro Data from Israel. *The Journal of Political Economy* 84 (4): S163-S178.

Bledsoe, C. H., and B. Cohen. 1993. Social Dynamics of Adolescent Fertility in Sub-Saharan Africa. Panel on Population Dynamics of Sub- Saharan Africa, committee on Population, National Research Council. Washington, DC: National Academy Press.

Bloom, D. E., and J. G. Williamson. 1998. Demographic Transitions and Economic Miracles in Emerging Asia. *World Bank Economic Review* 12 (3): 419-455.

Bloom, D. E., D. Canning, G. Fink, and J. Finlay. 2007. *Realizing the Demographic Dividend: Is Africa any different?* PGDA Working Paper 23. Program on the Global Demography of Aging, Harvard University.

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. Chicago: Aldine. London: Allen & Unwin.

Chaudhury, N., J. Hammer, and A. Pokharel. 2008. First Things First: Infectious Disease, Child Mortality and the Poor in India 1992-2005. Paper presented at Annual Bank Conference on Development Economics (ABCDE), Cape Town, South Africa, June 9-11.

Chaudhury, R. H. 1986. Reviewed works: The Influence of Female education, Labor Force Participation and Age at Marriage on Fertility Behavior in Bangladesh. *Studies in Family Planning* 17 (1): 53.

Coale, A. J., and E. M. Hoover. 1958. *Population Growth and Economic Development in Low-Income Countries.* Princeton: Princeton University Press.

Central Statistical Agency [Ethiopia] and ORC Macro. 2001. Ethiopia Demographic and Health Survey 2005.Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro.

Central Statistical Agency [Ethiopia] and ORC Macro. 2006. Ethiopia Demographic and Health Survey 2005.Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro.

CSA. 2008. *Summary and Statistical Report of the 2007 Population and Housing Census*. Addis Ababa.

DHS. 2010. Measure DHS Stat-Compiler. Demographic Health Surveys, Sponsored by USAID. <http://www.statcompiler.com/>. Accessed November 22.

Dzekedzeke, K. and N. Nyangu. 1994. *Fertility Patterns and their Determinants in Zambia: Findings from the Zambia Demographic and Health Survey.* Demographic and Health Surveys. Macro International Inc. Columbia, Maryland USA

Dudley, K., and B. Pillet. 1998. Fertility Levels, Trends, and Differentials in Sub-Saharan Africa in the 1980s and 1990s. *Studies in Family Planning* 29 (1): 1-22.

Eastwood, R., and M. Lipton. 2004. The impact of changes in human fertility on poverty. *Journal of Development Studies* 36 (1): 1-30.

Engelhardt, H., K. Tomas, and P. Alexia. 2004. Fertility and Women's Employment Reconsidered: A Macro-Level Time-Series: Analysis for Developed Countries, 1960-2000. <https://dspace.lboro.ac.uk/dspace/bitstream/2134/271/1/Engelhardt%20et%20al._PopSt_2004_final%20draft.pdf > Accessed May 12, 2010

Filmer, D., and L. Pritchett. 2001. Estimating wealth effects without expenditure data - or tears: an application to education enrollment in states of India. *Demography* 38 (1): 115-132.

Foster A. D & M. R. Rosenzweig. 2006. Does Economic Growth Reduce Fertility? Rural India 1971-99, *India Policy Forum, Global Economy and Development Program, The Brookings Institution*, 3(1): 179-213

Freedman, D. S. and A. Thornton. 1982. Income and Fertility: The Elusive Relationship. *Demography* 19 (1): 65-78.

Garenne, M. M. 2008. *Fertility Changes in Sub-Saharan Africa*. Macro International Inc. Calverton, Maryland, USA

Garrett, J. L., and M. T. Ruel. 1999. *Are determinants of rural and urban food security and nutritional status different?* FCND discussion papers 65. International Food Policy Research Institute.

Gurmu, E., and R. Mace. 2008. Fertility Decline Driven by Poverty: The Case of Addis Ababa. *Journal of Biosocial Science* 40 (3): 339-358.

Hailemariam, H. A., and A. Y. Zewoldi. 1994. *Proximate Determinants of Fertility in Ethiopia: An application of the Bongaarts Model*. Demographic training and Research Centre, Institute of Development Research, Addis Ababa University. Addis Ababa.

Hasketh, T., L. Lu, and Z. Xing. 2005. The effects of China's One-Child Family Policy after 25 Years. *New England Journal of Medicine* 353 (11): 1171-1176.

Headey, D. 2011. Turning Economic Growth into Nutrition-Sensitive Growth. Paper presented at 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health, New Delhi, India, February 10-12.

Henderson, J. V. 2010. Cities and Development. *Journal of Regional Science* 50 (1): 515-540.

Jain, A. K. 1981. The Effect of Female Education on Fertility: A Simple Explanation. *Demography* 18 (4): 577-595.

Kirk, D. and B. Pillet. 1998. Fertility levels, trends and differentials in sub-Saharan Africa in the 1980's and 1990's, *Studies in Family Planning* 29(1): 1-22.

Kuznets, S. 1974. Rural-Urban Differences in Fertility: An International Comparison. *Proceedings of the American Philosophical Society* 118 (1): 1-29.

Li, H., J. Zhang, and Z. Yi. 2005. The Quantity-Quality Tradeoff of Children in a Developing Country: Identification Using Chinese Twins. <http://reap.stanford.edu/research/publications/hongbin-quantity-quality-twins.pdf>. Accessed on July 14, 2011.

McNown, R. 2003. A Cointegration Model of Age- Specific Fertility and Female Labor Supply in the United States. *Southern Economic Journal* 70 (2): 344-358.

Murthi, M., A.-C. Guio, and J. Drèze. 1995. Mortality, Fertility and Gender Bias in India – A District level Analysis. *Population and Development Review* 21(4): 745-782.

Nguyen,T. and R. Purnamasari. 2011. *Impacts of International Migration and Remittances on Child Outcomes and Labor Supply in Indonesia: How Does Gender Matter?* World Bank Policy Research Working Paper No. 5591. Available at SSRN: http://ssrn.com/abstract=1792248

Pankhurst, R. 1985. *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century.* Addis Ababa.

Population Studies and Training Center. 2003. Demographic Training and Research Center (Addis Ababa University). *Proximate determinants of fertility in Amhara region, Ethiopia: An application of the Bongaarts model.* Brown University, USA.

Raftery, A. E., L. Alkema, P. Gerland, Clark, S. J., F. Pelletier, T. Buettner, G. Heilig, N. Li, & H. Sevcikova .2009. White paper: Probabilistic projections of the total fertility rate for all countries for the 2010 world population prospects. In United Nations Expert Group Meeting on Recent and Future Trends in Fertility. United Nations, Department of Economic and Social Affairs, Population Division. Available at http://www.un.org/esa/population/meetings/EGM-Fertility2009/egm-fertility2009.html.

Ringheim, K., C. Teller, and E. Sines. 2009. *Ethiopia at a Crossroads: Demography, Gender, and Development.* Population Reference Bureau Policy Brief. <http://www.prb.org/pdf09/ethiopia.pdf > . Accessed on July 8, 2011

Rosenzweig, M. R., and K. Wolpin. 1980. Testing the Quantity-Quality Fertility Model. *Econometrica* 48 (1): 227-240.

Schmidt, E., and M. Kedir. 2009. *Urbanization and Spatial Connectivity in Ethiopia: Urban Growth Analysis Using GIS.* ESSP II Discussion Paper 3. International Food Policy Research institute, Addis Ababa. http://www.ifpri.org/sites/default/files/publications/esspdp03.pdf

Schultz, T. P., and Y. Zeng. 1995. Fertility of Rural China: Effects of Local Family Planning and Health Programs. *Journal of Population Economics* 8 (4): 329-350.

Schultz, T. P. 1997. Demand for Children in Low Income Countries. In *Handbook of Population and Family Economics,* edited by M. R. Rosenzweig, and O. Stark. Amsterdam: Elsevier Science.

Shapiro, D. and B. O. Tambashe. 2000. Fertility Transition in Urban and Rural Areas of Sub-Saharan Africa. Revised version of paper presented at the Chaire Quetelet Symposium in Demography, Catholic Univeristy of Louvain, Louvain-la-Neuve, Belgium. University Park, PA: Department of Economics Working Paper, Pennsylvania State University.

Sibanda, A., Z. Woubalem, D. P. Hogan, and D. P. Lindstrom. 2003. The proximate determinants of the decline to below-replacement fertility in Addis Ababa, Ethiopia. *Studies in Family Planning* 34 (1): 1–7.

Smith, L. C., M. Ruel, and A. Ndiaye. 2004. *Why is Child malnutrition lower in urban than rural areas?* FCND Discussion 179. Washington, DC: International Food Policy Research Institute.

United Nations, Department of Economic and Social Affairs, Population Division. 2011. *World Population Prospects: The 2010 Revision*. New York

Westoff, C. F., and T. Frejka. 2007. Religiousness and Fertility among European Muslims. *Population and Development Review* 33 (4): 785-809.

Winkelmann R. and K. Zimmermann. 1994. Count data models for demographic data. *Mathematical Population Studies* 4(3): 205-221.

Wooldgridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Dat*a. MIT Press. London

World Bank. 2007. *Capturing the Demographic Bonus in Ethiopia: Gender, Development and Demographic Actions.* Report No. 36434-ET.

Yusuf, M., A. Mekonnen, M. Kassie, and J. Pender. 2005. Cost of Land Degradation in Ethiopia: A Critical Review of Past Studies. Unpublished manuscript.

POVERTY ANALYSIS OF CHILDREN IN CHILD HEADED HOUSEHOLDS IN ADDIS ABABA[1]

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Abstract

This study attempts to analyse the economic and social situation of children living in child-headed households using a poverty analysis framework. The study used family of indexes developed by Foster, Greer and Thorbecke (1984) commonly known as FGT measures to measure aggregate poverty and micro-econometric method to uncover the various determinants of poverty status of children in child-headed households. Quantitative method (Household survey) was used to generate information. From the descriptive statistics we found out that the average monthly per capita income is about half of the poverty line and the average level of consumption is also by far below the poverty line. We found out that about 77.3% of the total CHHs are below the absolute poverty line. This figure is far below from the national urban average poverty level, reflecting the miserable living standard of CHHs. The difference in level of income and consumption between male-headed and female-headed households is very high. Close to 90% of female CHHs are living below the poverty line while the percentage for male CHHs is 59%. Gender differential is obvious in CHHs, indicating that female child headship leads to low level of welfare.

From the regression result we found out that sex, size of household and age are determinants of child poverty. Male CHHs are less exposed to poverty compared to females. Household size increases the probability of falling into poverty, while its square reduced the probability of falling into poverty indicating the presence of economies of scale at the household level. The age of the head shows that the risk of poverty increases as age increases but at a decreasing rate as indicated by the coefficient on its squared variable. Likewise, increase in mean household age statistically is likely to worsen poverty.

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1. Introduction

Children in Ethiopia constitute about 52% of the Ethiopian population (MoLSA, 2004:6). The figure clearly indicates that the future of the country rests on its children. Ethiopian children should, thus, be provided with better standards of life in larger freedom without discrimination of any kind, such as sex, language, religion, social origin or social and property status. They should also be progressively provided with access to education and need to have the highest attainable standard of health on the basis of equal opportunity for all. To this end, the Government of Ethiopia has ratified a number of conventions, declarations and charters.[3] This shows the Government's commitment to the welfare of all the children in the country.

Despite this unequivocal commitment of the government to its children, Ethiopian children have been found to be vulnerable to various problems. While a great number of them belong to poor families who have no access to education, health, etc. some others are unattended. They are either abandoned by their parents or separated from their parents due to various reasons. There are also children who are orphans. In relation to this, the Ethiopia's National Plan of Action for Children (ENPAC) document acknowledges that about 3 million children in the country are, in one form or another, deprived of their family environment. The Plan for Accelerated and Sustained Development to End Poverty (PASDEP) document also states 'out of the total number of children under age 18, about 12% are found to have lost at least one parent, comprising 8% that are orphaned of their father, 3% orphaned of their mother, and 1.3 % orphaned by both parents. … the proportion of children orphaned by both parents is higher in Addis Ababa than other regions' (MoFED, 2006:30). This makes the absolute number of children orphaned of both parents to be over 0.5 million.
The public concern given to the grave situation of children abandoned by or separated from their parents, children without sufficient family support, and children living in child-headed households (here after, CHHs) is not commensurate o the problem. The

[3] The UN Convention on the Rights of the Child (CRC), the African Charter on the Rights and Welfare of the Child (ACRWC), Universal Declaration of Human Rights (UDHR), the International Covenant on Civil and Political Rights (ICCPR), the International Covenant on Economic, Social and Cultural Rights (ICESCR), the Convention on the Elimination of all forms of Discrimination Against Women (CEDAW), the African Charter on Human and Peoples Rights (ACHPR), and two conventions of International Labour Organisation (ILO) (1973 of the Minimum Age Convention and the 1999 Convention on the Worst Forms of Child labour).

need to critically see the social and economic conditions of children living in CHHs is, therefore, imperative.

The main objective of this study is, thus, to analyse the socio-economic condition of children living in CHHs. Added to that, the study aims to examine why children are forced to lead this kind of life.

Studies examining children's life, survival, and development in an environment where there is no parental support are practically non-existent. While the emergence of CHHs has been very apparent, there are disturbingly no dataset on the prevalence of these households even in Addis Ababa, leave alone in other administrative regions.[4] The current study, thus, hopes to advance our knowledge on the socio-economic conditions of CHHs in Ethiopia and contribute to the debate in the literature.

The rest of this paper is organised as follows. Section 2 looks into methodological issues. Section 3 gives a descriptive analysis of the survey results in terms of demographic profile and education and health conditions of children in CHHs. Section 4 provides a synthesis of the analysis and discussion presented in the preceding sections in terms of poverty profile on the basis of the poverty indices and regression analysis. Concluding remarks are provided in section 5.

[4] This lack of data is in fact rightly captured by the UN Committee on the Rights of the Child, under item 18, in its Concluding Observations of 29 September 2006 on the report submitted to it by the Ethiopian Government in relation to implementation of the CRC. Part of the concluding observation reads, "The Committee notes with concern the lack of data on areas including domestic adoption, street children, children involved in armed conflicts, children without parental care, children involved in the justice system, sexually abused and trafficked children".

2. Methodology of the study and methods of data collections

2.1. Methodological issues

The study employs descriptive and analytical methods to analyse poverty profile of CHHs. While a simple household budget analysis method is employed to discuss the income and expenditure patterns of CHHs, family of indexes developed by Foster, Greer and Thorbecke (1984) is employed to measure aggregate poverty which commonly known as FGT measures. The study also used micro-econometric method to uncover the various determinants of poverty status of CHHs.

The study used quantitative method to generate the required information. A detailed and well-structured household level questionnaire that measures the level of consumption, income, demographic characteristics, and other variables is utilized. Effort was made to measure consumption and income at an item level so as to capture a disaggregated level of consumption and income. This approach is believed to be important to minimize a common problem of measurement errors in survey exercises.

In least developed countries like Ethiopia, measuring income level is very difficult and researchers usually use consumption expenditure to proxy income. In our study, we tried to capture the level of income from different sources. These sources include: salary or wages from formal employment, remittance, friends, income earning assets, aid, etc.

2.1. Some notes about the processes and challenges of data collection

Consultation with NGOs working on Orphan and Vulnerable Children (OVC) revealed that there is no dataset on CHH in all the sub-cities of Addis Ababa. Since all the organisations consulted are found to have the list of children they support irrespective of vulnerability status, they were approached to identify CHHs from all other children in their record. All organisations working on OVC were approached for this purpose. After some taxing exercise, we managed to get a list of about 118 CHHs.

While the survey was being carried out, it was found that some of the children were not child-headed. A few of them could not be traced. Finally, we managed to get 72

CHHs for the survey. In the process of carrying out the survey, 20 questionnaires were found to have some technical problems out of which 4 were automatically discarded. New questionnaires were used to collect data on the rest of the 16 CHHs for the second time. Still, it was 14 of the new questionnaires which were found to be useable. Eventually, it was from 66 CHHs that the quantitative primary data on income and expenditure pattern were generated.

3. Demographic and social situation of children

3.1. Demographic features

The 66 CHHs surveyed in this study consist of 130 household members of which 73 are girls (56.2%) and 57 are boys (43.8%). As can be observed from Table 1, the average household size is 1.97 ranging from 1 to 6. The second row of the table tells us an interesting gender differential story. It reveals that there are considerably more girl CHHs with larger size of households than those headed by boys.

Table 1: Household size and relative incidence of female-headed child households

Sex	Frequency	Average household size	Minimum	Maximum	% share of CHHs
Female-headed	39	2.1	1	6	59.1
Male-headed	27	1.7	1	5	40.9
Total	66	1.97	1	6	100.0

Source: Author's calculation from survey data.

In terms of ethnicity, the CHH members are composed of 5 different ethnic groups, the Amhara forming the single most important category (73%) followed by the Oromo which accounts for 15.4%.

Table 2: Ethnic composition of household members

	Frequency	Percent

Amhara	95	73.1
Gurage	5	3.8
Kembata	3	2.3
Oromo	20	15.4
Tigre	7	5.4
Total	130	100.0

Source: Same as Table 1.

With regard to religion, Christianity is the dominant one. While Christianity accounts for 99.2%, Orthodox Christianity forms the single most important category within this group (88.4%). There is only one Muslim child who is also the head of single household.

There are various factors that led children to be heads and members of CHHs. The survey shows that poverty, child abuse by parents, and being orphan to be the major reasons for this. The responses given by respondent when asked how they have become the member of CHHs are summarised in the following table.

Table 3: Reasons why current child became member of CHHs

Reasons	Whole sample		Male		Female	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Orphan	118	90.8	50	87.7	68	93.2
Non-Orphan: left parents or chased by parents	12	9.2	7	12.3	5	6.8
Total	130	100	57	100	73	100

Source: Same as Table 1.

As may be observed from the table above, 90.8% of the respondents say that they have become members because they happened to be orphans and this is in agreement with the stories reported by participants of the nine case studies discussed in section 4: all nine households said they had their new role for being orphans. Like the case studies, the survey revealed that there is some kind of transition period between the death of parents and formation of CHHs. It was found that children are often cared for initially by a relative and it is usually a death of a care giver that would eventually lead to establishing to CHHs. Most of these caregivers have been found to live with the orphaned children for less than a year before their death. CHHs are then

established after death of relatives. On the other hand, the survey results show that there are instances whereby children (9 children - 6.9% of the total observation) leave their parents' houses either expelled by their parents or leaving their parents on their own accord. A more revealing data, however, is that what we see in the last columns of the table: there are considerably more female children that are orphan than male children.

Children were also asked to identify the causes of their parental death. As presented in Table 4 below, 44 children do not know the causes of the death of their parents. This is mainly because they lost their parents in their early childhood age. Among reasons well identified by the respondents HIV/AIDS accounts for 20%. Others types of disease make up 32.7%. There is, however, every likelihood that a considerable proportion of other types of diseases could be HIV/AIDS related. Given the stigma and discrimination particularly in the 1990s, parents might have not disclosed to their children that they were HIV positive. Nor would their respondents would be comfortable to reveal this information in a survey questionnaire even if they knew about it.

Table 4: Causes for the death of parents

Causes	Mother		Father	
	Frequency	Percent	Frequency	Percent
HIV/AIDS	22	20.0	22	20.0
Other	36	32.7	36	32.7
Accident	8	7.3	8	7.3
I don't know	44	40.0	44	40.0
Total	110	100	110	100

Source: Same as Table 1.

5.1. Education and health conditions

The access to education and health facilities is one of the reflections of the level of socio-economic development of a country. CHH members like any other children have full right for access to education and health care facilities and the government has

already committed to protect and promote this right. With that in mind, the survey sought to know the status of the respondents on this regard.

In terms of education the findings of the survey is very encouraging. As can be observed from the table below, 95.4% of the children are able to read and write. This percentage is considerably higher than the country average figure. Nearly half of the children are enrolled in primary school, while 32.4% are enrolled in first cycle secondary school.

Table 5: Highest grade of schooling of individuals

	Frequency	Percent
Read and write: Yes	124	95.4
Read and write: No	6	4.6
First cycle primary (1-4)	10	9.3
Second cycle primary (5-8)	42	38.9
First cycle secondary (9-10)	35	32.4
Second cycle secondary (11-12)	13	12.0
Vocational	7	6.5
Other	1	0.9
Total	108	100

Source: Same as Table 1.

Out of the total number of children surveyed, it is only 16.2% who are not attending school for various reasons.[5] According to the respondents, the most prevalent reasons given for not attending school are: health problems, school expenses, and the need to work for payment to support other members of the household. More specifically, among those who do not go to school, while 28.6% say that they have been unable to get to school because they are not able to afford to pay school expenses, 19.1% of them ascribe their failure to go to schools to ill health (see Table 6.

Table 6: Reason for not attending school

[5] It should be noted that 5 children are less than 7 years old.

	Frequency	Percent
Cannot afford school expenses	6	28.6
Engaged in other activity to support members of the household	2	9.5
Because of bad health	4	19.0
Other	9	42.9
Total	21	100

Source: Same as Table 1.

As regards to health, children were asked whether they suffer from illness or injury in the last four weeks, where they sought treatment, and if they had reasons for not visiting health facility, if there is any. Their responses are presented in Table 7a-b.

Table 7a: Illness incidence and visits to health facilities

	Suffered from any illness		Visit health Facilities		Places where treatment was sought for			
	Yes	No	Yes	No	Hospital	Health centre	Clinic	Traditional
Frequency	21	109	12	9	3	7	1	1
Percent	16.2	83.8	57.1	42.9	25.0	58.3	8.3	8.3

Table 7b: Reason for not visiting health facility

Reasons	Frequency	Percent
Illness was not serious	1	11.1
No money	7	77.8
Other	1	11.1
Total	9	100

Source: Same as Table 1.

As can be observed from the tables, 16.2% of the total children (12 female and 9 male) reported experiencing illness in the reference period. Of those who experienced illness, only 11 children visit health facilities and whereas 10 of them visited government owned health facilities, only one of them went to a private health facility. While nine of the children did not at all visit any kind of health facility, a child reported

he had visit traditional health facility (holly water, locally known as *tsebel*). Not surprisingly, lack of money was given as a major reason for not going to health facilities.

4. Income, expenditure, and poverty profile of CHHs

4.1. Methodology and tools of analysis

(i) Method of analysis

One of the main reasons of collecting household survey data is the measurement and understanding of living standard. At the least, such measurement requires data on consumption, income, household size, and prices (Deaton 1997). In our study, a detailed and well-structured household level questionnaire that measures the level of consumption, income, demographic characteristics, and other variables is utilized. Effort was made to measure consumption and income at an item level so as to capture a disaggregated level of consumption and income. This approach is believed to be important to minimize a common problem of measurement errors in survey exercises. The standard apparatus of welfare economics and welfare measurement concerns the well being of individuals. Nevertheless, a good deal of our data has to be gathered from household level.

