ROAD SECTOR DEVELOPMENT AND ECONOMIC GROWTH IN ETHIOPIA[1]

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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.

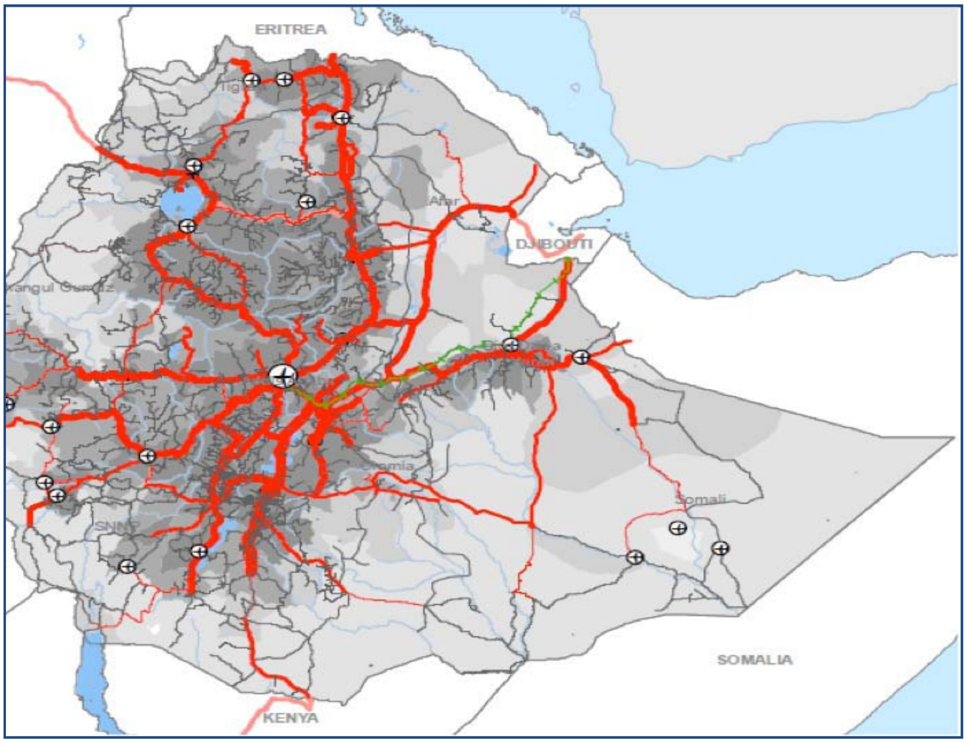
3.1. Road network

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.

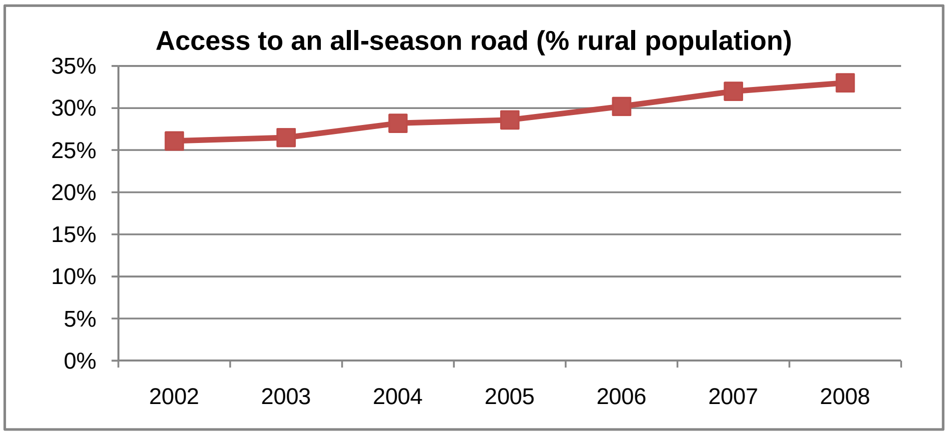
The accepted theory, according to ERA's (2008b) study, is that accessibility has three elements: 1) the location of the individual; 2) the location of the supply, service, or facility to which the individual needs access; 3) the link to bring the two together. The study used three approaches, namely, 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.

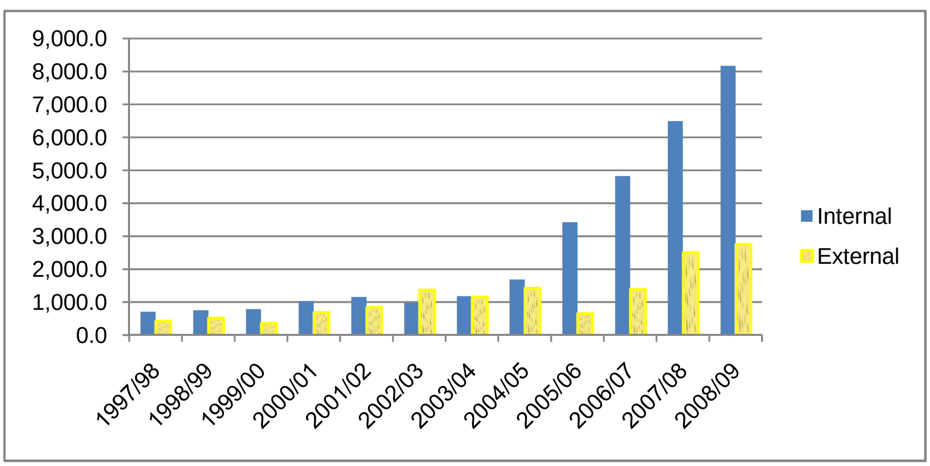
However, the future is not unwelcoming. It has been observed that a continuous support from the government and a serious commitment of the sector offices and other stakeholders would enable to achieve enhanced access of the rural population.