Another important issue in household budget survey is the choice of a recall period. When households are asked to report their income or expenditure, a choice has to be made about the reference or reporting period. Depending on the purpose of the survey and the variable/s to be measured, the recall period may vary from asking households to recall expenditures for a day to their last year consumption. Many budget survey handbooks suggest that the most commonly adopted recall period for consumption and a frequently purchased item is a period of between a week to a month since such a duration minimizes measurement errors that may result from memory tremble. With that in mind, the recall period we used in the present survey is, thus, one week or seven days.

(ii) Measuring consumption and income

Consumption is an important variable in household level analysis of budget, welfare or living standards. Total consumption can be measured in different ways. However, some individual items of expenditure are of interest in their own right because their consumption is of direct interest - health care, education, food, especially nutrient-rich foods such as milk, so that the pattern of demand has implications for different stakeholders. To utilize this feature of disaggregated measure of consumption and minimizing errors of aggregation, consumption is measured at an item level. The other concern of measuring consumption is expenditure on consumption and the quantity consumed. Households have different sources, such as own purchase, in kind gift from others, aid, etc. However, the amount of consumption is a combination of these different sources and respondents are asked to report the value of the consumption items consumed during the last seven days. The value of consumption of a certain item is aggregated to obtain the total level of consumption at the household level. The weekly level of consumption can easily be converted into a month or annum for convenience and comparison.

Another important issue that should be accounted was the problem of seasonality in consumption pattern. This problem is especially critical if one tries to measure during abnormal seasons or occasions such as holidays, where consumption patterns are usually inflated. With an aim of avoiding such possible inflation of consumption, the present survey was conducted by avoiding those seasons.

Income is often a more sensitive topic than expenditure/consumption is. Accurate estimates of income also requires knowledge of assets and their returns, a topic that is always likely to be difficult, and where respondents often have incentive to understate (Deaton 1997). The same problem is observed in our survey, where the average level of expenditure/consumption is greater than what the household gets from any sources. Since our intent is on household budget analysis, we are only interested to know the reported sources of income, not their level.

4.2 Income and expenditure patterns

4.2.1. Household budget allocation

(i) Consumption budget pattern

As noted earlier, the primary interest of this study is to understand the consumption level and the demand pattern of households headed by children. The value of consumption of each household is measured on a weekly recall basis and Table 8 presents the average consumption per month per capita of our sample.

Table 8: Mean level of consumption per capita (in Birr), food share and non-food share of total consumption by sex of the head (in %)

Households	Mean Consumption Per capita per month	Median Consumption Per capita per month	Food share	Non-food share
Whole	219.4	172.9	60.0	40.0
Male CHH	240.8	244.7	59.5	40.5
Female CHH	204.5	157.1	60.3	39.7

Source: Same as Table 1.

As can be read from the table, the average level of consumption per capita per month for the whole sample is about Birr 219. Disaggregated by sex of head of the household, male-headed households have larger level of nominal consumption, where the mean consumption per capita per month is Birr 240.8 for male-headed households and Birr 204.5 for the female-headed households. However, unlike the median, mean is very sensitive for extreme values. In fact the difference in level of consumption between male-headed and female-headed households is very high when we consider the median value. In this regard, one can imagine that female child headship leads to low level of welfare.

When we look at the demand pattern of consumption in the household, on average, the whole CHHs allocate 60% of their consumption to food items while the rest 40% is allocated to non-food purchases. Food items constitutes cereals, pulses, spices and cooking oil, milk, milk products, meat, fish, egg, bread, pasta, macaroni, vegetables, fruits, soft drinks, and stimulants. Non-food item basket, on the other hand, comprises education, local transport, water and electric bills, clothes, household consumables (matches, gasoline, charcoal, etc), health, house rent, etc. Of interest by their own

right, the share of these items in the total household budget is important. It reveals the demand pattern deemed to be important for policy implication and intervention.

The pattern of expenditure share among the food items is presented in Table 9

Disaggregating the food basket into its various items has important implication not only for the understanding of demand pattern but also for studying the nutritional status of children. As shown in the table clearly, the highest share of food budget (45.3%) goes to the consumption of cereals. This pattern is due to different factors: household preference, level of prices, seasonality, etc. However, the literature from least developing countries like Ethiopia attributes such kind of pattern to poverty and low purchasing power. Studies reveal that poor households purchase less nutritious foodstuffs and cannot afford to include high nutritious food items like meat, milk, and the like in their daily menu.

Table 9: Share of food items in total food consumption[6]

Food items	Whole sample	Male CHHs	Female CHHs
Cereals	0.453	0.457	0.45
Pulses	0.102	0.113	0.096
Spices and cooking oil	0.225	0.228	0.223
Milk and milk products	0.005	0.002	0.007
Meat, egg, fish	0.009	0.013	0.006
Bread, pasta, etc	0.065	0.066	0.064
Vegetables	0.038	0.028	0.044
Fruits	0.009	0.01	0.009
Drinks and stimulants	0.051	0.05	0.052
Total	0.957	0.966	0.951

Source: Same as Table 1.

The evidence from Table 9 implies that malnutrition remains a widespread problem in CHHs. The implication is far reaching. According to voluminous literature on child malnutrition, nutrition is an important dimension of child welfare, where the long-term productivity and growth of the child is determined by early childhood feed.

[6] Sum of the share of the different foodstuffs is less than unity for the fact that there are some households who consume prepared food.

The second more important food basket next to cereals are spices and cooking oil that serve as food flavours. Pulses, which are relatively nutritious than cereals represent only around 10% of the food budget of CHHs. Other items, which are known for their high protein, fat and vitamin contents like milk and milk products, meat, egg, fish, vegetables constitute only a marginal proportion. In fact, the proportion of all these items accounts about 5% of food budget. An intervention that aims at buttressing the calorie intake of CHHs should target at increasing the consumption of these items.

While scrutinizing the pattern of demand for food items at the household level is important, non-food items are equally vital in studying welfare of the CHHs. Table 4.3 shows the share of non-food items in total value of household consumption. The share of educational expenditure, which constitutes school fees and other educational expenses, in total consumption is very small accounting less than 1% of the total household budget (total consumption) implying the very low share that education has in CHH. That is the case despite of the fact child education is an important parcel of human capital. At the same time, it is worth noting the low budget share of education can partly be attributable to the fact that most public primary schools have do not charge school fees or most of the educational materials are covered by NGOs sponsoring children. And that explains as to why that a great majority (83.1%) of respondents described their primary occupation as “student”.

Table 10: Share of non- food items in total value of consumption

Non-food items	Whole sample	Male CHHs	Female CHHs
Education	0.006	0.012	0.001
Local transport	0.025	0.03	0.02
Water and electric bill	0.069	0.074	0.066
Clothes	0.026	0.01	0.037
Household consumables	0.118	0.122	0.115
Health	0.038	0.024	0.047
House Rent	0.064	0.073	0.057
Non-food	0.40	0.405	0.397

Source: Same as Table 1.

The major basket of non-food consumption item that constitutes 12% of the total consumption budget is household consumables. These items are things like matches, batteries, candles, charcoal, firewood, kerosene, soap, etc. Combined, water, electricity bill and house rent account for about 13% of consumption. The low share of rent is attributed to the fact that 80.3% of the households have rented from kebele, where the rent is usually small compared to the private tenancy. Health expenses account for about 3.7%, 2.4% and 4.7% of the whole sample, male child-headed and female CHHs, respectively. The observed pattern reflect that female CHHs spend more of their budget on health care than male CHHs implying that reproductive health and general medical assistance matters more to female CHHs than to their male counterparts.

(ii) Income levels and sources

Another important, but difficult to measure, variable in welfare economics is household income level. In least developed countries like Ethiopia in particular, measuring income level is very difficult and researchers usually use consumption expenditure to proxy income. In our study, we tried to capture the level of income from different sources. These sources include: salary or wages, remittance, income earning assets, aid, etc. The average monthly per capita income is about Birr 157.5, while the median is Birr 140. Likewise the level of consumption, the mean and median level of income per capita of male child-headed is higher than that of female CHHs. One can also observe the presence of downward bias in income report by comparing the level of per capita income and per capita consumption, where the former is less than the latter one (see Table 11).

Table 11: Level of income per capita per month and income shares (%)

Households	Mean	Median	Share from employment salary	Share form petty trading	Share from other sources
Whole sample	157.5	140	19.0	2.9	78.1
Male CHHs	193.2	168	20.2	3.1	76.7
Female CHHs	132.9	129	18.2	2.7	79.1

Source: Same as Table 1.

We classified the different sources of income into employment income, petty trading income, and income from other sources (see Table 11). All income from remittance, friends, and relatives, NGOs, and other sources are categorized under other sources. Not surprisingly, the share of income from other sources is about 78.1% of the total household income. Income from employment constitutes only 19% of the total income. Since most households are headed by children aged ≤18 years and their primary occupation is student, they cannot generate income through employment or other activities. They primarily resort to aid from formal sources like NGOs and informal sources. Further taxonomy of other income sources is made to identify the major source of income. Parts and participles of other income are shown in Table 12. The majority of households' source of income is from NGOs. We can see that, the majorities are supported by NGOs.

Table 12: Decomposition of other sources of income

Items	Frequency	Percentage
Non-resident household member	2	2.0
Relatives	14	13.7
Friends	2	2.0
NGOs	78	76.5
Other	6	5.9
Total	102	100.0

Source: Same as Table 1.

4.3. Poverty profile of CHHs

4.3.1. Measurement of poverty[7]

The important part in most of poverty analysis is identification of the poor, which necessitate the poverty line to be determined given the appropriate measure of welfare. Poverty line is understood as a level of standard of living below which a household is considered as being in poverty. There are a number of approaches to determine the poverty line (welfare approach and non-welfare approach such as direct caloric intake, food-energy intake, and cost of basic need methods). In the cost

[7] For different definitions, concepts and measurements of poverty see WB (2000), Ravallion and Huppi (1989), Ravallion and Bidani (1994), Ravallion (1994), and Sen (1979, 1983, and 1985).

of basic needs approach, developed by Ravallion and Bidani (1994), for instance, a basket of goods for which basic food requirements will be met is defined. The cost of this basket of goods at market price becomes the food poverty line. Then an allowance for non-food goods is added on the food poverty line to obtain the total poverty line.

However, due to absence of market price to value the basket of consumption commodities for the determination of the poverty line, we used an internationally comparable and the most commonly applied absolute poverty line that is sufficient for an individual to survive. The absolute poverty line is 1USD per day per capita and this is used as yardstick measuring poverty in the current study. Once the appropriate poverty line is determined, the next important step is to obtain the aggregate measures of poverty. The common aggregate measures of poverty indices are summary measures defined over mean income or consumption, the relevant poverty line, and the parameters characterizing the underlying income distribution (Bigsten et al. 1999). The most commonly applied measures, which are adopted for this study, are the family of indexes developed by Foster, Greer and Thorbecke 1984. These indices possess desirable properties for poverty comparison and are commonly known as FGT measures given by;

$$p_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{(z-x_i)}{z}\right]^\alpha ; \alpha = 0,1,2$$

Where x_i is income or consumption expenditure of household *i*, *z* is the poverty line, *n* is size of population and *q* is the number of poor. p_0 measures the incidence of poverty and tells us only the proportion of the population that are poor. p_1, on the other hand, measures the depth of poverty, how much on the average the poor fall below the poverty line. Finally, p_2 is a measure of poverty by weighting the situation of the poor by the square of the shortfall of their income or expenditure from the poverty line (Mekonnen 1999).

4.3.2. Poverty profile of CHHs

In this section, we briefly present the poverty profile of CHHs on the basis of the poverty indices briefly discussed above. Based on our definition of the poverty line, 30USD per month per individual, households who have less than this level of consumption per capita per month are considered poor.[8] As shown in Table 13 (see the details in Annex 1:1.1-1.3), 95% confidence interval of the head count index is between 66.89% and 87.65%. The normalized poverty gap index (p_1) is 33%. It shows the percentage of total consumption needed to bring the entire CHHs to the poverty line. The squared poverty gap or severity of poverty is about 18%.[9]

Table 13: Summary measures of poverty

	Whole sample	Male child-headed	Female child-headed
Head count poverty (p_0)	77.27%	59.26%	89.74%
Poverty gap (p_1)	33.11%	25.42%	38.43%
Squared poverty gap (p_2)	18.28%	15.02%	20.53%

Source: Same as Table 1.

Two important features stand out from the above table. The first feature is that an overwhelming majority of children are living below the poverty line. Put more specifically, 77.3% of the total CHHs are below the absolute poverty line. This figure is far below from the national urban average poverty level, reflecting the miserable living standard of CHHs.

The second most important feature is that the head count poverty rate is considerably higher for female CHHs than male CHHs. Close to 90% of female CHHs are living below the poverty line while the percentage for male CHHs is 59%. Gender differential is obvious in CHHs, where female-headed households are disadvantageous and live in absolute poverty.

4.4. Determinants of poverty of CHHs

[8] We used 1USD=Birr 10.466 (2009 rate), which gives us a poverty line of Birr 314 per capita per month.
[9] This figure should not be compared with the national poverty figure as the poverty line is determined differently.

4.4.1. The model

From the descriptive result, we understand that the majority of the households are below the absolute poverty line. In the poverty literature there are different ways of analyzing poverty dynamics, each with their desirable properties and shortcomings.

Using simple regression models, we can uncover the various determinants of poverty status of the sampled CHHs. The dependent variable is poverty status of the household, P_i, which take the value of 1 if the household is poor and zero otherwise. The models can be represented by the following equation:

$$P_i^* = \beta x_i + \varepsilon_i$$
$$\Pr ob(p_i = 1 | x_i) = F(\beta x_i + \varepsilon_i)$$

Where, P_i^* is the underlying response variable determining the latent poverty process, P_i is the poverty status of household *i,* x_i is a vector of exogenous determinants of household poverty status, β parameters to be estimated and ε_i is the error term. F is the probability function, which can take different forms depending on the assumption on the distribution of the error term. If it is assumed to be normally distributed, the econometric model will take the probit model or if we assume to be logistically distributed, the model will be estimated using logit estimation.

The right hand side regressors included into the estimation are size of the of household and its squared value, sex of the head, age and its squared value of the head, mean age in the household, occupation of the household head (dummy variable taking 1 if student and zero otherwise), location dummies where *Arada* and *Yeka* are entered into the regression and all other *Kifleketemas* are considered as base. Dummy variables capturing asset status inherited from parents are classified into two: productive assets and durable assets, taking unit value if there is any productive/durable assets left by parents and zero, otherwise. Dummy indicating whether the child is a victim of any abuse, location of residence, occupation and level of education of parents are included.

4.4.2. Discussion of results

Regression results from Stata are presented below in Table 14 (a-c) for Probit, Logit and Linear Probability models, respectively. We have corrected for the common problem of heteroscedasticity using White-Huber robust regression option. Since the size and variability of our sample is small, the results could not be claimed to be representative. As can be shown in Table 14 (a-c), household size increases the probability of falling into poverty, while its square reduced the probability of falling into poverty indicating the presence of economies of scale at the household level. The probability value of z indicates that both coefficients are statistically significant (at 5% in the probit model). Akin to the descriptive statistics, the regression result shows that male CHHs are less exposed to poverty compared to females. The coefficient on age of the head on the other hand shows that the risk of poverty increases as age increases but at a decreasing rate as indicated by the coefficient on its squared variable. Likewise, increase in mean household age statistically is likely to worsen poverty. Moreover, households headed by student child have lower probability of falling into poverty. This could be due to the fact that these children are sponsored by NGOs who not only cover their school fees but also some part of their consumption.

Table 14(a): Determinants of poverty of CHH: Probit Model

Probit regression		Number of obs	= 66
		Wald chi2(22)	= 28.89
		Prob > chi2	= 0.1479
Log pseudolikelihood	= -16.077914	Pseudo R2	= 0.5455

poor	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
House_size|	21.63504	9.165871	2.36	0.018	3.670265	39.59982
House_sizesqr	-2.98878	1.271627	-2.35	0.019	-5.481122	-.4964373
Sex_head	-2.081301	1.247242	-1.67	0.095	-4.52585	.3632479
Age_head	74.76863	33.6857	2.22	0.026	8.745874	140.7914
Age_headsqr	-2.412891	1.087544	-2.22	0.027	-4.544438	-.2813444
Mean_Age	2.717024	1.148833	2.37	0.018	.4653524	4.968695
Student	-8.308363	3.732834	2.23	0.026	15.62458	-.9921419
Arada	.6523297	1.635627	0.40	0.690	2.553441	3.8581
Yeka	.5409005	.9900807	0.55	0.585	-1.399622	2.481423
Prod'v_asset	-6.969231	2.883426	-2.42	0.016	-12.62064	-1.317821
Durable_asset	-5.588642	2.349881	-2.38	0.017	-10.19432	-.9829594
Abused	-.9651789	1.2143	-0.79	0.427	-3.345163	1.414805
Pvt_tenure	3.354147	1.990801	1.68	0.092	-.547751	7.256045
Mother_uran	2.682058	2.717927	0.99	0.324	2.644981	8.009097
Father_uran	-4.023199	2.477605	-1.62	0.104	-8.879215	.8328177
Mother_civil	-10.16843	5.01085	-2.03	0.042	-19.98952	-.3473473
Mom_domestic	-1.811166	1.469333	-1.23	0.218	-4.691005	1.068673
Mom_housewive	-3.885707	2.312063	-1.68	0.093	-8.417267	.6458537
Dad_pvtsector	1.669439	1.364578	1.22	0.221	-1.005085	4.343964
Dad_civil	4.504842	2.796245	1.61	0.107	-.9756985	9.985382
Mom_literate	-4.962132	2.501169	-1.98	0.047	-9.864334	-.0599302
Dad_literate	7.416888	3.523204	2.11	0.035	.5115359	14.32224
constant	-626.1522	278.9669	-2.24	0.025	-1172.917	-79.3871

Note: Standard errors are corrected using White-Huber robust regression.

Table 14 (b): Determinants of poverty of CHH: Logit Model

Logistic regression

Number of obs = 66
Wald chi2(22) = 23.10
Prob > chi2 = 0.3960
Log pseudolikelihood = -16.194943 Pseudo R2 = 0.5422

poor	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
House_size|	36.11661	18.27304	1.98	0.048	.3021083	71.93111
House_sizesqr	-5.001603	2.547974	-1.96	0.050	-9.995541	-.0076654
Sex_head	-3.559056	2.39344	1.49	0.137	-8.250112	1.132001
Age_head	125.5696	65.58912	1.91	0.056	-2.982717	254.1219
Age_headsqr	-4.05187	2.117494	-1.91	0.056	-8.202081	.0983418
Mean_Age	4.531044	2.23092	2.03	0.042	.1585222	8.903566
Student	-13.95919	7.219724	-1.93	0.053	-28.10959	.1912058
Arada	.9548636	2.762628	0.35	0.730	-4.459788	6.369515
Yeka	.8873376	1.594074	0.56	0.578	-2.23699	4.011665
Prod'v_asset	-11.60761	5.429525	-2.14	0.033	-22.24928	-.9659349
Durable_asset	-9.321564	4.439491	-2.10	0.036	-18.02281	-.6203212
Abused	-1.606815	2.625648	-0.61	0.541	-6.75299	3.53936
Pvt_tenure	5.462737	3.43514	1.59	0.112	-1.270014	12.19549
Mother_uran	4.570735	5.166845	0.88	0.376	-5.556095	14.69757
Father_uran	-6.811851	5.062083	-1.35	0.178	-16.73335	3.10965
Mother_civil	-17.10288	9.97504	-1.71	0.086	-36.6536	2.447837
Mom_domestic	-2.948396	2.428379	-1.21	0.225	-7.707932	1.81114
Mom_housewive	-6.593315	4.410183	-1.50	0.135	-15.23712	2.050486
Dad_pvtsector	2.898352	2.667357	1.09	0.277	-2.329571	8.126275
Dad_civil	7.601025	5.659151	1.34	0.179	-3.490706	18.69276
Mom_literate	-8.227563	5.185874	-1.59	0.113	-18.39169	1.936563
Dad_literate	12.40505	6.828009	1.82	0.069	-.9776042	25.7877
constant	-1050.925	545.1096	-1.93	0.054	-2119.32	17.47033

Table 14 (c): - Determinants of poverty of CHH: Linear Probability Model

Linear regression

Number of obs	= 66
F(22, 43)	= 2.00
Prob > F	= 0.0256
R-squared	= 0.3737
Root MSE	= .41087

poor	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
House_size|	.3336691	.2284564	1.46	0.151	-.1270573	.7943954
House_sizesqr	-.0471003	.0394771	-1.19	0.239	-.1267133	.0325128
Sex_head	-.2341293	.1305799	-1.79	0.080	-.4974688	.0292102
Age_head	1.800602	1.3533	1.33	0.190	-.9287308	4.529934
Age_headsqr	-.056021	.04176	-1.34	0.187	-.1402447	.0282013
Mean_Age	.011566	.0439078	0.26	0.793	-.0769824	.1001144
Student	-.0838334	.1502977	-0.56	0.580	-.3869377	.2192709
Arada	-.1593349	.1485717	-1.07	0.290	-.4589583	.1402885
Yeka	-.0641037	.184436	-0.35	0.730	-.4360543	.307847
Prod'v_asset	-.1024818	.2739631	-0.37	0.710	-.654981	.4500175
Durable_asset	-.2269859	.1465803	-1.55	0.129	-.5225933	.0686215
Abused	-.0544187	.1618102	-0.34	0.738	-.3807401	.2719027
Pvt_tenure	.2145039	.1610914	1.33	0.190	-.1103679	.5393757
Mother_uran	.2491324	.2841683	0.88	0.386	-.3239476	.8222123
Father_uran	.0445522	.2556574	0.17	0.862	-.4710302	.5601345
Mother_civil	-.0509466	.2572145	-0.20	0.844	-.5696691	4677759
Mom_domestic	-.0458221	.1218886	-0.38	0.709	-.2916338	1999896
Mom_housewiv e	.0191093	.1570982	0.12	0.904	-.2977095	.3359281
Dad_pvtsector	-.0785967	.1405537	-0.56	0.579	-.3620503	.2048569
Dad_civil	-.0759313	.1612753	-0.47	0.640	-.4011739	.2493113
Mom_literate	-.0113778	1280438	-0.09	0.930	-.2696027	.246847
Dad_literate	.1720625	.11174	1.54	0.131	-.0532828	.3974077
constant	-14.211	10.83899	-1.31	0.197	-36.0699	.647895

The coefficients on both location variables, where the majority of the sampled households reside (*Arada* and *Yeka*) are positive but not statistically significant in all the three models. On the other hand, location of resident of parents, especially when father used to live in urban area seems to lower risk of poverty of CHHs. Education

level of mother has significant impact in reducing the probability of falling into poverty.

Owning one or more productive and durable assets from parents has been found to reduce the probability of falling into poverty, which is indicated by the negative and statistically significant coefficients on two appropriate models in the table below. These assets, productive assets like house, livestock, and the like in particular, are found to be important since they have the capacity of generating income for the household. Reinforcing the result, households living in rented houses from private tenure have higher risk of falling into poverty. Reported cases of child abuse have, however, found to have no relation with the status of poverty of the child.

6. Concluding remarks

The data generated through household survey revealed that more than three-fourth of the total CHHs live below the absolute poverty line. Gender differential is evident in CHHs, where female-headed households are at a disadvantage. Gender differential is evident in CHHs, where female-headed households are at a disadvantage both in level of income and consumption. Close to 90% of female CHHs are living below the poverty line while the percentage for male CHHs is only 59%.
The main determinants of child poverty are found to be sex, size of household and age. Household size increases the probability of falling into poverty, while its square reduced the probability of falling into poverty indicating the presence of economies of scale at the household level. The age of the head shows that the risk of poverty increases as age increases but at a decreasing rate as indicated by the coefficient on its squared variable. Likewise, increase in mean household age statistically is likely to worsen poverty.

While the emergence of CHHs is very apparent, there are disturbingly no dataset on the prevalence of these households even in Addis Ababa, leave alone in other regional states. Without adequate data nobody knows the degree of the problem and the right package for intervention. Given the importance of children, both in volume and future of the country, the government needs to develop a mechanism for developing data base for orphan and vulnerable children in general and children living in CHHs in particular.

References

Assefa Admassie. 2003. Investing in Children: The Experience of Sub Saharan African Countries, unpublished.

Berhanu et al. 2005. Mainstreaming Children: A Child-focused Analysis of Ethiopia's Sustainable Poverty Reduction Program's Poverty Analysis, Policy Goals and Targets, SCUK: Addis Ababa.

Bigsten A. et. al. 1999. Poverty and Welfare in Ethiopia: Profile and Determinants. *Ethiopian Journal of Economics*, vol. 3, no. 1, pp: 21-36.

Central Statistics Authority (CSA). 2002. Ethiopia Child Labour Survey Report 2001, Statistical Bulletin 262, CSA: Addis Ababa.

Deaton, A. 1997. The Analysis of Household Survey: A Micro-econometric Approach to Development Policy. Published for The World Bank, The Johns Hopkins University Press, Baltimore and London.

Foster, J., Greer, J., and Thorbecke, E. 1984. A Class of Decomposable Poverty Measures. Econometrica, vol. 52, no. 3, pp: 761-766.

Getnet Alemu and Assefa Admassie. 2004. The Impact of Macro Economic Policy Reforms on the Wellbeing of Children: The Macro-micro Linkage, A Study Prepared for Save the Children UK Young Lives Project, Addis Ababa, Ethiopia.

National HIV/AIDS Prevention and Control Office (HAPCO) and Ministry of Health (MoH). 2004. Ethiopian Strategic Plan for Intensifying Multi-sectoral HIV/AIDS Response, Addis Ababa, Ethiopia.

Richter, L. and Sharmla, R. 2006. Building Resilience: A Right-based Approach to Children and HIV/AIDS in Africa, Save the Children Sweden

Mekonnen Tadesse. 1999. Determinants of Dynamics of Urban Poverty in Ethiopia". *Ethiopian Journal of Economics*, Special Issue, vol. 3, no. 1, pp: 61-81.

Ministry of Finance and Economic Development. 2006. Plan for Accelerated and Sustained Development to End Poverty, Volume I, Main Text, Addis Ababa.

_____. 2002. Ethiopia: Sustainable Development and Poverty Reduction Program, Addis Ababa.

Ministry of Labour and Social Affairs. 2004. Ethiopia's National Plan of Action for Children covering the period 2003-2010 and beyond, Addis Ababa.

Ravallion, M. and B. Bidani. 1994. How Robust is a Poverty Profile? The World Bank Economic Review, vol. 8, no. 1, pp: 75-102.

Ravallion, M. 1994. *Poverty comparisons*. Chur, Harwood Academic Publishers.

Ravallion, M. and Huppi. 1989. Poverty and Under-nutrition in Indonesia during the 1980s'. World Bank Policy, Planning and Research, Working Paper No. 286, World Bank, Washington, Dc.

Sandra Liebenberg. 1999. 'Socio-Economic Rights', in Chaskalson, et. al., Constitutional Law of South Africa, (3rd Revision Service, 1999), Juta & Co.: Cape Town.

Save the Children Sweden. 2006. Memory Book: Memory, Grief and Identity: Life Stories from Orphaned Children, Avant Garde, Nairobi, Kenya.

Sen A. 1979. Personal Utilities and Public Judgments: Or What's Wrong with Welfare Economics. *The Economic Journal*, vol. 89, no. 335, pp: 537-558.

_____. 1983. Poor Relatively Speaking. Oxford Economic Papers, vol. 35, pp: 153-169.

_____. 1985. *Commodities and Capabilities*. Amsterdam, North Holland.

Tilahun Teshome and Getnet Alemu. 2006. Good Governance and Budget Tracking from a Child Rights Perspective, SCS - Eastern and Central Africa: Addis Ababa

UN-Committee on the Rights of Child. 2006. Consideration of Reports Submitted by State Parties Under Article 44 of the Convention, Concluding Observations: Ethiopia, CRC/C/ETH/CO/3.

World Bank. 2004. Ethiopia: Public Expenditures Review The Emerging Challenge, Volume I, Report No. 29338-ET.

_____. 2000. World Development Report: Attacking Poverty. New York, Oxford University Press.

_____. 1990. World Development Report, Washington DC: World Bank.

World Health Organization. 1985. Energy and Protein Requirements. WHO Technical Report Series, no. 724, Geneva.

Yonas Birmeta. no date. Child Rights Duty Bearer's Hand Book, SCS-Ethiopia and Federal Supreme Court Juvenile Justice Project Office: Addis Ababa.

Annex 1: Poverty measures

1.1: FGT measures of poverty for the whole sample.

Poverty measures for the variable cons_mpc: consumption per capita per month
Survey mean estimation

pweight: <none>	Number of obs	=	66
Strata: <one>	Number of strata	=	1
PSU: <observations>	Number of PSUs	=	66
	Population size	=	66

Mean	Estimate	Std. Err.	[95% Conf. Interval]		Deff
p0	.7727273	.0519793	.6689175	.876537	1
p1	.3310922	.0335473	.2640936	.3980908	1
p2	.1827745	.0245522	.1337403	.2318087	1

1.2: FGT measures of poverty for male CHHs.

Survey mean estimation

pweight: <none>	Number of obs	=	27
Strata: <one>	Number of strata	=	1
PSU: <observations>	Number of PSUs	=	27
	Population size	=	27

Mean	Estimate	Std. Err.	[95% Conf. Interval]		Deff
p0	.5925926	.096362	.3945176	.7906676	1
p1	.2542163	.0573786	.1362729	.3721598	1
p2	.1502259	.0412485	.0654383	.2350135	1

1.3: FGT measures of poverty for female CHHs.

Survey mean estimation

pweight: <none>	Number of obs	=	39
Strata: <one>	Number of strata	=	1
PSU: <observations>	Number of PSUs	=	39
	Population size	=	39

Mean	Estimate	Std. Err.	[95% Conf. Interval]		Deff
p0	.8974359	.0492161	.797803	.9970688	1
p1	.3843139	.0389368	.3054904	.4631374	1
p2	.2053081	.030106	.1443617	.2662546	1

Source: Author's calculation from survey data using STATA statistical software.

ROAD SECTOR DEVELOPMENT AND ECONOMIC GROWTH IN ETHIOPIA[1]

Ibrahim Worku[2]

Abstract

The study attempts to see the trends, stock of achievements, and impact of road network on economic growth in Ethiopia. To do so, descriptive and econometric analyses are utilized. From the descriptive analysis, the findings indicate that the stock of road network is by now growing at an encouraging pace. The government's spending has reached tenfold relative to what it was a decade ago. It also reveals that donors are not following the footsteps of the government in financing road projects. The issue of rural accessibility still remains far from the desired target level that the country needs to have. Regarding community roads, both the management and accountancy is weak, even to analyze its impact. Thus, the country needs to do a lot to graduate to middle income country status in terms of road network expansion, community road management and administration, and improved accessibility. The econometric analysis is based on time series data extending from 1971-2009. Augmented Cobb-Douglas production function is used to investigate the impact of roads on economic growth. The model is estimated using a two-step efficient GMM estimator. The findings reveal that the total road network has significant growth-spurring impact. When the network is disaggregated, asphalt road also has a positive sectoral impact, but gravel roads fail to significantly affect both overall and sectoral GDP growth, including agricultural GDP. By way of recommendation, donors need to strengthen their support on road financing, the government needs to expand the road network with the aim of increasing the current rural accessibility, and more attention has to be given for community road management and accountancy. Lastly, gravel road expansion has to be made to meet the target level of the road network and simultaneously ascertain rural accessibility, thereby improving agricultural productivity and market access of the poor rural population.

Author Keywords: Road sector development, Stock of achievements, Impact on Overall and Sectoral Economic Growth, Two-step GMM Estimation, Ethiopia

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1. Introduction

Since 1993/94, the Ethiopian government has been implementing various reforms that have involved the processes of structural adjustment programs along with commercialization of agriculture, private sector development, and a number of related poverty alleviation programs. Successful implementation of the programs requires an efficient infrastructural system. In particular, road transport is supposed to create a network over a wide array of infrastructural facilities. In addition, the road transport sector is essential for developing countries for the reason that provision of other advanced means of transportation is expensive. For instance, Fan and Rao (2003), citing numerous studies, indicated that public spending in rural infrastructure is one of the most powerful instruments that governments can use to promote economic growth and poverty reduction and among these services road transport sector is considered as the crucial one.

A well-developed road transport sector in developing countries is assumed to fuel up the growth process through a variety of activities of the development endeavors of a nation. Among these, creation of market access opportunities for agricultural products is the major one. The issue of market access is more relevant for a country like Ethiopia where rural population accounts for about 85% of the national population who are engaged in production for both the domestic and international market. Moreover, road transport facilities play a role in both the production and consumption decisions of every household in their day-to-day activities. Besides, road transport facilities are essential for expanding education, health service provision, trade facilitation – both within the country and the export market, and better public as well as private service provisions, including banking and insurance services, to the destitute and marginalized rural dweller. Likewise, roads serve as key infrastructural units, which provide linkages to other modes of transportation like railways, shipping, and airways.

In Ethiopia road transport is the dominant mode and accounts for 90 to 95 percent of motorized inter-urban freight and passenger movements. However, because of its limited road network, provision of infrastructure has remained one of the formidable challenges for Ethiopia in its endeavor towards socio-economic development and

poverty reduction (ERA, 2008a).The Ethiopian Road Authority (ERA) investigated the link between the country's development plan and the road sector policy (ERA 2008a). The study generally indicated that there is a well-established nexus between the development plan of the nation "A Plan for Accelerated and Sustained Development to End Poverty, Ethiopia's version of Poverty Reduction Strategy" (PASDEP) and the road sector policy.

Because of the imperative nature of the sector, it is relevant to undertake critical investigation of the road transport sector of Ethiopia. Government expenditure patterns in Ethiopia have changed dramatically over the last few years. Thus, it is also important to study the trends in the levels and composition of government expenditures in the road transport sector, and assess the impact of these changes over time. It is even more important to analyze the contribution of such expenditure in the overall growth aspiration of the nation. The study will also provide important information for more efficient targeting and use of limited financial resources of the country in designing an efficient and effective road transport system and developing the road transport policy of the nation. Added to this, making such an investigation contributes to the stock of knowledge regarding the road transport sector.

The aim of the study is to analyze the performance of the road transport sector in Ethiopia. The study will have the following specific objectives:

- The study will analyze the stock of achievements and the performance of the road network in Ethiopia;
- The study will review the available reports and policy strategy documents;
- The study will identify and characterize the links that exist between road network development and overall and sectoral growth; it will also attempt to capture the impacts of different types of road on the overall and sectoral economic growth;

Based on the findings of the aforementioned analysis, the study will come up with recommendations for improved performance of the road sector development on the overall and sector specific economic growth.

To analyze the stock of achievements in the road transport sector of Ethiopia, time series data are used for the econometric analysis. The major data source regarding most of road related variables is obtained from the Ethiopian Road Authority (ERA).

Other relevant variables are collected from government authorities such as the Ministry of Finance and Economic Development (MOFED), and the Central Statistical Authority (CSA 2008; CSA 1970-2010). In addition, whenever necessary, African Development Indicators CD-ROMs and other relevant publications are also used in the data compilation process.

In order to achieve the stated objectives, various empirical methodologies are utilized. In analyzing the trends in the road transport sector over the last few decades, both descriptive statistics and econometric methods are employed. Time series analysis is used to investigate the trends in the road transport sector over the previous years and its impact on overall and sectoral economic growth. Descriptive analysis is deployed to capture the link between the road transport sector and performance indicators, like rural accessibility, road density, road network, road financing, and community road management. The study also attempts to investigate the stock of road transport in Ethiopia and its impact on economic growth. To this end, the study reviewed the scattered knowledge in the area and uses a number of tools in analyzing its impact on overall and sectoral economic growth.

The limitation of the study is that it is difficult to deal with the socio-economic impact of the sector. Analyzing the socio-economic impact requires a baseline survey on the status of the society before and after provision of road infrastructure. This task would require a significant stock of data, time, and financial resource. It also requires a long-term plan, which is designed in parallel with a new road project intervention. Upcoming studies might deal with this issue to see its impact on socio-economic development.

The study is organized as follows. Section two provides an overview of the road sector in Ethiopia. Section three presents descriptive analysis of the road sector: road network, road density, rural and urban road accessibility, community road network, and financing of the sector. The conceptual framework and econometric model specification and discussion on data related issues are discussed in section four, as well as the econometric analysis along with estimation issues and discussion on the findings. Section five finalizes the study with a brief conclusion and stating plausible policy recommendations.

2. Overview of road sector policies in Ethiopia

The starting point is the federal government's vision, which is to transform Ethiopia from a least developed country into a middle-income country by 2028, by sustaining the two digit economic growth registered in the recent years (2003–2010/11). Achieving this Government vision requires sustainable growth of the Ethiopian economy, which in turn depends on the development of infrastructure in general and expansion and improvement of the road network of the country in particular (MOFED 2006).

The Ethiopian economy is highly dependent on agriculture, which accounts for around 50 percent of the gross domestic product (GDP). An estimated 85 percent of the population is directly or indirectly depending on the agricultural sector. More than 90 percent of export earning is generated from the agricultural sector. Second to the agricultural sector, services account for more than one-third of economic activity. The composition of service earnings has shifted only slowly in response to economic liberalization, with recent slight growth in the construction, transport, and tourism sectors. Contribution of the construction industry to GDP at constant factor cost is about 6 percent for 2006/07 (Central Statistical Authority 2008). On the other hand, industry accounts for almost 12 percent of economic activity where most of the manufacturing firms are concentrated in Addis Ababa. However, these days it is also common to see manufacturing industries being established in some other cities and towns. Industrialization of towns outside of Addis Ababa obviously requires more road infrastructure and efficient transportation operation.

Since its commencement the Ethiopian Roads Authority (ERA) has administered the road sector. ERA was established in 1967 by proclamation No 256/67 to provide for the control and regulation of travel and transport on the road. The ERA is responsible for the use of all roads within Ethiopia, vehicles using these roads, and to all matters relating to road transport activities of the country. After the downfall of the military government, ERA restructured its obligations with a vision to ensure the provision of a modern, integrated, and safe road transport service to meet the needs of all the communities of a strong and unitary economic and political system in Ethiopia.

When we look at the road network of the country over the past five decades, compared to the year 1951 the total road network has increased with factor seven to reach the level in 2009. In 1951 the total stock of road network was only 6400 km; in 2009 that is 46812 km (ERA 2009). The rise in the length of road is due to the emphasis given to the sector. In particular, the current government, the Federal Democratic Republic of Ethiopia, has placed increased emphasis on improving the quality and size of the road infrastructure. To address the constraints in the road sector related to restricted road network coverage and low standards, the Government originally formulated a 10-year Road Sector Development Program in 1997 (RSDP 1997-2007).

The first phase of the RSDP (1997-2002) focused on the restoration of the road network to an acceptable condition. Specifically, the program focused on (1) rehabilitation of main roads; (2) upgrading of main roads; (3) construction of new roads; and (4) regular maintenance on the network. Side by side, the program also considered major policy and institutional reforms.

The program was launched with a very significant donor support to create adequate capacity in the road sector and to facilitate the economic recovery process through the restoration of essential road network. The first five year of the program (RSDP I), 1997-2002, was officially launched in September 1997, and has been completed in June 2002. Accomplishment under RSDP II is rather encouraging. The total disbursement rate of investment on federal and regional roads for the 5 years of RSDP II is about 125% and 73%, respectively, whilst the corresponding physical accomplishment is 134% and 145% of the planned. Within the ten years period of the program, the total disbursement of projects planned for the execution amount 25.4 billion Birr (US$ 2.9 billion). This would enhance the integration of domestic markets and the potential growth of exports in terms of volume and international competitiveness (ERA 2008b). Having looked at policies road sector policies, hereafter achievements and constraints of the sector are described.

3. Descriptive analysis of relevant factors of the road sector

In this section, attention is given to the road network, road density and accessibility, financing, construction, and maintenance and betterment costs, as factors are indicators for the sector's contribution to a wide range of growth inducing factors.

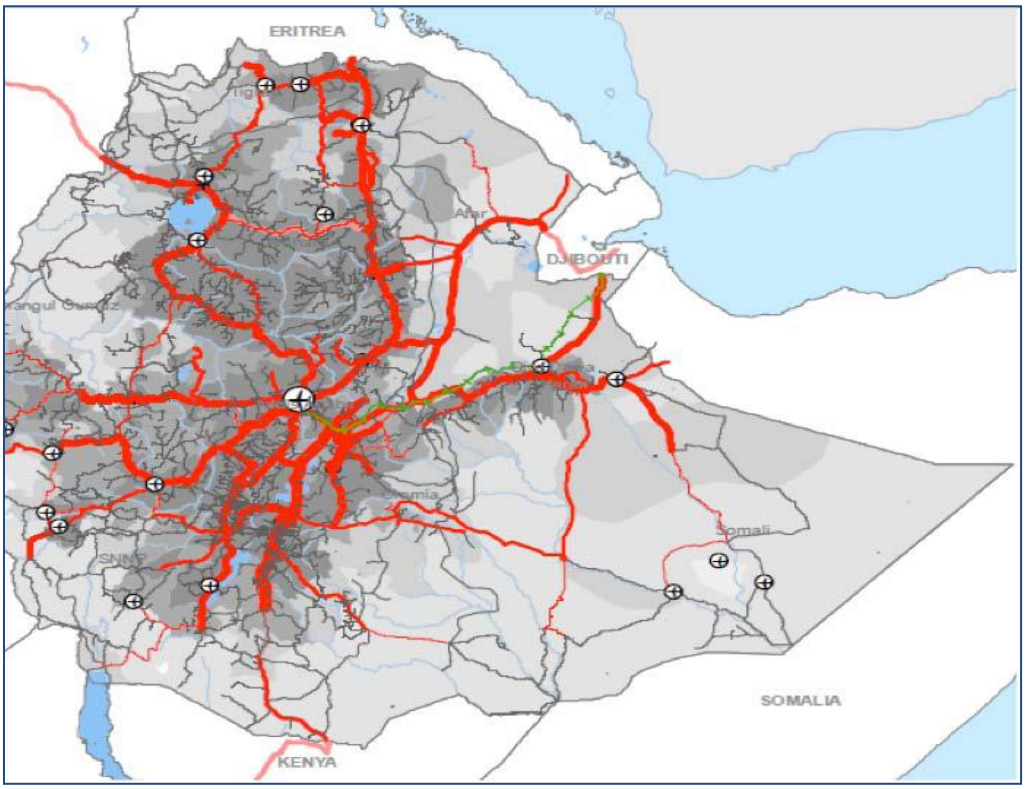
3.1. Road network

In 1951 the total stock of road network was only 6400 km of which 3400 km was asphalt and the remaining 3000 km was gravel road. This entire network was found only in urban areas. When the Imperial regime lost power, the network has reached to 9160 km in 1973. On average, the network has been growing at a rate of 2.05 percent per annum over the period 1951-1973. During the Derg regime, 1974-1991, the stock road increased to 19017 km with a growth rate of 6.2 percent per annum. With the current EPRDF regime, the road network has reached 46812 km in 2009 with an average annual growth rate of 9.35 percent. Over the period 1991 to 2009, 28731 km of new road network was constructed.

As shown in Figure 1, the red lines depict asphalt roads while the grey ones show the graveled roads. As it can clearly be seen from the figure, the development of road network is yet to go far. A large space in the country is networked with only a few roads. Though the development is good, more construction is important for connecting the remote areas. Especially, the rural part of Ethiopia is less networked with roads.

According to World Bank (2010), only 10 percent of the rural population lives within two kilometers of all weather roads. Thus, the remaining 90 percent of rural people live at a distance of more than two km from all weather roads. The underdevelopment of the road network has its implication for the development of the agricultural sector which is the mainstay of the rural people and the country in general. Visual inspection indicates that a lot has to be done to put a sufficient network in the country.

Figure 1: Ethiopian road network pictorial representation



Source: World Bank (2010)

Similarly, Table 1 shows the road network length in Ethiopia by type. Though there was an increase in the length of roads between 1974 and 1989, it was somewhat constant in the years 1989 to 1991. After, the takeover of EPDRF the government has invested much in construction of asphalt roads. Especially after 2001 there is a significant growth in asphalt road length. However, there is a negative growth in gravel road length. This happened in the recent years like 2003, 2005 and the last two years.

One possible cause for the negative growth in gravel roads would be the fact that community roads, which could be considered as part of gravel road, are being constructed with Productive Safety Net Projects (PSNP). This type of road is not counted or included as gravel road for the very reason that it fails to meet the standard set by the Ethiopian Roads Authority (ERA). In addition, either the federal or

regional road authorities do not administer this type of road. Another cause may be the fall in expenditure for maintenance and reconstruction, mainly over the period 2003 and 2005.