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 contribution
	RSDP I	RSDP II	RSDP III (2yrs)	(12 yrs)	
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.

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

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.

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

And the service sector GDP specification will be

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

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:

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

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,

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

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.

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

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**	
Road^2 |	-.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.

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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		
Model |	1.63507733	7	.233582476	Number of obs	= 39
Residual|	.098164414	31	.003166594	F(7, 31)	= 73.76
Total|	1.73324175	38	.045611625	Prob > F	= 0.0000
				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

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		---------- Interpolated Dickey-Fuller ------------		
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
```

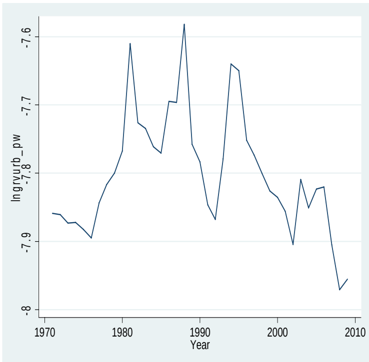
lnsrgdp_pw |	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lncapnet_pw|	.7795128	.1345526	5.79	0.000	.505091	1.053935
lnelect_pw |	.0150187	.1194418	0.13	0.901	.2586219	.2285846
lnhcap_pw |	.1508255	.0337444	4.47	0.000	.0820033	.2196477
lnroadtot_pw |	.0550367	.1519828	0.36	0.720	.2549343	.3650076
rsdp2 |	.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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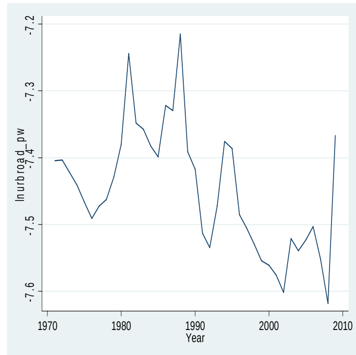
-7.8
-7.7
-7.6
1970
1980
1990
2000
2010
Year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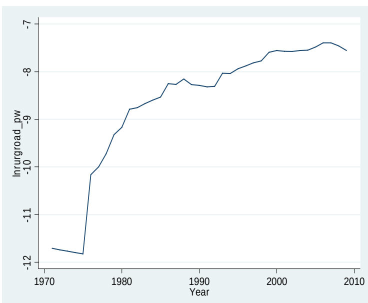
-7.5
-7.4
-7.3
-7.2
1970
1980
1990
2000
2010
Year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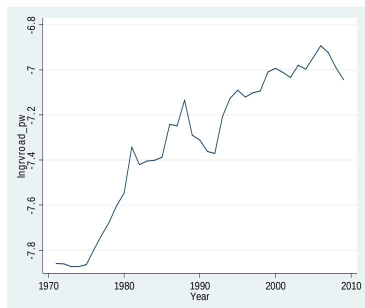
-11
-10
-9
-8
-7
1970
1980
1990
2000
2010
Year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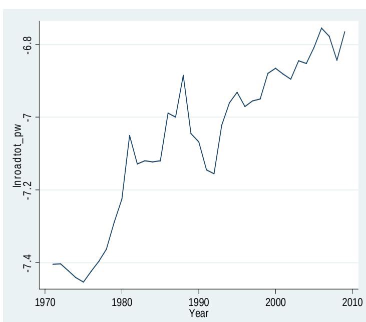
-7.6
-7.4
-7.2
-7
-6.8
1970
1980
1990
2000
2010
Year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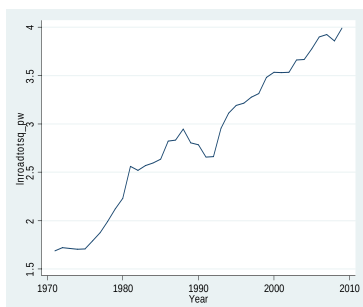
-7.2
-7
-6.8
1970
1980
1990
2000
2010
Year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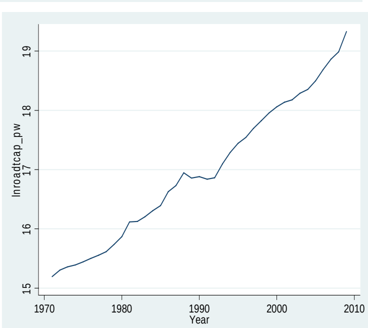
2
2.5
3
3.5
4
1970
1980
1990
2000
2010
Year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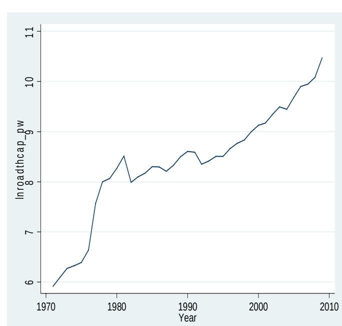
16
17
18
19
1970
1980
1990
2000
2010
Year


lnroadthcap_pw
6
7
8
9
10
11
1970
1980
1990
2000
2010
Year