Table 1: Classification of road network (length in km)

Year	Asphalt	Growth Asphalt	Gravel	Growth Gravel	Rural	Urban	Total	Growth
1974	3360		5900			9260	9260	
1975	3280	-2.38	6080	3.05		9360	9360	1.08
1976	3200	-2.44	6200	1.97	120	9400	9520	1.709
1977	3126	-2.31	6290	1.45	652	9416	10068	5.756
1978	3051	-2.4	6801	8.12	790	9852	10642	5.701
1979	3115	2.1	7328	7.75	1091	10443	11534	8.382
1980	3285	5.46	7328	0	1595	10613	12208	5.844
1981	3515	7	7430	1.39	1830	10945	12775	4.644
1982	3769	7.23	8532	14.83	2630	12301	14931	16.877
1983	3916	3.9	8532	0	3053	12448	15501	3.818
1984	4000	2.15	8738	2.41	3420	12738	16158	4.238
1985	4042	1.05	8788	0.57	3808	12830	16638	2.971
1986	4050	0.2	8989	2.29	4198	13039	17237	3.6
1987	4062	0.3	8994	0.06	5158	13056	18214	5.668
1988	4109	1.16	9270	3.07	5232	13379	18611	2.18
1989	4109	0	9270	0	5232	13379	18611	0
1990	4109	0	9287	0.18	5550	13396	18946	1.8
1991	4109	0	9298	0.12	5610	13407	19017	0.375
1992	3542	-13.8	8966	-3.57	5573	12508	18081	-4.922
1993	3555	0.37	9011	0.5	5800	12566	18366	1.576
1994	3622	1.88	10100	12.09	7812	13722	21534	17.249
1995	3630	0.22	12000	18.81	8043	15630	23673	9.933
1996	3656	0.72	12133	1.11	9100	15789	24889	5.137
1997	3708	1.42	12162	0.24	10680	15870	26550	6.674
1998	3760	1.4	12240	0.64	11737	16000	27737	4.471
1999	3812	1.38	12250	0.08	12600	16062	28662	3.335
2000	3824	0.31	12250	0	15480	16074	31554	10.09
2001	3924	2.62	12467	1.77	16480	16391	32871	4.174
2002	4053	3.29	12564	0.78	16680	16617	33297	1.296
2003	4362	7.62	12340	-1.78	17154	16702	33856	1.679
2004	4635	6.26	13905	12.68	17956	18540	36496	7.798
2005	4972	7.27	13640	-1.91	18406	18612	37018	1.43
2006	5002	0.6	14311	4.92	20164	19313	39477	6.643
2007	5452	9	14628	2.22	22349	20080	42429	7.478
2008	6066	11.26	14363	-1.81	23930	20429	44359	4.549
2009	6938	14.38	14234	-0.9	25640	21172	46812	5.53

Source: ERA 2009, *the road network in Eritrea is deducted

3.2. Road density

The proper level of road network is assessed by road density, which is measured by road length per 1000 persons or by road length per 1000 km^2. In the three RSDP periods, there was a plan to increase the road density form 0.43 to 1.5 km per 1000 persons and from 21 to 116 km per 1000 km^2, starting 1997 through 2009.

At the end of the first phase the road density has increased achieving the target of the government. In 2002 the road density was exactly at the aimed level, which is 0.49 km per 1000 persons whereas the road length per 1000 km^2 is more than the target level by 30.27 km per 1000 km^2.

When the second phase of RSDP continued, the government has also targeted for higher levels, i.e. targeted road density of 0.5 km per 1000 persons and 30 km per 1000 square km. At the end of RSDP II, road density has reached 0.55 km per 1000 persons and 38.6 km per 1000 km^2 in the year 2007. The accomplishment of the second phase was thus a success.

Table 2: Road densities per 1000 persons and per 1000 km^2

Year	Road Density /1000 person	Road density /1000sq. km	Total Road Length
1997	0.46	24.14	26550
1998	0.46	25.22	27737
1999	0.47	26.06	28662
2000	0.5	28.69	31554
2001	0.5	29.88	32871
2002	0.49	30.27	33297
2003	0.49	30.78	33856
2004	0.51	33.18	36496
2005	0.51	33.6	37018
2006	0.53	35.89	39477
2007	0.55	38.6	42429
2008	0.56	40.3	44359
2009	0.57	42.6	46812

Source: ERA (2009)

However, the targeted figures were a bit high for the third phase, which could not be attained at the end of the period. This phase is the shortest period, which lasted only

for two years. At the expiration of RSDP III, road density of Ethiopia has reached 0.57 km per 1000 persons and 42.6 km per 1000 km^2, where 1.5 km per 1000 persons and 116 km per 1000 km^2 were the targeted ones. Although road density has increased, it has not improved that much as planned. At the year 2009, the road density is still much below the average road density of Africa, that is, 60 km per 1000 km^2 (ERA 2008b).

Table 3: Performance of road infrastructure of African regions

Average road length per capita, km/ 1000 persons			
Regions	**1960-1975**	**1976-1985**	**1986-1997**
Central	6.6	4.6	4.2
Eastern	3.3	2.8	2.2
Northern	3.8	2.9	2.4
Southern	7.1	6.3	5.6
Western	2.8	2.7	2.2

Source: Richaud, C. et al. (1999)

In spite of the successes achieved in improving the road density of Ethiopia, the current level is much below the different African regions in 1997 (Table 3). Ethiopia's road density is even less than the average road density of Eastern Africa. This indicates that even if there is much investment on construction and maintenance of roads, the need for further development in the sector remains.

In the calculation of road density, the total road network is used which is a sum of the good and bad condition ones. For a better indication of the network level, it is good to investigate also the condition of the roads. Table 4 shows that the total road in good condition has increased after the implementation of the RSDP programs, while total road in bad condition has decreased. At completion of the last RSDP program, the targeted proportion of good condition roads is not yet attained. In the year 2009, the total good condition road has reached 54% while the planned was 82%.

Table 4: Proportion of different condition of roads in RSDP program

Year	Good	Fair	Poor
1997	22	26	52
1998	23	26	51
1999	25	30	45
2000	28	32	41
2001	28	29	43
2002	30	30	40
2003	32	30	38
2004	37	28	35
2005	39	26	35
2006	47	22	31
2007	49	22	29
2008	53	20	27
2009	54	24	22

Source: ERA (2009)

International Road Federation Statistical Report (2006), as can be observed form Table 5, indicated that both lower and middle-income countries have a developed road network system as reflected by road density per square kilometer. The current average road density per square kilometer of lower middle-income countries is 0.30 km/km^2. Ethiopia's current road density is only 0.0468 km/km^2 of the total land area. If we consider 80% of the land area to be populated, the country by now has 0.058 km/km^2 of road density. Clearly, one can easily observe that the Ethiopian Road Network compares poorly even with other low income countries – including some Sub-Saharan Africa. This indicates that a lot has to be done in expanding the road network, which requires about four fold of the existing road network.

Table 5: Road densities of lower middle income countries

Lower Middle Income Countries	Road Density (Km/Sq. Km)	Lower Middle Income Countries	Road Density (Km/Sq. Km)
Algeria	0.05	Indonesia	0.19
Djibouti	0.12	Kiribati	0.92
Egypt	0.09	Micronesia	0.34
Iran	0.11	Philippines	0.67
Iraq	0.10	Samoa	0.82
Jordan	0.08	Thailand	0.11
Morocco	0.13	Tonga	0.91
Tunisia	0.12	Vanuatu	0.09
Bolivia	0.06	Albania	0.63
Brazil	0.20	Armenia	0.27
Colombia	0.10	Azerbaijan	0.68
Cuba	0.55	Belarus	0.45
Dominica Republic	0.26	Bulgaria	0.39
Ecuador	0.15	Georgia	0.29
El Salvador	0.48	Kazakhstan	0.03
Guatemala	0.13	Macedonia	0.34
Guyana	0.04	Moldova	0.39
Honduras	0.12	Serbia	0.16
Jamaica	1.94	Turkmenistan	0.05
Nicaragua	0.14	Ukraine	0.29
Paraguay	0.07	Angola	0.04
Peru	0.06	Cameron	0.11
Suriname	0.03	Cape Verde	0.25
China	0.20	Congo	0.05
Fiji	0.19	Lesotho	0.20
Namibia	0.05	Sri Lanka	1.48
Swaziland	0.21		
Average	0.30 Km/Sq. Km		

Source: International Road Federation Statistical Report (2006)

3.3. Road accessibility

Access refers to the opportunity to use or the right to or the ability to reach some destiny. Accessibility is measured as the percentage of population having access to all weather roads. The benefits of having access to a road network is measured in terms of reductions in monetary costs or time needed by beneficiaries to access output markets or key public social services like health and education.

The accepted theory, according to ERA's (2008b) study, is that accessibility has three elements: 1) the location of the individual; 2) the location of the supply, service, or facility to which the individual needs access; 3) the link to bring the two together. The study used three approaches, namely, the random model approach, the graph theory approach, and the squire grid approach to cover the country's network demand. This demand was estimated as such that all rural population could have access to all weather roads within a 5 km distance.

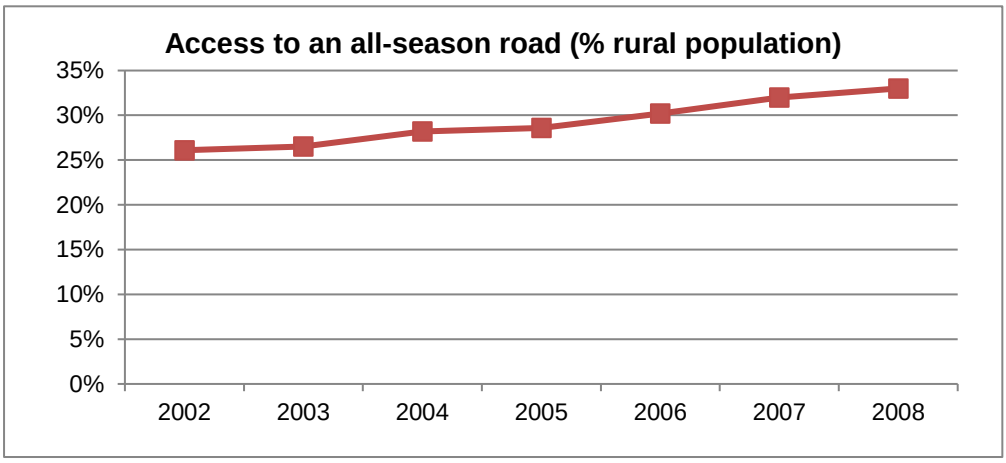
According to the ERA study the country is required to construct 200,000 km of optimum national road network, which is considered as a target road network on the assumption that it will give reasonably good accessibility. Whereas, for the country to be competitive enough and enter into middle income category, the targeted road density which secures the rural population to have access to all weather road is estimated to be 0.3 km/km^2, the average road density of the lower middle countries. In this case the road transport network has to reach 330,000 km.
The same study defined the concept measured in terms of average distance from the road network and proportion of area farther than 5 km from all weather roads as lack of access, which deprives people from the opportunities to improve their lives. Access is composed of two elements: mobility, reflecting the ease or difficulty in traveling to a service or facility; and proximity of those services and facilities. The study considered access to be one key element in providing the opportunity for both social and economic development, and a key determinant of both poverty itself and opportunities to escape from the poverty trap.

When we look at the recent trend regarding society's access to the all weather road network, we find a slight improvement over the past seven years. However, in 2008 only about 33% of the rural population had access to an all weather road within a distance of 5 km. Given the fact that around 80 million people are living in rural area, such a low rate exacerbates the problem of poverty. Improving the current access rate should be a major concern of the country's road sector expansion program.

Similarly, African Development Indicators (ADI) (2008/09) data indicates that the country has made an effort to provide access to all weather roads, though it is not satisfactory. The graph below depicts that the problem of accessibility is resolved only very sluggishly. Within a period of seven years (2002 to 2008), an additional seven

percent of the rural population is provided with access to all weather roads (from 26% to 33% of the rural population). ERA (2008b) study also indicates that with the recent construction of new roads, the average distance from a road has been reduced from 21km in 1997 to 11.7 km in 2009.

Figure 2. Trends over access to all-season road per percentage of rural population



Source: ADI (2009)

On the other hand, the proportion of area farther than 5 km from all weather roads, which was 79% in 1997, has been reduced to 65.3% in 2009. Therefore, the issue of accessibility calls for a kind of 'big-push' approach in expanding all weather roads for the destitute rural poor. The problem of accessibility could also be addressed through a well-designed planning process coinciding with the parallel trends towards the decentralization of decision making and the concern to involve the local communities in the decision making process. The effort made so far towards the improvement of main roads and rural roads is a necessary but not sufficient measure to enhance rural accessibility.

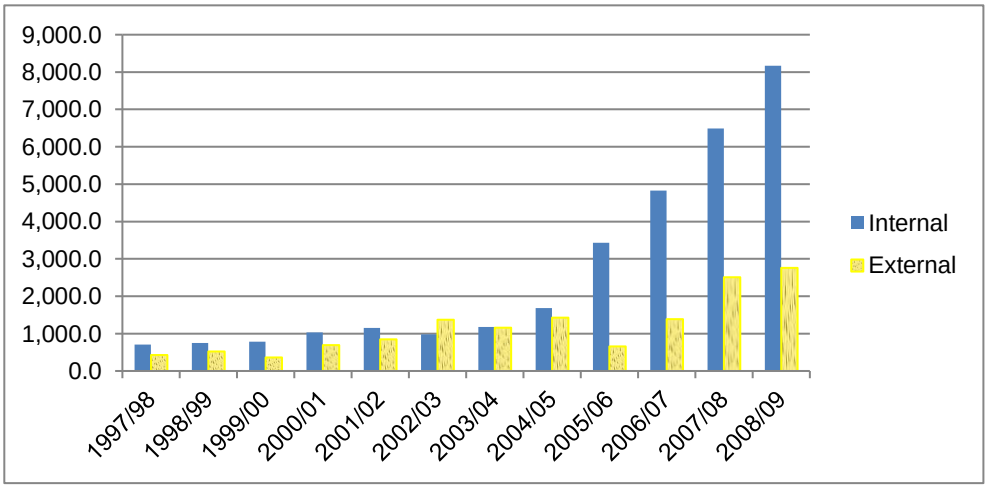
However, the future is not unwelcoming. It has been observed that a continuous support from the government and a serious commitment of the sector offices and other stakeholders would enable to achieve enhanced access of the rural population.

3.4. Road sector financing

Construction and maintenance of roads is not an easy investment. It requires a huge amount of expenditure with foreign currency. This huge amount of money is not affordable only by the government of Ethiopia from internal sources. Hence, the government of Ethiopia finances road construction and maintenance through loans and aid from other countries and organizations in addition to domestic finance. In recent periods, the lion share of finance is the government of Ethiopia followed by International Development Association. The other following financers are European Union and African Development Bank.

Looking at the trends in the road sector financing (Figure 3), the pattern shows that the internal financing in 2008/09 has increased to be more than ten times what it has been a decade before. The trend also indicates that the total amount of external financing is also growing but it has only multiplied by a factor five over the same comparable period. The domestic financial expenditure share in 1997 has been only twice that of the external source. Whereas, the recent expenditure is about four times that of the external source in the face of growing financial expenditure over the sector.

Figure 3: Share of internal and external financing in the road sector



Source: ERA, 2008b and author's compilation

Additionally, the government of Ethiopia's financial expenditure in the RSDP programs had also been consistently rising (see also Table 6).

All in all, the above discussion reveals that the government is making a relentless effort towards the development of the road network. In this regard, one key constraint is the availability of sufficient funding to achieve an adequate road network comparable with at least the African average of 60km per 1000 km^2 (ERA 2008b). The ERA (2008b) study also indicated that inadequate funding and resource mobilization are major problems in the road sector. Insufficient public resources lead to under-funding of road transport infrastructure needs (road network maintenance needs as well as road network expansion). The problem is found to be worse in expanding the network in rural areas. The available fund for rural roads development and maintenance is limited. The possible remedial measure would be to look for an alternate and sustainable finance.

Table 6: Source of finance by the pursued RSDP programs

Financier	Disbursement				% of
	RSDP I	RSDP II	RSDP III (2yrs)	(12 yrs)	contribution
IDA	1,432.9	3,135.3	1,848.8	6,416.9	14.2
EU	678.1	1,049.7	2,334.7	4,061.9	9.0
ADB	506.4	517.8	275.7	1,299.8	2.9
NDF	14.8	63.9	56.9	135.6	0.3
Japan	164.9	380	274.6	819.5	1.8
Germany	27.7	302.6	54.8	385.0	0.8
Sweden	0.0	5.0	0.0	5.0	0.0
Ireland Aid	2.6	20.9	0.0	24.1	0.1
UK	23.2	135.1	28.2	186.4	0.4
OFID	0.3	293.3	167.9	461.5	1.0
BADEA	0.0	59.9	133.9	193.7	0.4
SDF	0.0	39.3	92.9	132.2	0.3
GOE	3,455.5	8,669.5	11,139.1	23,264.	51.3
Road Fund	978.2	2,555.8	3,053.1	6,587.1	14.5
Community	0.0	884.8	469.6	1,354.4	3.0
TOTAL	7,284.6	18,112.	19,930.0	45,327.	100.0

Source: ERA (2009)

3.5. Few points on community roads

According to the ERA (2008b) study, community roads are being developed in different woredas. The roads are being constructed as part of the Productive Safety Net Project (PSNP). Table 7 depicts that 57,000 km of community roads were constructed in the period 2004-2008 under the "food for work" scheme. Within this food for work, substantial amounts of community roads are being maintained and constructed in all the regions.

Table 7: Existing stock of community roads (2007)

Region	Existing in 2006 (Km)	Constructed in 2007 (Km)	Total Community
Tigray	5,803	578	6,381
Afar	-	-	-
Amhara	11,980	4,000	15,980
Oromia	13,839	3,489	17,328
Somali	1,273	-	1,273
SNNP	10,754	2,027	12,781
Benishangul-Gumz	2,230	1,001	3,231
Gambella	464	-	464
Total	46,640	11,124	57,438

Source: ERA, 2008b

As per the same study, it shows that community roads are not well accounted and managed by either the federal or regional road administration. In this regard the study clearly cites the problem as follows:

However, it's worth noting that, for these community roads their design standard, location, condition, ownership and for that matter their existence is not known in the form of a national database. Further, the issue of how sustainable (in terms of both financially and administratively) these community roads are with respect to development and maintenance is unclear – as there is no institution that finances the maintenance costs of these rural/community roads and nobody is accountable to them institutionally both at the federal and regional levels. The mileage of community roads will continue to grow rapidly – and the needed maintenance costs for rural/community roads alone would become substantial. (ERA, 2008a)

Community road development and its sustained maintenance is a key point in ensuring the accessibility/mobility of the rural poor and to connect them to the improved federal and regional road network. Hence, an in-depth assessment of the

status of the community road development program and the future development and maintenance strategy is recognized as an urgent task.

4. Econometric modeling and the data

In order to analyze the economic impact of the road sector on the growth process of a country, studies adopted 'augmented Solow growth model'. Recently, there is a wide array of literature written towards identifying the relationship between economic growth and road sector development. However, the focus of previous studies has been to investigate the link between infrastructure, which is an aggregated measure, and economic growth.

Previous studies, for instance, Fan et al. (2002), Fan and Chan-Kang (2005), Canning and Bennathan (2000), Canning and Pedroni (2004) used the standard Cobb-Douglas type production function to analyze the impact of infrastructure on the overall GDP growth, which per se is assumed to be a measure of overall economic growth. Dercon et al. (2008) also used an analogous type of specification to see the impact of road and agricultural extension on growth and poverty reduction in a panel data set of selected fifteen Ethiopian villages. Fan and Chan-Kang (2005) indicated that there is strong link between road development, economic growth, and poverty reduction.
In specifying the production function, we need to take into account different specifications for paved and gravel roads on the overall productivity. For the reason cited above, augmented Solow trans-log production function is used to see the impact of road on GDP growth.

Few of the previous studies consider the issue of diminishing return, which could be captured by looking to the coefficient of the square of road network. If the coefficient happens to be negative, the negative sign indicates that road network, used in the regression, is abided by "neoclassical" paradigm. In case the coefficient happens to be positive, the sign indicates that road network is a self sustaining input, governed by an "endogenous growth" paradigm, which is mostly believed to be true for developed countries.

The possible existence of reverse causality, i.e. the fact that infrastructure accumulation could be driven by productivity growth, need to be accounted in analyzing the relationship between infrastructure variables and economic growth. In this regard, Canning (1999), Canning and Bennthan (2000), Canning and Pedroni (2004) and Calderon (2009 explicitly stated the need to account for the possible existence of reverse causality in estimating the growth function which is augmented with an infrastructure variable, like road network.

The study also looks at the impact of road network on sectoral GDP. For instance, Dorosh et al. (2009) analyzed the importance of road connectivity to agricultural productivity in Africa. The findings indicate that lower return from having high density is exhibited to be low for West Africa. Whereas, longer travel time decreases total crop production, and reducing travel time significantly increases adoption of high-input/high-yield technology in East Africa. The findings showed the importance of increased road connectivity in East Africa.

Following the aforementioned studies, this study utilizes similar specifications to see the impact of roads on the overall economic growth. The general specification of the model is an augmented Solow Growth model. Such a model is basically a log transformation of the Cobb-Douglas production function. The logarithmic form of this production function of Solow growth model allows including any relevant variable which affects the growth of GDP. It also allows us to include a dummy variable which captures the impact of any policy intervention in the analysis period. In addition, Fan and Chan-Kang (2005) indicated that different types of roads can create different economic return. Therefore, it is important for us to see the implication of road quality on the productivity.

4.1. Conceptual framework of the model

Having the theoretical inter-linkage on the relevance of road network to economic growth from the above discussion, the following section provides the conceptual framework used in modeling road network. To do so, the starting point is the simplest production function that has the following specification.

$$GDP = f(L, K) \qquad (1)$$

Where, *GDP* is the gross domestic product of the country, *L* is labor and *K* denotes capital. The above general Cobb-Douglas type functional specification will be augmented with road so as to identify its impact on economic growth. Accordingly, the above functional specification will be reformulated as

$$GDP = f(L, K, R) \quad (2)$$

Where, *R* is road length and the others are as stated above.

Here again, Fan and Chan-Kang (2005) criticize previous studies for not recognizing the fact that the return from different types of road on economic growth might be different. Thus, in this study the road variables will be classified into paved and gravel road in order to see the impact of the difference on the overall growth. The function, which takes care of the difference on road type, will be specified as;

$$GDP = f(L, K, R_T) \quad (3)$$

$$GDP = f(L, K, Rp, Rg) \quad (4)$$

Where *Rp* and *Rg* represent paved and gravel roads respectively.

We can also specify the production function for agricultural GDP, with the inclusion of gravel roads as an input. Such specification makes it interesting for the reason that the agricultural populations rarely have the opportunity to use paved roads for transportation purposes and thus the impact might be negligible for agricultural GDP growth. Therefore, we might anticipate at this stage to state the functional specification on agricultural productivity. The model could now be stated as;

$$AGDP = f(L, K, R_T) \quad (5)$$

$$AGDP = f(L, K, R_p, R_g) \quad (6)$$

Where *AGDP* denotes the agricultural GDP and R_g is gravel road length and R_p paved road length, and the rest are as already defined.

In addition to the *AGDP*, the impact of roads could be seen on non-agricultural sector GDP growth rates by disaggregating it into industrial GDP (*IGDP*) and service sector GDP (*SGDP*). For this purpose, similar type of production functions will be estimated with their respective variables. The regression is run on the total road network.

$$IGDP = f(L, K, R_T) \quad .(7)$$
$$IGDP = f(L, K, R_p, R_g) \quad .(8)$$

And the service sector GDP specification will be

$$SGDP = f(L, K, R_T) \quad .(9)$$
$$SGDP = f(L, K, R_p, R_g) \quad .(10)$$

In order to account for other factors, which are missing in the above functional specification, once again, the model is augmented with policy dummy to see the impact of any relevant policy intervention in the regression function. At this stage, the policy dummy is entered in the functional specification on the aggregate production function. Thus, the specification will be stated as follows:

$$GDP = f(K, H, R_p, R_g, D_{pi}) \quad .(11)$$

D_{pi} denotes dummy for policy interventions, which are introduced to account for any policy intervention over the analysis period.

4.2. Specification of the model

Once the variables within the model are clearly defined, the next step is to derive out the estimable production function. Accordingly, the aggregate Cobb-Douglas production function along with the road component, which could be estimable, can be reached through the following procedure,

$$GDP_t = \gamma_t H_t^{\alpha} K_t^{\beta} \left(R_{pt}.R_{gt}\right)^{\rho} \quad (12)$$

Where: H_t is human capital at time t
K_t is physical capital at time t

R_{pt} and R_{gt} is road network for paved and gravel roads, respectively at time t and whereby the variables are written in per worker terms, and α, β and ρ are parameters of interest.

The model is then transformed to the logarithmic form whereby the resulting equation is set as follows.

$$\ln GDP_t = \gamma + \alpha \ln h_t + \beta \ln k_t + \rho_1 \ln \gamma_{pt} + \rho_2 \ln \gamma_{gt} + \varepsilon_t \quad .(13)$$

Given the above specification, policy and other structural shift indicator dummies are introduced in the following specification.

$$\ln GDP_t = \gamma + \beta_1 \ln h_t + \beta_2 \ln k_t + \beta_3 \ln \gamma_{pt} + \beta_4 \ln \gamma_{gt} + \beta_5 D_p + \varepsilon_t \quad (14)$$

Where D_p is policy dummy reflecting the introduction of a new policy which is related to road provision.

Finally, once the estimable functional form specification is reached in the estimation procedure, GDP will further be disaggregated to identify the impact of road on agricultural, manufacturing and service sector productivity. In addition, the model will also be estimated for the agricultural GDP for a more disaggregated rural road network to see whether there exists a significant relationship among these variables. At the end, the marginal return per unit length of different types of road on each of the three sectors productivity will be computed.

4.3. The data

The objective of the study is to estimate the impact of road infrastructure on the overall economic growth. A time series data spanning over the period 1971-2009 is used for the analysis. The aggregate output function is setup with a set of explanatory variables constituting physical capital, human capital, and road network and policy intervention dummy variable. The detail on the source and type of each of the variables is presented below.

Real GDP per worker is obtained from ministry of finance and economic development (MOFED). The data set from the period 1991 to 2009 is not compatible with prior year's data. To deal with this problem, prior year growth rate of GDP is used to extrapolate and have consistent GDP values with their respective GDP growth rates.

Given the above functional specification, most of the variables could be obtained from different macroeconomic databases. What is not clearly explained in the above general specification is as to how the physical capital and human capital variables could be handled in the model. While the capital variables could be derived from Kohler's (1988) capital accumulation function, which is referred as perpetual inventory method. The procedure for deriving the capital stock is set as follows.

$$K_t = I_t + (1-\delta)k_{t-1} \qquad (15)$$

Where K_t is capital stock in period t which could be computed as the sum of I_t, which is gross capital formation in year t. δ is the rate of depreciation of capital. Fan and Chan-Kang (2005) took the rate of depreciation to be 10%. This study will also adopt similar assumption to arrive at the stock of capital.

Following Fan and Chan-Kang (2005) and similar other studies, the initial capital stock is computed using the following mathematical representations.

$$k_t = \frac{I_t}{(\delta + r)} \qquad .(16)$$

Where r is the real interest rate and δ is rate of depreciation of capital. Using the above formula, the initial stock of capital is computed for the year 1970. Previous studies tend to make assumption on the real interest rate and the depreciation rate. For instance, Kohler (1988) computed the initial capital stock to be 7.4 times gross capital formation of the beginning year, which is 1978, taking 8 percent depreciation rate of the stock of capital. In this study too, I assumed 8 percent depreciation rate. The computed initial capital stock is found to be 5.88 times the gross capital formation of the year 1970. Then after, the remaining capital stock data are computed using the above stated capital accumulation function.

As already explained above, the data on physical capital was constructed using the perpetual inventory method. To implement it, the initial level of the capital stock was estimated using data on the capital stock and real output from MOFED. The year 1970 is taken as the initial period for which gross capital formation is used. The physical capital is set up as net of gross capital formation for each period. Since the stock of road network is used as one variable, it is deducted from the gross capital formation to avoid double counting.

For human capital, secondary school enrolment rate is used as a proxy. Secondary school enrolment rate is obtained from Central Statistical Agency annual bulletin. The best proxy for human capital as indicated by Fan and Chan-Kang (2005) study is average years of schooling. However, Ethiopian data regarding years of schooling are not available. With regard to the human capital variable, Calderón (2009) choose secondary school enrolment to account for human capital in dealing with the impact of infrastructure and growth in Africa. Not only Calderon (2009), similar other studies, for instance Cohen and Soto (2001) also used secondary school enrolment as a proxy for human capital in the growth regression function. So, following the above studies, taking secondary school enrolment as a proxy for human capital in this study is justified.

Finally, the labor for converting all inputs in per worker terms is obtained from African Development Indicators (ADI) (2009) CD-Rom, which is part of World Bank's World Development Indicators. Electricity Power generation is also obtained from ADI CD-Rom.

Road network with a classification of paved urban road, gravel urban road, gravel rural road and road total network (in kilometers) for the entire period under consideration is obtained from Ethiopian Road Authority. In the econometric estimate all the variables are expressed in per worker units.
In addition, a number of ERA publications, ADI, IMF web data set, MOFED and CSA data are used for the descriptive analysis part.

4.4. Econometric analysis

4.4.1. *Test for unit roots*

The data set deployed for this study is a time series data. When dealing with time series data it is important to test the stationary or non-stationary nature of the data set for the reason that non-stationary variables might lead to spurious regression. In this regard Harris (1995) stated that:

> *…models containing non-stationary variables will often lead to a problem of spurious regression, whereby the results obtained suggest that there is statistically significant relationship between the variables in the regression model when in fact all that obtained is evidence of contemporaneous correlation rather than meaningful causal relation.*

Thus, the first step is to test the stationary nature of individual variables that will be included in the regression. To test the stationary nature of the variables, the Augmented Dickey-Fuller (ADF), the modified version of the Dickey-Fuller, test is used. According to the ADF test, null hypothesis is that the variable is assumed to have/contain a unit root. The time series nature of the data will be tested against the alternative, where a stationary process generates the variable. Other common unit-root tests that could alternatively be used to test stationarity include the DF-GLS test of Elliot, Rothenberg, and Stock (1996) and the Phillips-Perron (1988) test.

Pperron test in stata command performs the Phillips-Perron test that a variable has a unit root. The null hypothesis is that the variable contains a unit root, and the alternative is that the variable is generated by a stationary process. Pperron uses Newey-West standard errors to account for serial correlation, whereas the augmented Dickey-Fuller test implemented in dfuller uses additional lags of the first-difference variable. Stata automatically select the appropriate lag length when we use pperron. So, this study uses both the pperron and ADF tests to check the stationary nature of the variables.

In testing the unit root, most macroeconomic variables, in practice, are suspected of showing a time trend. To control for the trending nature of the variables, the graphic visual inspection test is also conducted. A summary table on test for stationarity of the variables is reported following the graphic trend test (Annex Figure A.1).

With the exception of agricultural GDP per worker, urban gravel road and urban road, the other variables exhibit trends. Therefore, unit root tests require a trend term in both the ADF and pperron tests.

Table 8. Summary table on Phillips-Perron test for unit root Newey-West lags stata routine lag length selection

	Statistic Z(t) at level [a]	Statistic Z(t) at level with trend [b] *	Statistic Z(t) at first difference [c]
lnrgdp_pw	-0.926	-0.731	-5.701
lnargdp_pw	-2.407	-2.167	-6.193
lnsrgdp_pw	1.209	-0.428	-5.729
lnirgdp_pw	-1.189	-1.696	-4.887
lncapnet_pw	1.747	-1.335	-4.260
lnhcap_pw	-1.813	-2.283	-4.313
lnelect_pw	0.389	-3.035	-7.596
lnroadtot_pw	-0.977	-2.693	-6.457
lnroadtotsq_pw	-0.425	-2.560	-5.461
lnaspurb_pw	-1.630	-1.194	-5.707
lngrvroad_pw	-1.599	-1.553	-5.903
lnrdcapnet_pw	1.429	-1.954	-4.016

Notes: [a] 1%, 5%, and 10% Critical Values at levels are -3.662, -2.964 and -2.614

b 1%, 5%, and 10% Critical Values at levels with trend are -4.260, -3.548 and -3.209

[c] 1%, 5%, and 10% Critical Values at difference are -3.668, -2.966 and -2.616

Lag length of three is chosen to be the optimal lag length

* Based on the graphics inspection, de-trending is made for variables showing a trend behavior

As the above table indicates, all of the variables are found to be non-stationary in levels whereas few of the variables are marginally stationary in the case of ADF test, only at 10% significant value. The ADF test at times might lead to acceptance of stationarity even though the variables are not stationary. For this reason, only the pperron test is chosen. Both tests indicate that all of the variables seem to be stationary at first difference. In other words, all of the variables are found to be integrated of order 1, and hence are called I (1) variables. Thus, to be safe the order of integration for all the variables is considered to be I (1)

Regarding the existence of trend component within a time series data set, Harris 1995 underlined that trend in a data set can lead to spurious correlation that may imply relationships between the variables in a regression equation, when all that is present are correlated time trends. The time trend in a trend stationary variable can either be removed by regressing the variable on time trend (with the regression forming a new variable which is trend-free and stationary) or nullified by including a deterministic time trend as one of the regressers in the model. Harris (1995)

4.4.2. Test for co-integration

Having tested our time-series for stationarity, the next step of time-series analysis is testing for co-integration, which amounts to checking whether the linear combination of the variables is also stationary or not. It requires that the variables of interest have the same order of integration. It is only when the variables are integrated of the same order that a linear relationship among them can be expected. Variables are said to be co-integrated if a long run equilibrium relationship exists among them.

Engle and Granger (1987) argue that for such relationships to exist, the error terms of the model should be stationary. We have applied the Engle-Granger procedure to test for co-integration. When variable *x* is said to Granger-cause variable *y* if, given the past values of *y*, past values of *x* are useful for predicting *y*. The first stage of the co-integration test involves estimating model/equation and saving the error terms. In time series analysis, estimating a relationship between non-stationary variables that are not co-integrated gives rise to the problem of spurious regression; the error term in the regression is non-stationary, producing a high degree of "noise" in the relationship, and inconsistent parameter estimates. In order to test the stationary nature of the data set both the ADF and pperron tests are applied on the error terms. If the error terms are found to be stationary, the variables are said to be co-integrated and this necessitates the estimation of an Error Correction Model (ECM) involving long run relationships. If, on the other hand, the variables are not co-integrated, then the regression leads to spurious results. A number of approaches are forwarded to deal with such kind of problem. Modeling should proceed with the differenced time-series. Annex Table A.1 reports the test statistics from the unit root tests. As can be seen

from the table, the first and second stage estimation results of the ECM show that ECM could be applicable to estimate the model.

The Engle-Granger two step estimates indicate that the variables are co-integrating at 10% significant level. The Durbin-Watson test statistic also shows the existence of serial correlation in both models. Therefore, it is possible for us to estimate the model using ECM. However the problem with OLS is that it fails to account for the problem of endogeneity within the model, which is created, in particular, due to the existence of physical capital as one potential explanatory variable in the model that is significantly correlated with GDP. In addition, it is also difficult to deal with a model of variable with a suspect of heteroskedasticity of the error terms.

4.4.3. Method of estimation and pre-estimation requirements

When the above problems are persistent in a time series data set, the best way to deal with is to opt for generalized method of estimation (GMM) technique for a number of significant advantages. The recently devised two-step GMM estimator would be an ideal tool to deal with multiple time series data with endogenous variable and as well is suspected of having heteroskedasticity. According to Baum et al. (2007), unlike instrumental variables or two-stage least square estimators, GMM estimator does not require additional assumption on the error terms. The former estimators are specific cases of GMM estimation, which require homoskedastic assumption and independent error terms. Without stating those assumptions one can estimate a model efficiently and consistently using two-step GMM estimation technique. In addition, Baum et al. (2007) state that the two-step GMM estimator could also be applied when the errors are serially correlated, which is a typical nature of time series data set that we are now dealing with. (See also Bond, Hoeffel, and Temple 2001).

In general, the model that is used to estimate the time series data will have the following econometric specification.

$$y_t = \beta_i x_t + \varepsilon_t \qquad .(17)$$

β_i s' are the coefficients that are going to be estimated.

Since some of the regressors are endogenous, $E(x_t \ \varepsilon_t) \neq 0$.

To estimate this model, it requires instruments for endogenous variables in such a way that the instrumented variable need not be correlated with the error term so that

$$E(Z_{t,} \ \varepsilon_t) = 0.$$

Lanne and Saikkonen, (2009) highlight the problem in using the first-differenced GMM panel data estimator to estimate cross-country growth regressions, which essentially is similar to time series data set. When the time series are persistent, the first-differenced GMM estimator can poorly behave, since lagged levels of the series provide only weak instruments for subsequent first-differences. According to the work of Caselli, Esquivel and Lefort (1996) this problem may be much more serious in practice. The authors suggest using a more efficient GMM estimator that exploits stationarity restrictions, and this approach is shown to give more reasonable results than first-differenced GMM in our estimation of an empirical growth model. Accordingly, this study utilized two-step efficient GMM estimator to handle this problem.

To do so, the model is estimated using two-step GMM estimator with the robust option for the reason that such an estimate is liable for inefficient estimate of downward biased standard errors. So, the robust two-step estimation procedure is chosen to estimate the above specified model with an automatic bandwidth selection with robust standard error.

Another key issue when estimating a model using two-step GMM is that capital is assumed to be endogenous. In addition, human capital is suspected to be potentially endogenous. To account for these restrictions, Baum et al. (2007) estimation technique allows us to instrument the model for the problem of endogeniety and setup ortogonality condition on the suspect of instrument. Thus these facts are well taken care of in the estimation procedure with an ivreg2, gmm2s orthog bw( ) stata installed command.

After conducting Granger causality test, for instance, Rouvinen (2002) also used lagged levels from the second one onwards as instruments. In this study, to avoid

over-fitting the model, the second and third lags and lagged differences are used as potential instruments.

Care has to be made over the selection of ideal instrument, when estimating time series model with endogenous variable. After estimating the model, one has to cautiously look at test of exogeniety of the instruments before interpreting the result.

4.4.4. Discussion on post-estimation requirements and discussion on the results

Having paid enough attention for all the pre-estimation factors regarding two-step efficient GMM estimation, the resulting summary table on eight models is presented below (Table 9). These models are regressions of the growth function, with dependent variables labeled as total real GDP worker, on agriculture, service and industrial GDP.

lnrgdp_pw = f (lncapnet_pw, lnhcap_pw, lnelect_pw, lnroadtot_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnrgdp_pw = f (lncapnet_pw, lnhcap_pw, lnelect_pw, lnaspurb_pw, lngrvroad_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnargdp_pw = f (lncapnet_pw, lnhcap_pw, lnroadtot_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnargdp_pw = f (lncapnet_pw, lnhcap_pw, lnaspurb_pw, lngrvroad_pw, lnelect_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnirgdp_pw = f (lncapnet_pw, lnhcap_pw, lnroadtot_pw, lnelect_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnsrgdp_pw = f (lncapnet_pw, lnhcap_pw, lnelect_p, lnroadtot_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

lnsrgdp_pw = f (lncapnet_pw, lnhcap_pw, lnaspurb_pw, lnelect_pw, lngrvroad_pw, lnroadtotsq_pw, prersdp, rsdp1, rsdp2, rsdp3, year)

Where *lnrgdp_pw, lnargdp_pw, lnirgdp_pw and lnsrgdp_pw* are logarithm of real GDP of total, agricultural, industrial, and service GDP in per worker units respectively.

lncapnet_pw is capital stock net of road in per worker units

lnhacap_pw is logarithm of human capital in per worker units

lneclect_pw denotes logarithm of electricity power generation in per worker units

lnroadtot_pw is the logarithm of total road network in per worker

lnaspurban_pw is the logarithm of asphalt urban road network in per worker

lngrvroad_pw is the logarithm of gravel road network in per worker

prersdp is policy dummy for the period 1991-1997 to account for change of regime

rsdp1 is policy dummy for the period 1997-2001 to account for the first RSDP program
rsdp2 is policy dummy for the period 2002-2006
rsdp3 policy dummy for the period 2006-2009
year time dummy included to account for trending nature of the fundamental components of the model

For all the above alternative models estimation is undertaken. But, before interpreting the finding of the regression result, the following post-estimation issues are considered. Otherwise the parameters would not be considered as efficient and consistent to make a valid statistical inference.

Stata estimate for two-step GMM estimation is produced with a number of statistical outputs that are indicators of the efficiency of the estimators. For the parameters to be interpreted, the first task is to check the consistency of these statistical results with the expected hypothesis that need to be satisfied (Baum et al. 2010). According to Hayashi (2000), two-step efficient GMM estimator needs to pass test of exogeneity of instruments, weak identification and overidentifying restrictions. These three statistics are of our interest that the estimated models need to satisfy.

First, we need to test that the instruments are exogenous with respect to the instrumented variable. Theoretically, this condition is satisfied when lagged differences and lag levels are taken as instruments with GMM estimates. In this regard, Lanne and Saikkonen (2009), for instance, argue that when there is causality, as causality is already tested using Engle-Granger two-step procedure, within a time series framework it would be appropriate for one to use lagged variables and lagged differences as best instruments in GMM estimation. Following this proposition, capital is instrument by its second and third lagged level and lagged difference. In this regard, Hayashi (2000) sets the requirement over the null statistics. The C statistic (also known as a "GMM distance" or "difference-in-Sargan" statistic) allows us to test exogeneity of one or more instruments. Under the null hypothesis that both the smaller set of instruments and the additional, suspect instruments are valid, the C statistic is distributed as chi-squared in the number of instruments tested. Note that failure to reject the null hypothesis requires that the full set of orthogonality conditions be valid. Test of exogeneity is reported along with the summary table for all the models under consideration. The models pass the test of exogeneity.

Second, the instruments should be relatively highly correlated with the instrumented variable, so that they act as an effective predictor. Weak identification tests are a category of tests to check for this condition, and the specific version the stata routine reports Kleibergen-Paap rk Wald F statistics. When the independently and identically distributed (i.i.d.) assumption is dropped and ivreg2 reports heteroskedastic, AC, HAC or cluster-robust statistics, the Anderson LM and Cragg-Donald Wald statistics are no longer valid. In these cases, the LM and Wald versions of the Kleibergen-Paap (2006) rk statistic, stata output reports also distributed as chi-squared with (L1-K1+1) degrees of freedom. The rk statistic can be seen as a generalization of these tests to the case of non-i.i.d. errors. To pass the test, a value of ten or greater is typically required. As shown in the regression summary table (Table 9), for each model these instruments pass the test.

Third, the instruments should not influence the dependent variable except via the instrumented variable. Overidentification tests are a category of tests used to test for this condition, and the specific version which is presented with the Stata routine output is called the Hansen J statistic. According to Hayashi (2000), under the assumption of conditional homoskedasticity, Hansen's J statistic is consistent in the presence of heteroskedasticity and (for HAC-consistent estimation) autocorrelation, where a p-value result that is greater than 0.1 is typically considered passing. As shown in Table 9, the three instruments pass this test. For all the models under consideration, the Hansen J statistics is greater than 0.4.

Stata output also automatically reports tests of both underidentification and weak identification. The underidentification test is an LM test of whether the equation is identified, i.e., the excluded instruments are "relevant", meaning correlated with the endogenous regressors. Under the null that the equation is underidentified, the statistic is distributed as chi-squared with degrees of freedom (L1-K1+1). A rejection of the null indicates that the model is identified. For the models under consideration, the models pass the underidentification tests (Baum 2006).

In sum, while estimating the models, the estimator is forced to compute estimators that are heteroskedasticity and autocorrelation consistent (HAC) standard errors. To do so, while estimating the models automatic bandwidth selection and robust option

are imposed to produce an estimate which accounts for the existence of heteroskedasticity and autocorrelation in time series data set (HAC). With the HAC standard errors, various summary statistics are “robustified” as well, in the sense that the post estimation criteria are satisfied.

Once all the post estimation issues are well handled, it would be safe for us to report the estimated results. Accordingly, the following section discusses on the findings of these results.

Table 9: Summary on two-step GMM estimation results of the impact of road network on overall and sectoral GDP

Variables|	model1	model2	model3	model4	model5	model6	model7	model8
Dependant|	RGDP	RGDP	ARGDP	ARGDP	SRGDP	SRGDP	IRGDP	IRGDP
Explanatory								
Phy_capital |	.356***	.184*	-.0304	-.117*	.423***	.43***	.428***	.436***
Hum_capital |	.0539***	.0455**	.038	.0572*	-.0585*	-.0644***	.0661***	.0632***
Electricity |	.345***	.165	.352	.294	.286*	-.00567	.251*	-.0209
Road |	.575*		1.31***		1.18***		.568**	
Road² |	-.401**	-.186	-.759***		-.537***	-.126	-.453***	-.122
Pre_RSDP |	-.0921***	.0222	.0209	.129*	-.378***	-.22***	-.211***	-.0764
RSDP 1 |	-.0253	.131*	.162***	.256***	-.341***	-.18**	-.152***	-.0284
RSDP 2 |	.0316	.117	.162*	.15	-.253***	-.121	-.0788	.0264
RSDP 3 |	.194***	.222*	.444***	.27***	-.172*	-.112	.0808	.126
Year |	-.0182*							
Asphalt |		.582***		.585***		.62***		.426**
Gravel |	-.0699			-.374***		.214		-.102
Road*Ph_capit |								
Constant |	45.3***	10.9***	17.3***	9.1***	11.7***	10.2***	8.05***	7**
r2_a |	.808	.786	.623	.609	.856	.873	.928	.933
rmse |	.0416	.0438	.0598	.0609	.0583	.0535	.0481	.0454
N |	35	35	35	35	35	35	35	35
K |	20.406	87.309	106.206	42.852	106.206	131.911	106.206	99.961
K P|	.5148	0.5166	0.4921	0.3173	0.5201	0.4201	0.6580	0.5863
J |	0.5368	0.4467	0.3280	0.1302	0.2671	0.2073	0.4782	0.4475
C |	0.8396	0.8894	0.4969	0.9401	0.7833	.7036	0.5633	0.4835
F |	2685	978	157	115	2520	696	2378	1828

Notes: * p<0.05; ** p<0.01; *** p<0.001, all the explanatory variables are in log and per-worker units

As can be seen from Table 9, eight models are estimated. The general model, the first model labeled as model1, is on the impact of roads on aggregate real GDP per worker. The result indicates that road network per worker is positively related with economic growth.

In the second model, the study examined the impact of different types of road (classified as asphalt and gravel road) on economic growth, captured by logarithm of overall and sectoral real GDP growth. The findings indicate that expansion of asphalt road has positive influence on overall economic growth. The coefficient for asphalt road is also statistically significant. Similarly, though it is statistically insignificant, gravel road has positive impact on growth.

Model3 up to model8 are estimated with the aim of investigating the impact of road network on sectoral output, i.e. agricultural GDP, industrial GDP and service GDP. All of them are expressed in per worker terms. In order to see the impact of road quality on total and sectoral GDP, each sector GDP is estimated on asphalt and gravel road. Accordingly, model3 and model4 are estimation results on the impact of total and disaggregated road on agricultural GDP. In both cases, road network has positive influence on the growth of agricultural GDP. The impact of total road is statistically highly significant. Nonetheless, the impact of the disaggregated road, asphalt and gravel, fails to be as such significant. The possible explanations would be that the road sector is not highly integrated with the agricultural sector in terms of accessibility to the rural dweller. The other possible explanation would be that disaggregated roads fail to reach the threshold level, which is required spurring agricultural GDP growth. Moreover, another plausible explanation ascribed for such unexpected finding might be the fact that the rural area is not as such networked with asphalt and gravel road and access to these networks is somehow thin which essentially proves lesser impact on agricultural GDP growth. Rather, in this area community roads play a more significant role than these two types of road networks. As already explained in the descriptive analysis section, community road is not well accounted by the road authority for it to be in incorporated within the regression equation.

Model5 and model6 are on the impact of road on industrial GDP. In here, again both total road network and classified roads are found to have positive impact on this sector GDP growth. Here again, the asphalt road has significant and positive impact

on industrial GDP. Intuitively, this is true for the reason that the asphalt road is networked where industries are operating, i.e. city areas. This shows that road network is concentrated around cities. In contrast, gravel network in urban areas are not prevalent. Thus, their impact on this sector GDP is negligible.

When we look at model7 and model8, we find that the impact of road on service sector GDP is positive for the total and asphalt road network. The result is concurrent with the intuitive perception that road quality is essential for the well performing service sector.

In sum, the findings of all the previous models are consistent with the intuitive and theoretical explanation. Having this fact in mind, road network is found to have much more pronounced impact on sectoral GDP than on total GDP. For the road sector to have significant output on each sector, sector specific objectives regarding road network expansion is relevant. That is, for the impact of road on agricultural GDP to be significant, the road network fails to reach the threshold level for it to have significant impact on this sector. In addition, gravel road expansion is not as such important for increasing service sector GDP.

In the estimation process, I tried to include other interaction terms, but it resulted in multicollinearity. When it happened with two-step efficient GMM estimator, the stat routine command automatically drops those variables. So it is not possible to see the impact of interaction terms.

Regarding the other inputs used in the models, in all cases the coefficients are found to be with the theoretical expectation that both human and physical capital have positive impact on economic growth.

Finally, when we come back to the impact of policy interventions introduced over the period under study, for all of the models RSDP III, which has been introduced over the period 2006-2009, has more significant growth spurring impact than the other two. Here it requires careful interpretation in that, RSDP II also has positive and significant impact for most of the models. We need to note that policy intervention on infrastructure would have a pronounced impact in later years than the moment the policy is introduced. That is, we need to be cognizant of the fact that such kind of

policies, policy on infrastructure, will have impact lag. It would take time for it to spur growth than having a direct and shorter impact. Such investments will have a very strong impact over a long time horizon. In all the models the policy dummy for the period 1991-1997 has a negative influence for the country and fails to have any growth spurring impact. That period was more a period of political stabilization than growth. The result is also consistent with this fact.

5. Conclusions

This study investigated achievements in the road sector in Ethiopia and its impact on both the overall and sectoral economic growth. To do so, the study econometrically analyzed the impact of roads on economic growth by using a time series data set. To this end, the study reviewed theoretical and empirical researches related to the road development over a wide array of perspectives. It also reviewed relevant literature on the link between road transport and economic growth and certain aspects of road transport in the context of Ethiopia and some other countries experiences.

Ethiopia has a respectable growth performance in the post-1991 period. In particular, over the period 2004-2009, the economy averaged 10 percent growth rate of GDP, which signals the country's future economic prospects and lays down promising momentum for further economic growth. Keeping up the growth momentum and ascertaining its sustainability is a key to boost domestic investment and also attract foreign investment. In this regard, to sustain the growth performance of the economy, through creation of a favorable macroeconomic environment, developing vital infrastructure, ensuring the quality of institutions as well as improving the quality of human capital, road network development is supposed to play a major catalytic role.

The findings from the descriptive analysis indicate that the government in the recent decade is making a relentless effort towards expanding the road network of the country. However, an important key indicator is the issue of accessibility. The country's overall accessibility is far below from what is needed to graduate to the club of lower middle income countries. Accessibility is a good indicator to investigate the impact of poverty on socioeconomic development. This indicator is linked with rural population. The issue of access is not a challenge for the urban population. Therefore,

in order to reduce rural poverty or provision of public utilities, expanding the road network in rural areas would be the best way to reach the rural population.
The recent trend shows that the government is showing strong commitment to expand and improve the current performance. The analysis also shows that the government in this decade has made sufficient attention in financing road projects. By now the government's expenditure has reached tenfold of what it has been a decade before. The analysis also reveals that the donor's share of money spent on the road network is not increasing as such in the face of the rising road expenditure by the government and the expansion of the road network.

Community roads should be given sufficient attention both in terms of expansion, management, and accountancy by either regional or federal road authorities. At this point, Ethiopian Road Authority should design an easy way to get detailed information regarding community road networks from regional road authorities. Future community road expansion need to be an integral part of the road networks as these might be an easy way to ascertain access to the destitute rural poor. Community roads are supposed to better reflect the community demand of which roads should be constructed or upgraded.

When we come to findings of the econometric results according the link between road length and economic growth, the results indicate that road network per worker is positively related with economic growth and that expansion of asphalt road has a positive influence on overall economic growth. Similarly, though statistically insignificant, gravel road has a positive impact on economic growth.

Finally, at the heart of the above analysis one key question is, are the efforts made so far sufficient to spur the overall economic growth of the nation and thereby to have an impact on the livelihood of the rural poor? The impact is seen to be less strong on the agricultural GDP growth and addressing the issue of accessibility to the rural poor. The effort is relatively better and has pronounced impact on industrial and service sector GDP. Nevertheless, for it to have a far-reaching impact on agricultural growth and poverty reduction, a lot more has to be done.

References

African Development Indicators (ADI). 2009. CD-ROM.

Baum, C. F. 2006. *An Introduction to Modern Econometrics Using Stata.* College Station, TX: Stata Press.

Baum, C. F., M. E. Schaffer, and S. Stillman. 2007. *Enhanced Routines for Instrumental Variables/GMM Estimation and Testing.* Boston College Economics Working Paper 667.

Baum, C. F., M. E. Schaffer, and S. Stillman. 2010. *IVREG29: Stata module for extended instrumental variables/2SLS and GMM estimation (v9).* Boston College Department of Economics, Statistical Software Components S4254010.

Bond, S., A. Hoeffler, and J. Temple. 2001. *GMM Estimation of Empirical Growth Models.* CEPR discussion paper 3048.

Calderón, C. 2009. *Infrastructure and Growth in Africa.* Policy Research Working Paper 4914. African Sustainable Development Front Office, World Bank.

Caselli, F., G. Esquivel, and F. Lefort. 1996. Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth* 1 (3): 363-389.

Canning, D. 1999. *Infrastructure's Contribution to Aggregate Output.* Development Research Group Public Economics, Policy Research Working Paper 2246. Washington, D.C.: World Bank.

Canning D. and Bennthan. 2000. *The Social Rate of Return on Infrastructure Investments*. Development Research Group, Public Economics and Private Sector Development and Infrastructure Group. World Bank.

Canning, D., and P. Pedroni. 2004. *The Effect of Infrastructure on Long Run Economic Growth.* Harvard University, Williams College.

Central Statistical Authority (CSA). 2008. Summary and Statistical Report of the 2007 Population and Housing Census, Population Size by Age and Sex. Addis Ababa: CSA.

_____. 1970-2010. *Annual Report, Statistical Abstract.* Addis Ababa: CSA.

_____. *National Abstracts.* www.csa.gov.et.

Cohen, D., and M. Soto. 2001. *Growth and Human Capital: Good Data, Good Results*. OECD Development Centre Technical Papers 179. Paris: OECD.

Dercon, S., D. O. Gilligan, J. Hoddinott, and T. Woldehanna. 2008. The Impact of Agricultural Extension and Roads on Poverty and Consumption Growth in Fifteen

Ethiopian Villages, Food Consumption and Nutrition Division, IFPRI *Discussion Paper* 00840. Washington, D.C.: International Food Policy Research Institute.

Dorosh, P., H.-G. Wang, L. You, and E. Schmidt. 2009. *Crop Production and Road Connectivity in Sub-Saharan Africa: A Spatial Analysis.* Africa Infrastructure Country Diagnostic (AICD). Washington, D.C.: World Bank.

Engel, R., and C. Granger. 1987. Cointegration and Error Correction: Representation, estimation and testing. *Econometrica* 55: 251-276.

Elliott, G., T. J. Rothenberg, and J. H. Stock. 1996. Efficient Tests for an Autoregressive Unit Root. *Econometrica* 64: 813-836.

Ethiopian Roads Authority (ERA). 2008a. *Rural Transport Infrastructure.* Addis Ababa.

_____. 2008b. *Enhancing Rural Accessibility. Concept Paper.* Addis Ababa: Federal Democratic Republic of Ethiopia, Ministry of Works and Urban Development.

Ethiopian Roads Authority (ERA). 2009. *RSDP Performance: Twelve Years Later.* Addis Ababa.

Fan, S., and C. Chan-Kang. 2005. Road Development, Economic Growth, and Poverty Reduction in Chain. *Research Report* 138. Washington, D.C.: International Food Policy Research Institute.

Fan, S., and N. Rao. 2003. Public Spending in Developing Countries: Trend, Determination and impact. *EPTD Discussion Paper 99*. Washington, D.C.: International Food Policy Research Institute.

Fan, S., L. Zhang, and X. Zhang. 2002. Growth, Inequality and Poverty in Rural China, The Role of Public Investment. *Research Report 125*. Washington, D.C.: International Food Policy Research Institute.

Hayashi, F. 2000. *Econometrics.* Princeton: Princeton University Press.

Harris, R. I. D. 1995. *Using Cointegration Analysis in Econometric Modelling*. FT Prentice Hall Publication.

International Monetary Fund. http://www.imf.org/external/data.htm

International Road Federation Statistical Report. 2006. *World Road Statistics.* www.irfnet.org.

Kleibergen, F., and R. Paap. 2006. Generalized Reduced Rank Tests Using the Singular Value Decomposition. *Journal of Econometrics* 127(1): 97–126.

Kohler, F. D. 1988. The Effect of Defense and Security on Capital Formation in Africa: An Empirical Investigation. Rand Publication, N-2635-USDP, Santa Monica.

Lanne, P., and M. Saikkonen. 2009. Noncausal Autoregression, Instrumental Variables, Test of Overidentifying Restrictions. *Journal of Economic Literature*.

Ministry of Finance and Economic Development (MoFED). 2006. Ethiopia: Building on Progress, A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10). Volume I. Addis Ababa.

_____. Macroeconomic Unit, data base.

Phillips, P. C. B., and P. Perron. 1988. Testing for a Unit Root in Time Series Regression. *Biometrika* 75: 335-346.

Richaud, C., K. Sekkat, and A. Varoudakis. 1999. Infrastructure and Growth Spillovers: A Case for Regional Infrastructural Policy in Africa. OECD mimeo

Rouvinen, P. 2002. R&D–Productivity Dynamics: Causality, Lags, and Dry Holes. *Journal of Applied Economics* V (1): 123-156.

World Bank. 2010. *Ethiopia's Infrastructure: A Continental Perspective*. Africa Infrastructure Country Diagnostic Country Report, The International Bank for Reconstruction and Development. Washington, D.C. World Bank.

Annex Table A.1. Error Correction Model

reg lnsrgdp_pw lncapnet_pw lnelect_pw lnhcap_pw lnroadtot_pw rsdp2 rsdp3 year

Source|	SS	df	MS	Number of obs = 39		
Model |	1.63507733	7	.233582476	F(7, 31) = 73.76		
Residual|	.098164414	31	.003166594	Prob > F = 0.0000		
Total|	1.73324175	38	.045611625	R-squared = 0.9434		
				Adj R-squared = 0.9306		
				Root MSE = .05627		
lnsrgdp_pw	Coef.	Std. Err	t	P>|t|	[95% Conf.	Interval]
lncapnet_pw	.7795128	.1345526	5.79	0.000	.505091	1.053935
lnelect_pw |	-.0150187	.1194418	-0.13	0.901	-.2586219	.2285846
lnhcap_pw |	.1508255	.0337444	4.47	0.000	.0820033	.2196477
lnroadtot_pw |	.0550367	.1519828	0.36	0.720	-.2549343	.3650076
rsdp2 |	.1385427	.0381224	3.63	0.001	.0607916	.2162937
rsdp3 |	.2481983	.0666627	3.72	0.001	.1122389	.3841577
year |	-.0448544	.0079673	-5.63	0.000	-.0611038	-.0286051
_cons |	91.0019	14.73099	6.18	0.000	60.95784	121.046

```
. predict resid
. estat dwatson
Durbin-Watson d-statistic(  8,    39) =   1.22548
. pperron resid, noconstant regress

Phillips-Perron test for unit root          Number of obs    =      38
                                            Newey-West lags =        3

                    ---------- Interpolated Dickey-Fuller ------------
             Test       1% Critical      5% Critical      10% Critical
           Statistic       Value            Value            Value
-------------------------------------------------------------------------------
 Z(rho)      0.148        -12.420          -7.508           -5.404
 Z(t)        1.966         -2.639          -1.950           -1.605
-------------------------------------------------------------------------------
      resid |     Coef.     Std. Err.     t      P>|t|     [95% Conf.   Interval]
-------------+-----------------------------------------------------------------
      resid |
       L1. |   1.003896   .00181   554.63   0.000    1.000229    1.007564
-------------------------------------------------------------------------------

. estat dwatson
Durbin-Watson d-statistic(  1,    38) =  1.682735
```

Annex Table A.2: Stata output on the Engle-granger two-step procedure test of co-integration

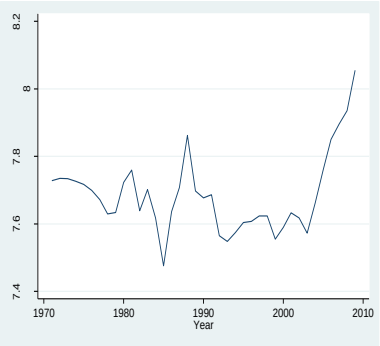
. reg lnsrgdp_pw lncapnet_pw lnelect_pw lnhcap_pw lnroadtot_pw rsdp2 rsdp3 year

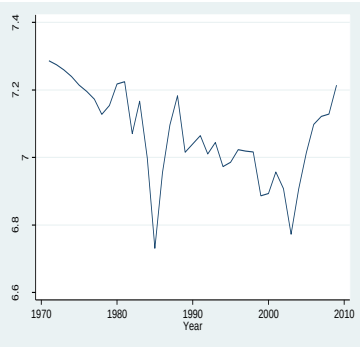
```
  Source |       SS       df       MS              Number of obs =    39
-------------+------------------------------           F(  7,    31)  =   73.76
   Model |  1.63507733     7  .233582476           Prob > F      =  0.0000
  Residual |  .098164414    31  .003166594           R-squared     =  0.9434
                                                   Adj R-squared =  0.9306
   Total |   1.73324175    38  .045611625           Root MSE      =  .05627
```

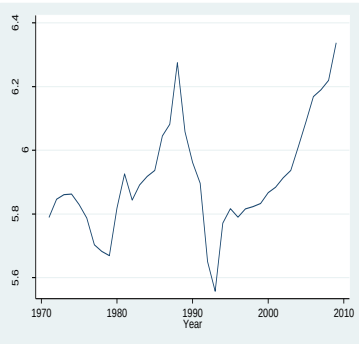
lnsrgdp_pw |	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lncapnet_pw|	.7795128	.1345526	5.79	0.000	.505091	1.053935
lnelect_pw |	.0150187	.1194418	0.13	0.901	.2586219	.2285846
lnhcap_pw |	.1508255	.0337444	4.47	0.000	.0820033	.2196477
lnroadtot_pw |	.0550367	.1519828	0.36	0.720	.2549343	.3650076
rsdp2 |	.1385427	.0381224	3.63	0.001	.0607916	.2162937
rsdp3 |	.2481983	.0666627	3.72	0.001	.1122389	.3841577
year |	.0448544	.0079673	5.63	0.000	.0611038	.0286051
_cons |	91.0019	14.73099	6.18	0.000	60.95784	121.046

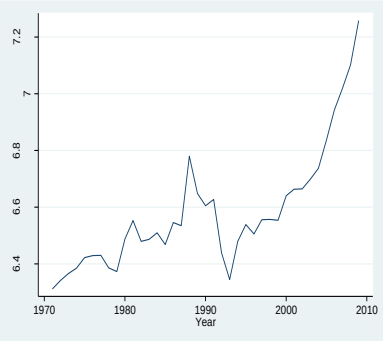
```
. predict resid
. estat dwatson
Durbin-Watson d-statistic (  8,    39) =   1.22548
. pperron resid, noconstant regress
Phillips-Perron test for unit root                    Number of obs     =   38
                                                      Newey-West lags =     3

                                   Interpolated Dickey-Fuller
                   Test        1% Critical      5% Critical      10% Critical
                 Statistic        Value            Value             Value
------------------------------------------------------------------------------------------
Z(t)          1.966           -2.639           -1.950            -1.605

------------------------------------------------------------------------------------------
    resid |        Coef.        Std. Err.     t       P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------------------
resid | L1. |  1.003896     .00181   554.63   0.000     1.000229    1.007564
```

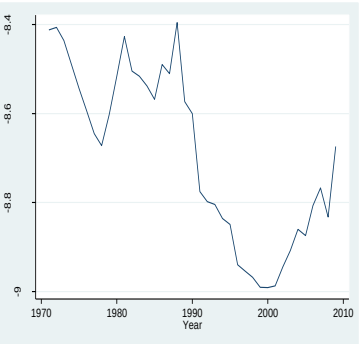
Annex Figure A.1: Graphic visual inspection test on the existence of trend







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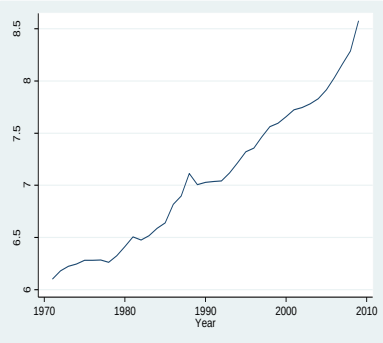
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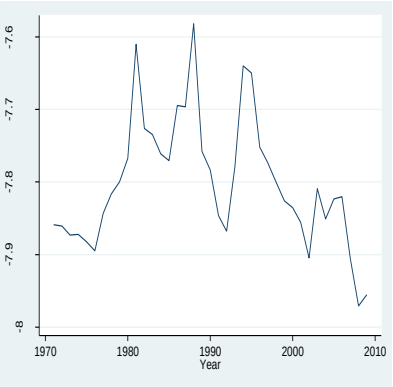
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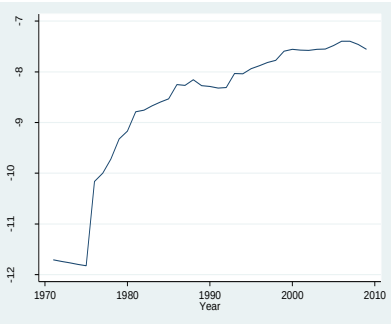
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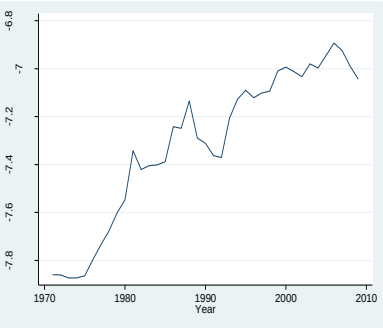
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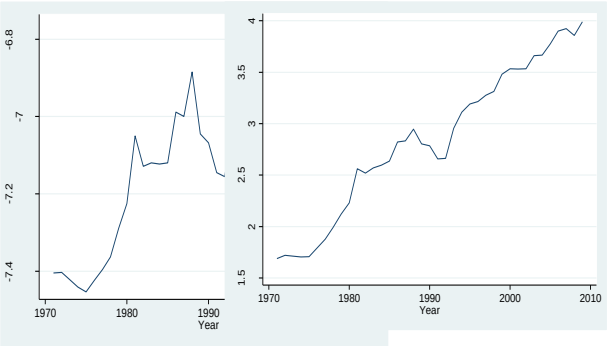
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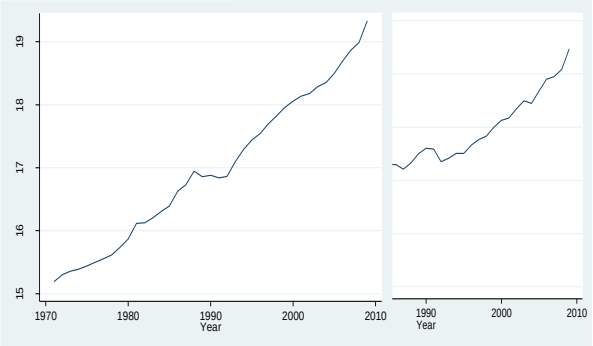
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INFRASTRUCTURE AND AGRICULTURAL GROWTH IN NIGERIA[1]

Clement A.U. Ighodaro[2]

Abstract

The study considered infrastructure and agricultural growth in Nigeria using a time series data for over four decades and the Parsimonious Error Correction Model estimation technique. It was found that various performance indicators with respect to physical infrastructure used for the study have not been encouraging in Nigeria. The provision of infrastructure in Nigeria, particularly physical infrastructure is characterized by the predominance of public enterprises except for telecommunications sector in recent time. The empirical part of the study revealed different relative response rates of the different component of infrastructure used in the study to the growth of the agricultural sector in Nigeria. There was unidirectional causality between telecommunication facilities and agricultural production. The same result was found between labour and agricultural production. It was recommended that the sectoral specific effects of the various forms of infrastructure should be taken into consideration when designing policy for promoting agricultural growth in Nigeria.

Key Words: Infrastructure, Growth of Agriculture and VAR
JEL: H54, O13

1. Introduction

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The major focus of infrastructure investment has been on irrigation, transportation, electric power, agricultural markets etc. These not only contribute to agricultural growth at macro level but also to the wide disparity between different regions with respect to the growth of agriculture (Venkatachalam, 2003). World Bank (1994) in the 1994 World Development Report defined infrastructure in a narrow way as long lived engineered structures, equipment and facilities as well as the services they provide that are used in economic production and by households. The agricultural sector plays a dominant role in alleviating poverty and overall growth of the economy. In other words, the level of infrastructure in agricultural sector is one of the major factors that could explain regional imbalances in the growth of the agricultural sector (Venkatachalam, 2003). Agricultural related infrastructures are expected to reduce farmers' costs and accelerate growth in agriculture (e.g., Antle, 1983).

The growth of agriculture in Nigeria has not been encouraging because of falling labour input, particularly because of high rural – urban labour force migration. Another reason is deficient transport infrastructure like road which is a vital determinant of low technological adoption, cropping choices and of low agricultural productivity in developing countries (Antle, 1983; Zeller, Diagne and Mataya, 1998). On the other hand, price policies, with respect to transport pricing might create distorting signals. For example, Ahmed and Hussein (1990) showed that the fertilizer use in agriculture sector increases with the improvement in the quality of the roads.

At macro level, the relationship between infrastructure and the growth of agriculture is still not clear for Nigeria. For example, it is natural to expect that aggregate agricultural growth is positively related to infrastructure development. However, how to strengthen such a relationship at the operational level remains debatable. A conventional approach in this regard is to estimate an aggregate production function of agriculture as done in (Mundlak *et al*., 2004; Bravo-Ortega and Lederman, 2004).

This paper therefore aims to empirically determine the impact of infrastructure on the growth of the agricultural sector in Nigeria using the parsimonious error correction estimate. Since it is not only infrastructure that may affect agricultural production, the effect of labour was also tested jointly with the infrastructure variables in order to test if labour exhibits decreasing returns to scale in agricultural

production contrary to previous studies for Nigeria. Section two dwells on literature review on infrastructure and agricultural growth, section three discussed infrastructure development in Nigeria while section four considers agricultural sector in the Nigerian economy. Section five explains the model and results while section six explains the policy implication of results and conclusion.

2. Literature on infrastructure and agricultural growth

Generally, evidences showed that public investment in infrastructure- specifically, in the rehabilitation of rural roads, improves local community and market development. For example, rehabilitation of rural roads raises male agricultural wages and aggregate crop indices in poor villages of Bangladesh (Khandker et al. 2006). Also, in Vietnam, the result is an increase in the availability of food and the wages of agricultural workers (Mu and van de Walle, 2007). Furthermore, other studies found that access to new and improved roads in rural areas enhance opportunities in non-agricultural activities in Peru (Escobal and Ponce, 2002) and in non-farm activities among women in Georgia (Lokshin and Yemtsov, 2005). In Nigeria, Egbetokun (2009) used infrastructural index on the sampled village level data in Oyo State by summing the individual cost of access (TCi) to the some eight basic infrastructure elements in the study area. It was found that provision of infrastructures served as incentives for increased economic efficiency and productivity of the rural dwellers. The study further showed that rural infrastructures are very crucial to the growth of agriculture in the study area. Poor access to infrastructural facilities like health centers, educational institutions, communication gadget, and water supply all leads to a low agricultural production.

Jacoby (2000) using data from Nepal showed that there is a negative relationship between farmland value and its distance to agricultural markets. As indicated by this author, if farmland behaves like any asset, its price would equal the net present value of the benefits its cultivation generates and therefore this relationship - between farmland value and distance to agricultural markets – is an indicator of the capital gains generated by the improvement of road infrastructure.

As cited by Pinstrup – Andersen and Slimokama (2006), in one of the technical background documents for the World Food Summit held about a decade ago, it was concluded that "Roads, electricity supplies, telecommunications and other infrastructure services are limited in all rural areas, although they are of key importance to stimulate agricultural investment and growth" (Food and Agriculture Organization of the United Nations, 1996). The document further put forward that "Better communications are a key requirement. They reduce transportation cost, increase competition, reduce marketing margins and in this way can directly improve farm incomes and private investment opportunities". This conclusion is supported by several studies of infrastructure in developing countries like Antle 1984; Binswanger, Khandker, and Rosenzweig 1993; Fan, Hazell, and Thorat 2000; as well as Fan and Zhang, 2004). These studies showed that investment in infrastructure is essential to increase farmers' access to input and output markets to stimulate the rural non-farm economy. It also facilitates the integration of less-favoured rural areas into national and international economies.

Fan, Hazell, and Thorat (2000) found that public investment in rural roads has a large positive impact on agricultural productivity growth in India. Fan and Zhang (2004) presented one of the most careful econometric analyses in this area. They controlled for the reverse causality problem by employing a dynamic GMM method. According to their estimates, investments in roads and irrigation significantly contribute to agricultural growth. At the same time, agricultural growth induces a much larger demand effect on irrigation than on roads. This may be because irrigation is sector-specific infrastructure and thus its demand is more directly influenced by agricultural growth while the demand on roads depends on several other factors besides agricultural growth.

Fan and Chan-Kang (2005) documented that the quality of infrastructure is an important determinant of agricultural growth and poverty reduction in China. Market integration over space and time requires good infrastructure and effective market institutions. Where spatial market integration is poor, favourable local growing conditions, improved production practices or adoption of modern technologies that result in increasing marketable surpluses may result in drastic drops in local prices while other areas may suffer from deficits and rapidly increasing prices. For example, according to Pinstrup-Andersen (2002), maize prices in Ethiopia tripled from 1997-

1998 to 1999- 2000 followed by an 80 % drop from 1999-2000 to 2000-2001. In Malawi, the price of maize quadrupled between April 2001 and April 2002. The supply response by small farmers is also seriously affected by the state of infrastructure and market. Chhibber (1988) found that a one percent increase in output prices would result in a supply response of 0.3% - 0.5% in areas with poor infrastructure and 0.7% - 0.9% in areas with good infrastructure.

The farmers' willingness to adopt productivity-enhancing technology depends very significantly on the infrastructure and market situation with which they are faced. Hazarica and Alwang (2003) documented that credit constraint negatively influence plot size while Groppenstedt, Demeke and Meschi (2003) documented that it negatively affected fertilizer use. On the other hand, Freeman, Ekhin, and Jabbar (1998) concluded that it negatively affect total productivity. Binswanger, Khandker and Rosenzweig (1993) showed that private banks are more likely to be located in areas with better road infrastructure and marketing systems.

Temel and Maru (2007) assessed infrastructure and use of Information and Communication Technology (ICT), such as radio, television, printing press, telephony, fax, computers, and the internet in national agricultural research organizations in Georgia. It also identified their needs to improve information flow and management. The study concluded that Georgia has a well-established radio and television broadcasting network, but its linkage with agricultural development, especially with extension, is extremely weak. ICT infrastructure in Georgian agricultural organizations and agricultural research system is extremely poor compared to that of their Western counterparts. Lalli (2007) study evaluated the importance of infrastructure in agricultural development in Haryana, the spatial dimensions in its distribution over time as well as the interlinkages in agricultural facilities available in the state. It was found that agricultural infrastructure is a necessary but not a sufficient condition for development in agriculture, implying the role of some other factors in the process of development. It was found that disparities in the distribution of agricultural infrastructure tended to result in inequalities in the agricultural productivity. Furthermore, a decline in disparities in its distribution tended to narrow down inequalities in agricultural productivity among the districts and delineated productivity regions.

Limi and Smith (2007) in their study concluded that aggregate agricultural growth is expected to be accelerated by public infrastructure provision. Though, the potential infrastructure impact may vary across commodities. The estimation results indicated that agricultural production could be promoted by different infrastructures, depending on commodity. For example, according to them, roads and irrigation facilities could strengthen production efficiency in the coffee and cocoa industries. Telecommunications infrastructures are also important for branding these commodities. Conversely, dairy production requires more water in rural areas.

3. Stylized fact on some infrastructure development in Nigeria

The state of infrastructure in Nigeria has remained a matter of concern given its importance in the growth of agriculture and in the overall economic well being of the populace. However, various performance indicators with respect to these physical infrastructure facilities point to the fact that their performance has not been encouraging. The provision of infrastructure in Nigeria is characterized by the predominance of public enterprises (Central Bank of Nigeria, 2003).

The Nigeria road system is classified into four broad categories. These are; the Federal Trunk 'A' Roads; these are under federal government ownership and they are developed and maintained by the federal government. The Federal Trunk 'F' Roads were formerly under state ownership but were taken over by the Federal Government with a view to upgrading them to federal highway standards. The Trunk 'B' Roads are under the ownership and management of the component states. The Trunk 'C' Roads are under the local government ownership and management. Each tier of government has the responsibility for planning, construction and maintenance of the network of roads under its jurisdiction. While the federal government controls 17% of the total roads network in Nigeria, the state government controls 16% while the local government authority controls 67% (Central Bank of Nigeria 2003).

Until the early 1980s, the telecommunications sector was viewed as quintessential public utility. Economies of scale combined with political sensitivity created large entry barriers and externalities (Jerome, 2003). Beginning from the 1980s however, policy makers gradually began to recognize that telecommunications system is an essential infrastructure for the growth of the agriculture and the entire economy. As

the economy broadens and becomes critically dependent on vastly expanded flows of information, telecommunications acquires strategic importance for agricultural growth hence, overall economic growth and development. Following the commercialization of Nigeria Telecommunications Limited in 1992 which was quickly followed by deregulation, the federal government of Nigeria through the promulgation of Nigerian Communications Commission (NCC) Decree No.75 of 1992 introduced private participation in the provision of telecommunication services in Nigeria.

According to the Federal Republic of Nigeria (2006), by 2005, the transmission network consisted of 5000 km of 330 kV lines and 6000 km of 132 kV lines. The 330 kV lines fed 23 substations of 330/132 kV rating with a combined capacity of 6,000 MVA at utilizing factor of 80%. In turn, the 132 kV lines fed 91 sub - stations of 132/133 kV rating with a combined capacity of 7,800 MVA or 5,800 MVA at utilization factor of 75%. The distribution grid consisted of 23,753 km of 33 kV lines and 19,226 km of 11 kV lines. These in turn fed 679 sub – stations of 33/11 kV rating and 20,543 sub stations of 33/0.415 kV ratings. Also, there were 1,790 distributed transformers and 680 injection transformers.

Federal Republic of Nigeria (2006) further documented that Power Holdings Company of Nigeria's business operations are inefficient. The system suffers from chronic under - investment, poor maintenance, un-recorded connections and under - billing arising from a preponderance of un-metered connections (this has been presently reduced as a result of the introduction of pre-paid meter by the federal government of Nigeria).

4. Agricultural sector in the Nigerian economy

Agricultural sector in Nigeria covers the main fields of primary production in terms of crops, livestock, forestry, wildlife and fisheries. During the 1980s, the sector employed on the average, about 80% of the country's working population. It has constituted a

significant but declining proportion of gross national product. In the 1950s and 1960s in Nigeria, agriculture was the leading sector in terms of contribution to gross domestic product. In 1960, the country was still largely an agricultural country with the sector accounting for approximately 64% of output as well as employing over 73% of the total labour force. It was the major foreign exchange earner used to pay for imported capital/ manufactured goods. However, the discovery of crude oil in commercial quantity brought about reduction in agricultural share of gross domestic product; from a gross domestic product share of almost 64% in 1960 to about 49% in 1969. Between 1980 and 1989 it fell to an average of 33.4%.

Agriculture's contribution to gross domestic product between 1990 and 1997 averaged 29.34% (Iyoha, 2003). This clearly shows that agriculture contribution's to gross domestic product has been on the downward trend particularly since the early 1970s. Generally, there had been a lack of consistency in the growth performance of the agricultural sector in the 1981-2000 periods, with some evidence of unstable or fluctuating trends, probably due to inconsistencies in policies and policy implementation in the period.

Also, overall food supply has been on the downward trend, probably because of low productivity. To make up for the shortfall in food supply, Nigeria resorted to massive importation of some food items. For example, while Nigeria spent about N400.05 million between 1962 and 1970, it spent about N11,288.532 million between 1971 and 1985 on food importation. In 1981, the nation's food import bill rose to N2,115 million. It decreased to N843.2 million in 1984. The overall consequence of this was that huge amount of foreign exchange that would have been used for accumulating capital was used for food importation.

In terms of export earnings, agricultural exports accounted for 86% of total exports in 1955 - 59, 80% in 1960 - 64 and 57% between 1965 - 69. Part of the decline in 1965 - 69 may have been due to destructions in production caused by civil war of 1967 - 70 (Aigbokhan, 2001). Aigbokhan further observed that from 1970, the decline became very dramatic and this coincided with the evolution of the petroleum sector as the country's main export commodity. In the 1970 - 74 periods, agriculture accounted for 26% of total exports, thereafter, it accounted for less than 10%, being 5.7% in 1975 -

79, 2.7% and 5.6% in `1980 - 84 and 1985 - 89 respectively. In 1990, it fell to the lowest level at 1.8% before some recovery in 1994 - 98 to 8.6%.

5. Agricultural sector in the Nigerian economy

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6. Theoretical framework model estimation, results and analysis

The study adopted the Barro (1990) framework with slight modification by assuming the production function has the Cobb - Douglas technology form as:

$$Y_t = A_t K_t^{\alpha} G_t^{\beta} L_t^{1-\alpha-\beta} \qquad (1)$$

Where: t is time trend chronologically.
Y = Aggregate output from agricultural sector,
A = Technical progress,
K = Capital stock,
G = Infrastructure,
L = Labour force.

Being constant returns to scale means that capital has to grow along with one type of infrastructure. From (1), the respective marginal products of G and K are given as;

$$\frac{\partial Y_t}{\partial G_t} = \beta A_t K_t^{\alpha} G_t^{\beta-1} L_t^{1-\alpha-\beta} \succ 0 \qquad (2)$$

$$\frac{\partial Y_t}{\partial K_t} = \alpha A_t K_t^{\alpha-1} G_t^{\beta} L^{1-\alpha-\beta} \succ 0 \qquad (3)$$

The respective marginal products from (2) and (3) show that K is enhanced by infrastructure (G), just as the productivity of G is enhanced by capital stock (K). Given the assumption that infrastructure provision is financed by a flat rate tax on total

output (Y) from agricultural sector in (1), the budget constraint can be represented as:

$$G_t = \tau_t Y \qquad (4)$$

Where τ is tax rate, G_t and Y_t are as earlier defined. Equation (4) constraints the government to run a balanced budget which is not likely to hold for a developing country like Nigeria. That is the government can neither finance deficits by issuing debt nor run surpluses by accumulating assets. Theoretically, a proportional tax on output affects Given the assumption that infrastructure provision is financed by a flat rate tax on total output (Y) from agricultural sector Let the capital accumulation identity be specified as:

$$K_t = (1-\delta)K_{t-1} + I \qquad (5)$$

where δ represents depreciation of capital and assuming depreciation of capital is zero, (5) can be re – arranged to get:

$$\Delta k = k_t - k_{t-1} = I \qquad (6)$$

For simplicity, assume a constant savings rate and that capital fully depreciates each period, infrastructure for the next period is a proportion of total savings so that:

$$G_{t+1} = \tau Y_{t+1} \qquad (7)$$

Therefore from (7), investment in capital stock is determined by:

$$K_{t+1} = (1-\tau_t)sY \qquad (8)$$

Substituting capital accumulation equations (7) and (8) into equation (1) produces a difference equation for the evolution of growth rate of output from the agricultural sector:

$$(Y)_{t+1} = A_{t+1} s^{\alpha+\beta}(1-\tau_t)^{\alpha}\tau_t^{\beta}(Y)_t^{\alpha+\beta}(L_{t+1})^{\alpha+\beta} \qquad (9)$$

Assuming the evolution of technical progress is A_t, the share of investment going to infrastructure is τ_t, and size of labour force is L_t and assuming that each of these is determined by an exogenous stochastic process, total agricultural productivity can be modeled as:

$$a_t = a_0 + \sigma_t + \varepsilon_t \qquad \textbf{(10)}$$

where $\varepsilon_t = \delta\varepsilon_{t-1} + \omega_t$ for some $0 \leq \delta \geq 1$, and ω_t is a stationary random variable with $W[\omega_t] = 0$. Equation (10) implies that total agricultural productivity depends on a constant a_0, a trend growth rate of growth σ and a random term that is stationary if $\delta \prec 1$ and non – stationary if $\delta = 1$. While the driving force in the exogenous growth model is technical process, in the endogenous growth model, there is possibility that shocks to infrastructure have permanent effect on the level of growth of the agricultural sector. Furthermore, the sign of this permanent effect may be positive or negative depending on whether $\bar{\tau}$ has been set above or below the tax rate that maximizes expected growth from agriculture.

Empirical model

In reality, the relationship between infrastructure and the growth of the agricultural sector is likely to be more complex than the simple production function modeled. In line with our theoretical model and the studies of Canning and Pedroni (1999), Esfahani and Ramirez (2003) as well as Fedderke, Perkins and Luiz (2005), an equation for the empirical part of the study is specified in error correction form as:

$$\Delta LAGR_t = C_o + \sum_{j=1}^{M} \beta_i \Delta LG_{t-i} + \beta_i \Delta LLBR_{t-i} + ECM_{t-i} + \varepsilon_t \qquad \textbf{(11)}$$

Where L before a variable is the log of that variable and sub – script t is time trend in chronological order and Δ before a variable is the first difference of that variable, M is the lag length;

AGR = Growth rate of agricultural GDP (Proxy for growth of the agricultural sector)

C_o = constant term
G = Vector of physical infrastructure variables
LBR = labour force
ECM = Error correction term
ε = error term
The data were obtained from, Olayide (1976) and Central Bank of Nigeria Statistical Bulletin (2004), Vol. 15. Road infrastructures proxied by total length of roads in Nigeria were obtained from Olayide (1976), Canning David World Infrastructure Data Base (2005) and World Bank African Data Base (2005).

Stationarity test

The Augmented Dickey Fuller (ADF) [Dickey and Fuller, 1979] test was used to test for the stationarity of the variables. The ADF test is of the form:

$$\Delta\lambda_t = \delta\lambda_{t-i} + \beta_i \sum_{i=1}^{n} \delta_i \Delta\lambda_{t-i} + \varepsilon_t \qquad \textbf{(12)}$$

Where: λ_t is our variable of interest; Δ is the difference operator; t is the time trend and ε_t is the white noise residual of zero mean and constant variance; $(\delta_1, \delta_2, \beta_1, ..., \beta_m)$ is a set of parameter to be estimated.

Table 1: ADF test for stationarity

Variable	ADF Test-	Critical Value 1%	Remark
$LAGR$	-2.238356	-4.1837	Non-stationary
$\Delta LAGR$	-5.467513	-4.1896	I(1)
$LELEC$	-0.826020	-4.1837	Non-stationary
$\Delta LELEC$	-4.836835	-4.1896	I(1)
$LLRAD$	-2.2960613	-4.1837	Non-stationary
$\Delta LLRAD$	-4.136460	-3.5189 (5%)	I(1)
$LTELFAC$	-1.914396	-3.5889	Non-stationary
$\Delta LTELFAC$	-4.537138	-3.5930	I(1)
$LLBR$	-1.958253	-3.5889	Non-stationary
$\Delta LLBR$	-4.751795	-4.1896	I(1)

Note: The entire statistic is individually significant at 1% except LLRAD

The ADF result shows that all the variables were not stationary at their levels but stationary at first difference.

Cointegration test and result

The Johansen and Juselius (1990) multivariate Cointegration test was used by formulating the VAR model below:

$$\lambda_t = \Gamma_i(L)\lambda_{t-i} + \ldots + \Gamma_p(L)\lambda_{t-p} + \varepsilon_{t-p} \qquad \textbf{(13)}$$

Where λ_t is also our variable of interest; a column vector and $\Gamma_i(L)$ with $i = 1, \ldots, p$ is a lag operator; ε is the white noise residual of zero mean and constant variance. The order of lag of the model p is determined by Akaike Information Criterion (AIC).

Table 2: Cointegration results

Sample: 1960 2004
Included observations: 43
Series: LAGR LELEC LLRAD LTELFAC LLBR
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.638466	104.3197	87.31	96.58	None **
0.468135	60.57153	62.99	70.05	At most 1
0.274216	33.42278	42.44	48.45	At most 2
0.233523	19.64116	25.32	30.45	At most 3
0.173719	8.205264	12.25	16.26	At most 4

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

The result revealed one cointegrating vector. Since it has been ascertained that the variables are non-stationary at level but stationary after differencing ones, and they are cointegrated, we can formulate an error correction model. Error correction is necessary because, it helps to recover the long run information lost by differencing the variables.

Parsimonious error correction estimation

From Table 3 below, adopting the general to specific framework, an over parametized error correction model of equation twelve is estimated. Following Hendry's (1995) general to specific modeling using four lags for each of the explanatory variable, the insignificant variables were gradually eliminated from the general form of the ECM equation. The parsimonious error correction estimation was obtained as below given this process.

Table 3: Result from the Error Correction Model

Dependent Variable: D(LAGR)
Method: Least Squares
Sample(adjusted): 1965 2004
Included observations: 40 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.886441	2.930324	2.008802	0.0564
D(LELEC(-3))	-0.933139	0.376964	-2.475407	0.0211
LLRAD	-0.754374	0.369194	-2.043299	0.0526
D(LLRAD)	0.595613	0.529621	1.124602	0.2724
D(LLRAD(-4))	1.606691	0.670444	2.396460	0.0251
D(LTELFAC)	0.583900	0.675834	0.863969	0.3965
D(LTELFAC(-1))	-2.982692	0.831854	-3.585595	0.0016
D(LTELFAC(-3))	2.180013	0.656681	3.319743	0.0030
D(LTELFAC(-4))	1.861727	0.684435	2.720095	0.0122
LLBR	-1.521884	0.906169	-1.679472	0.1066
D(LLBR)	-0.318334	0.349126	-0.911803	0.3713
D(LLBR(-1))	1.611959	0.434370	3.711026	0.0011
D(LLBR(-3))	-1.112958	0.341987	-3.254390	0.0035
D(LLBR(-4))	-0.974677	0.356600	-2.733252	0.0118
LLBR^2	0.176929	0.104696	1.689936	0.1046
LAGR(-1)	-0.143913	0.112747	-1.276418	0.2145
ECM(-1)	-0.600759	0.141410	-4.248338	0.0003
R-squared	0.736982	Mean dependent var		0.038755
Adjusted R-squared	0.554013	S.D. dependent var		0.135843
S.E. of regression	0.090719	Akaike info criterion		-1.665478
Sum squared resid	0.189290	Schwarz criterion		-0.947704
Log likelihood	50.30955	F-statistic		4.027903
Durbin-Watson stat	2.095665	Prob(F-statistic)		0.001254

From Table 3, the R-squared value revealed that about 74% variation in agricultural production is explained infrastructural variables and labour while the F-statistic shows that the all the variables put together jointly significant at 1% level of significance in the determination of agricultural output in Nigeria. This implies that components of infrastructure used for the study have joint effect on the growth of the agricultural sector in Nigeria. The result further reveals that the error correction coefficient is statistically significant and it has the expected negative sign. It suggests a high speed

of adjustment to long run equilibrium and therefore confirms the validity of long run equilibrium relationship between agricultural growth and the selected infrastructure and labour in Nigeria.

Table 4: Granger causality result

Pairwise Granger Causality Tests
Sample: 1960 2004

Null Hypothesis:	Obs	F-Statistic	Probability
LLRAD does not Granger Cause LAGR	44	0.86796	0.35697
LAGR does not Granger Cause LLRAD		1.05124	0.31123
LTELFAC does not Granger Cause LAGR	44	4.56785	0.03859
LAGR does not Granger Cause LTELFAC		0.00886	0.92545
LLBR does not Granger Cause LAGR	44	4.16880	0.04764
LAGR does not Granger Cause LLBR		0.01231	0.91221
LTELFAC does not Granger Cause LLRAD	44	0.03322	0.85627
LLRAD does not Granger Cause LTELFAC		0.64489	0.42658
LLBR does not Granger Cause LLRAD	44	0.05992	0.80784
LLRAD does not Granger Cause LLBR		0.69831	0.40819
LLBR does not Granger Cause LTELFAC	44	0.05928	0.80886
LTELFAC does not Granger Cause LLBR		0.04148	0.83963

Specifically, the lag value of electricity supply though significant had contrary sign. It shows that it has an inverse relationship with agricultural output. This may result from non usage of agricultural specific infrastructure for the estimation. As expected, telecommunication infrastructure has a positive relationship and significant, though with a delayed effect. The third and fourth lag values of labour are significant with a delayed effect in the determination of agricultural production, though, with a negative sign. The one period lag value of agriculture was not significant and also with a contrary sign. This may imply that the previous year had poor harvest and this would seriously discourage people from farming in the current period. Surprisingly, the result further shows that labour is subject to increasing returns to scale rather than decreasing returns to scale. The recursive residual, Cusum and Cusum of square plots show that the estimation is stable and can therefore be used for prediction purposes.

The result shows that there is unidirectional causality between telecommunication facilities and agricultural production with causality from telecommunication facilities

to agricultural production. Causality also runs from labour to agricultural production but not the other way round.

7. Conclusion and policy implications of results

The result shows different relative response rates of the different infrastructure to the growth of the agricultural sector in Nigeria. A useful policy implication of the result is that in designing agricultural sector's policy, emphasis should be placed on the provision of roads, and telecommunications facilities; though, both will only impact on the agricultural sector after some time.

In conclusion, without efficient provision and maintenance of these infrastructures, the agricultural sector in Nigeria may be unable to contribute significantly to overall economic growth; a large portion of the population will be relegated to poverty, hunger and human misery. Even if there has been mixed empirical results on the relationship between infrastructure and the growth of the agricultural sector, the usefulness of infrastructure to the growth and development of the agricultural sector cannot be overemphasized.

References

Ahmed, R. and M. Hossain. 1990. Developmental Impact of Rural Infrastructure in Bangladesh. *International Foods Policy Research Institute, IFPRI. Research Report 83*. Washington D.C.

Aigbokhan B. E. 2001. *Resuscitating Agricultural Production (Cocoa, Cotton, Ground nut, Palm oil, Rubber etc) for Export.* A Paper Presented at the 10th Annual Conference of Zonal Research Unit of the Central Bank of Nigeria on the theme Resource Endowment, Growth and Macro-economic Management, Owerri June 4th – 8th

Antle, J. M. 1983. Infrastructure and Aggregate Agricultural Productivity: International Evidence *Economic Development and Cultural Change.*

Antle, J. M. 1984. Human Capital, Infrastructure and the Productivity of Indian Rice Farmers. *Journal of Development Economics.* No. 14. pp 163 – 181.

Barro, R. J. 1990. Government Spending in a Simple Model of Endogenous Growth. *Journal of Political Economy* Vol. 98, No.5, pp 5103 - 5125. October.

Bravo-Ortega, C. and D. Lederman. 2004. Agricultural Productivity and its Determinants: Revisiting International Experiences. *Estudios de Economía*, Vol. 31, pp. 133-163.

Binswanger, H. P., S. R. Khandker, M. R. Rosenzweig. 1993. How Infrastructure and Financial Institutions Affect Agricultural Output and Investment in India. *Journal of Development Economics*. No. 41. pp 337- 366.

Calderon, C and L. Serven. 2008. Infrastructure and Economic Development in Sub – Saharan Africa. *World Bank Policy Research Working Paper* No. 4712. The World Bank Development Research Group Macro-economics and Group Team, September

Canning, D and P. Pedroni. 1999. *Infrastructure and Long Run Economic Growth* CAER II Discussion Paper No. 57. Harvard Institute of International Studies. December

Central Bank of Nigeria. 2003. *Highway Maintenance in Nigeria: Lessons from other Countries.* Research Department; Occasional Paper No. 27.

Chhibber, A. 1988. Raising Agricultural Output: Price and Non Price Factors. *Finance and Development*. Vol. 25. No. 2. pp 44 – 47.

Dickey, D. A. and W. A. Fuller. 1979. Distribution of the Estimators for Autoregressive Times Series with a Unit Root. *Journal of American Statistical Association* Vol. 74, pp 427 – 431.

Egbetokun, O. A. 2009. Provision of Rural Infrastructure Oyo State, Nigeria. Agricultura – Ştiinţă şi practică nr. 1-2 (69-70]/2009

Escobal, J. and C. Ponce. 2000. *The Benefits of Rural Roads: Enhancing Income Opportunities for the Rural Poor* Group of Analysis for Development (GRADE) Working Paper No. 40, November.

Esfahani, H. and M. T. Ramirez. 2003. Institutions, Infrastructure and Economic Growth. *Journal of Development Economics.* No.70 pp 443 – 477.

Fan, S. P., P. Hazell, S. Thorat. 2000. Government Spending, Growth and Poverty in Rural India. *American Journal of Agricultural Economics.* Vol. 82, No. 4. pp 1038 – 1051

Fan, S. and X. Zhang. 2004. Infrastructure and Regional Economic Development in Rural China. *China Economic Review.* No. 15. pp 203 – 214.

Fan, S. and C. Chan – Kang. 2005. *Road Development, Economic Growth and Poverty Reduction in China.* International Food Policy Research Institute Report 138.

Fedderke, J. W., P. Perkins and J. M. Luiz. 2005. *Infrastructure Investment in Long – Run Economic Growth: South Africa: 1875 - 2001*. Paper presented at the 10th African Econometric Society in South Africa. July

Federal Republic of Nigeria. 2000. *National Telecommunications Policy*.

Federal Republic of Nigeria. 2006. *Federal Ministry of Power and Steel: Renewable Electricity Policy Guidelines* www.iccednigeria.org

Food and Agricultural Organization of the United Nations. 1996. *Technical Background Documents 6 – 11, Vol. 2*. World Food Summit; FAO, Rome.

Freeman, H. A., S. K. Ekhin, M. A. Jabbar. 1998. Credit Constraints and Smallholder Daily Production in the East African Highlands: Application of Switching Regression Model. *Agricultural Economics.* No. 19. pp 33 – 44.

Groppenstedt, A., M. Demeke, M. M. Meschi. 2003. Technology Adoption in the Presence of Constraints: The Case of Fertilizer Demand in Ethiopia. *Review of Development Economics.* Vol. 7. No. 1: pp 58 – 70.

Hazarica, G. and J. Alwang. 2003. Access to Credit, Plot Size and Cost Efficiency among Small Holders Tobacco Cultivators in Malawi. *Agricultural Economics* No. 29: pp 99 – 109.

Hendry, D. F. 1995. *Dynamic Econometrics* Oxford University Press, Oxford.

Iyoha, M. A. 2003. An Overview of Leading Issues in the Structure and Development of Nigerian Economy since 1960. In Iyoha, M.A. and G.O. Itsede (ed) *Nigerian Economy, Structure, Growth and Development* pp 3 - 28.

Jacoby, H. C. 2000. Access to Markets and the Benefits of Rural Roads, *Economic Journal*, No.110, pp. 713 - 737.

Jerome, A. 2003. *Public Enterprise Reform in Nigeria Evidence from the Telecommunications Industry* African Economic Research Consortium (AERC) Research paper 129, AERC, Nairobi, Kenya, March.

Johansen, S. and K. Juselius. 1990. Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money. *Oxford Bulletin of Economics and Statistics* Vol. 521, pp 169 -210.

Khandker, S. R., Z. Bahkt and G. B. Koowal. 2006. The Poverty Impact of Rural Roads: Evidence from Bangladesh. *World Bank Policy Research Working Paper* No 3875, April.

Lalli, S. A. 2007. *Infrastructure and Agricultural Development in Haryana--Policy Implications* New Delhi, Research India

Limi, A. and J. W. Smith. 2007. What is missing between Agricultural Growth in Infrastructure Development? Cases of Dairy in Africa. *World Bank Policy Research Working Paper No. 4411*. November.

Lokshin, M. and R. Yemtsov. 2005. Has Rural Infrastructure Rehabilitation in Georgia Helped the Poor? *The World Bank Economic Review* No. 19 Vol. 2, pp 311- 333

Mu, R. and D. van de Walle. 2007. Rural Roads and Poor Area Development in Vietnam. *World Bank Policy Research Working Paper* No. 4340, August.

Olayide, S. O. 1976. *Economic Survey of Nigeria (1960-1975).* Aromolaran Publishing Company Ltd, Ibadan, Nigeria.

Pinstrup – Andersen, P. and S. Shimokawa. 2006. *Rural Infrastructure and Agricultural Development.* Paper Prepared for Presentation at the Annual Bank Conference on Development Economics, Tokyo, Japan. May 29th – 30th.

Pinstrup – Andersen, P. 2002. Food and Agricultural Policy for Globalizing World: Preparing for the Future. *American Journal of Agricultural Economics*. Vol. 25, No. 2. pp 1201 – 1214.

Temel, T. and A. Maru. 2007. Georgia ICT Infrastructure and Use in Agriculture Agricultural Policy, Research and Education Organizations *http//srn.com/abstract=986496*

World Bank. 1994. *World Development Report 1994: Infrastructure for Development: Word Development Indicators* Washington D.C. The World Bank.

Zeller, M., A. Diagne and C. Mataya. 1998. Market Access by Small Holder Farmers in Malawi. Implication for Technological Adoption, Agricultural Productivity and Crop Income. *Agricultural Economics. Special Issue*.

Appendices

Table A1: Cointegration result

Sample: 1960 2004
Included observations: 43
Series: LAGR LELEC LLRAD LTELFAC LLBR
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.638466	104.3197	87.31	96.58	None **
0.468135	60.57153	62.99	70.05	At most 1
0.274216	33.42278	42.44	48.45	At most 2
0.233523	19.64116	25.32	30.45	At most 3
0.173719	8.205264	12.25	16.26	At most 4

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LAGR	LELEC	LLRAD	LTELFAC	LLBR	@TREND(61)
-1.325731	-0.596990	-0.223951	3.879140	-1.977223	0.040815
-0.681456	0.368422	1.909520	3.533008	-1.886071	-0.014284
-0.021857	-1.929884	0.703494	4.004075	-2.050792	0.031263
0.436122	-0.240564	2.759573	0.434534	-0.135693	-0.056426
0.005989	-0.036350	-3.094463	-1.404249	0.787033	0.040119

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LAGR	LELEC	LLRAD	LTELFAC	LLBR	@TREND(61)	C
1.000000	0.450310	0.168927	-2.926039	1.491421	-0.030787	-7.154748
	(0.18241)	(0.40490)	(0.45694)	(0.23645)	(0.00752)	
Log likelihood	264.8527					

Normalized Cointegrating Coefficients: 2 Cointegrating Equation(s)

LAGR	LELEC	LLRAD	LTELFAC	LLBR	@TREND(61)	C
1.000000	0.000000	-1.181183	-3.952335	2.071395	-0.007272	-0.001096
		(0.96560)	(1.06070)	(0.56837)	(0.01260)	
0.000000	1.000000	2.998179	2.279087	-1.287944	-0.052220	-15.88606
		(2.09126)	(2.29723)	(1.23096)	(0.02729)	
Log likelihood	278.4271					

Normalized Cointegrating Coefficients: 3 Cointegrating Equation(s)

LAGR	LELEC	LLRAD	LTELFAC	LLBR	@TREND(61)	C
1.000000	0.000000	0.000000	-2.432676	1.250701	-0.020004	-4.717659
			(0.37277)	(0.20410)	(0.00354)	
0.000000	1.000000	0.000000	-1.578240	0.795211	-0.019902	-3.914084
			(0.47181)	(0.25832)	(0.00448)	
0.000000	0.000000	1.000000	1.286557	-0.694807	-0.010779	-3.993084
			(0.33994)	(0.18612)	(0.00323)	
Log likelihood	285.3179					

Normalized Cointegrating Coefficients: 4 Cointegrating Equation(s)

LAGR	LELEC	LLRAD	LTELFAC	LLBR	@TREND(61)	C
1.000000	0.000000	0.000000	0.000000	-0.175724	0.002722	-2.992376
				(0.08411)	(0.02096)	
0.000000	1.000000	0.000000	0.000000	-0.130207	-0.005158	-2.794777
				(0.04893)	(0.01220)	
0.000000	0.000000	1.000000	0.000000	0.059579	-0.022798	-4.905526
				(0.03164)	(0.00789)	
0.000000	0.000000	0.000000	1.000000	-0.586360	0.009342	0.709212
				(0.03141)	(0.00783)	
Log likelihood	291.0359					

Figure 1: Stability Test Results

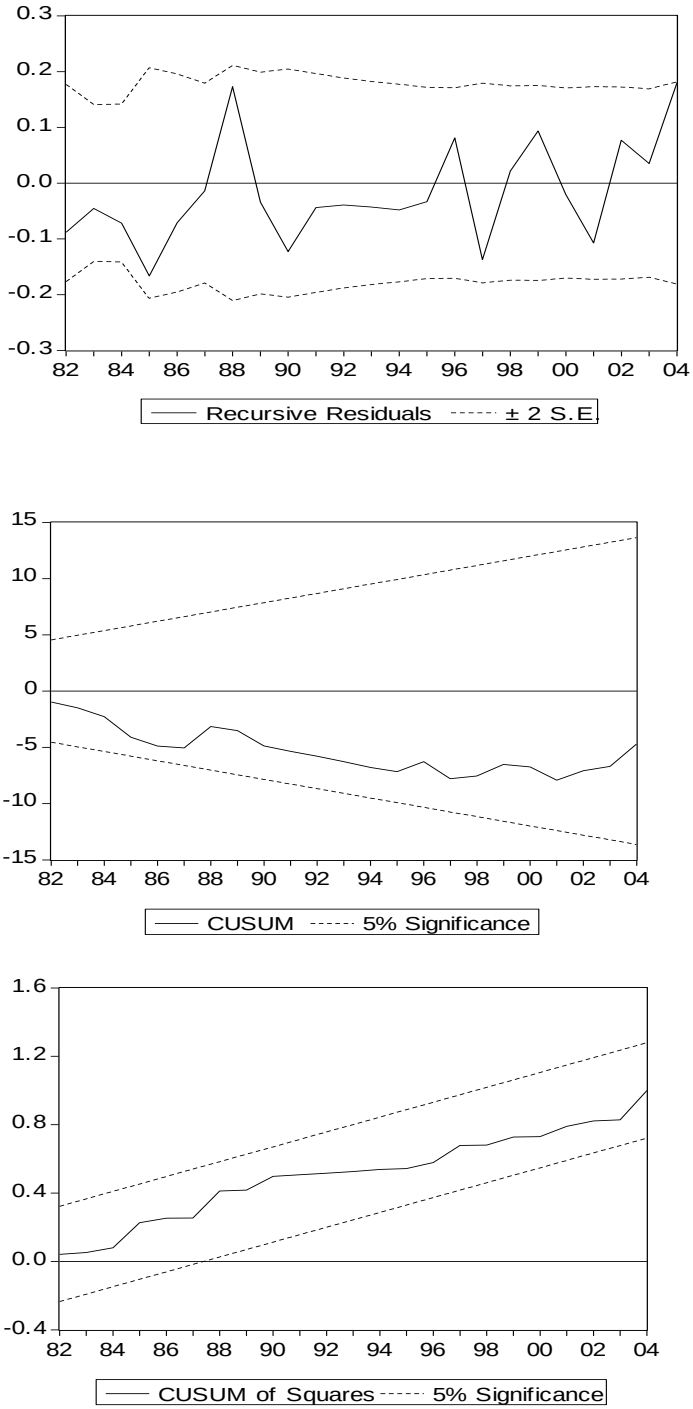

Table A2: General/Overparameterized Error Correction Model

Dependent Variable: D(LAGR)
Method: Least Squares
Date: 10/17/11 Time: 22:34
Sample(adjusted): 1965 2004
Included observations: 40 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.244826	58891.28	-2.11E-05	1.0000
LELEC	0.596467	12106.89	4.93E-05	1.0000
D(LELEC)	0.006702	12106.89	5.54E-07	1.0000
D(LELEC(-1))	0.157965	0.474636	0.332813	0.7446
D(LELEC(-2))	1.980576	0.497840	3.978335	0.0016
D(LELEC(-3))	0.830102	1.061939	0.781685	0.4484
D(LELEC(-4))	0.863225	0.694028	1.243790	0.2355
LLRAD	-0.129676	48147.46	-2.69E-06	1.0000
D(LLRAD)	0.120773	48147.46	2.51E-06	1.0000
D(LLRAD(-1))	-0.497679	0.635225	-0.783468	0.4474
D(LLRAD(-2))	-0.595286	0.565720	-1.052262	0.3118
D(LLRAD(-3))	-0.831627	0.666779	-1.247230	0.2343
D(LLRAD(-4))	2.203179	0.676229	3.258038	0.0062
LTELFAC	0.112845	123309.4	9.15E-07	1.0000
D(LTELFAC)	-0.036138	123309.4	-2.93E-07	1.0000
D(LTELFAC(-1))	-5.180762	1.386048	-3.737794	0.0025
D(LTELFAC(-2))	-0.779193	1.252347	-0.622186	0.5446
D(LTELFAC(-3))	2.383619	0.853498	2.792765	0.0152
D(LTELFAC(-4))	1.652826	0.595307	2.776426	0.0157
LLBR	-0.111172	65150.52	-1.71E-06	1.0000
D(LLBR)	0.072707	65150.52	1.12E-06	1.0000
D(LLBR(-1))	2.883644	0.737651	3.909224	0.0018
D(LLBR(-2))	0.525279	0.687749	0.763767	0.4586
D(LLBR(-3))	-1.143123	0.448733	-2.547445	0.0243
D(LLBR(-4))	-0.838984	0.305037	-2.750434	0.0165
LAGR(-1)	-0.038083	39797.28	-9.57E-07	1.0000
ECM(-1)	-0.915925	39797.28	-2.30E-05	1.0000

R-squared	0.917077	Mean dependent var	0.038755
Adjusted R-squared	0.751231	S.D. dependent var	0.135843
S.E. of regression	0.067754	Akaike info criterion	-2.319790
Sum squared resid	0.059678	Schwarz criterion	-1.179796
Log likelihood	73.39579	F-statistic	5.529699
Durbin-Watson stat	2.423979	Prob(F-statistic)	0.001192

Table A3: Data used in Log Form

obs	LAGR	LELEC	LLRAD	LTELFAC	LLBR
1960	3.153449	2.627067	4.771455	0.000000	1.244277
1961	3.165897	2.743231	4.817565	0.000000	1.255273
1962	3.206718	2.810141	4.820031	0.000000	1.266467
1963	3.224015	2.887210	4.858988	0.000000	1.277838
1964	3.224792	2.962178	4.864547	0.000000	1.289366
1965	3.228349	3.022453	4.900433	0.000000	1.300813
1966	3.251492	3.076560	4.935240	0.000000	1.302114
1967	3.233757	3.114204	4.951129	0.000000	1.313867
1968	3.237192	3.189490	4.964260	0.000000	1.325516
1969	3.241497	3.056306	4.966456	0.000000	1.325516
1970	3.252222	3.125136	4.969574	3.160000	7.354416
1971	3.531402	3.208390	4.972619	3.180000	7.365057
1972	3.553312	3.281013	4.975707	3.230000	7.375755
1973	3.525278	3.365241	4.982416	3.240000	7.386570
1974	3.511415	3.423937	5.009634	3.240000	7.397558
1975	3.527978	3.539515	5.012078	3.240000	7.408732
1976	3.670140	3.613440	5.014508	3.250000	7.419989
1977	3.707288	3.673261	5.021189	3.260000	7.431444
1978	3.645830	3.660780	5.025777	3.340000	7.443122
1979	3.554221	3.794174	5.028876	3.390000	7.455012
1980	3.596017	3.853723	5.033384	3.410000	7.467060
1981	4.388469	3.890779	5.034649	3.450000	7.478855
1982	4.399367	3.931036	5.036749	3.480000	7.490815
1983	4.398100	3.940168	5.036988	3.500000	7.502782
1984	4.376566	3.953450	5.036988	3.510000	7.514534
1985	4.443954	4.009498	5.041314	3.520000	7.525951
1986	4.482252	4.032038	5.042576	3.530000	7.537088
1987	4.468198	4.051747	5.044540	3.550000	7.547996
1988	4.508842	4.066479	5.044540	3.540000	7.558721
1989	4.633198	4.107654	5.046495	3.560000	7.569292
1990	4.547494	4.129139	5.048830	3.560000	7.579784
1991	4.562562	4.151266	5.049761	3.560000	7.592021
1992	4.571393	4.171838	5.050457	3.570000	7.604442
1993	4.577271	4.161506	5.052309	3.560000	7.616948
1994	4.587626	4.191199	5.233681	3.560000	7.629542
1995	4.603197	4.200210	5.286007	3.560000	7.642316
1996	4.620588	4.210661	5.286007	3.490000	7.655167
1997	4.638441	4.207282	5.287018	3.590000	7.667518
1998	4.655657	4.179264	5.287130	3.570000	7.679382
1999	4.676635	4.206521	5.287802	3.580000	7.690754
2000	4.690031	4.168114	5.287802	3.590000	7.701628
2001	4.706389	4.189294	5.287802	3.560000	7.713087
2002	4.729413	4.333326	5.287802	3.570000	7.724571
2003	4.740363	4.304990	5.288987	3.580000	7.736094
2004	4.774984	4.305330	5.288987	3.580000	7.743510