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The Economy Wide Impact of Investment on Infrastructure for Electricity in Ethiopia: A Recursive Dynamic Computable General Equilibrium Approach

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ABSTRACT

This study has applied a recursive dynamic computable general equilibrium model to examine the economic impact of investment on infrastructure for electricity using an updated 2009/10 social accounting matrix. Three simulations (foreign saving, domestic household and enterprises saving and mix of foreign and domestic saving to finance the investment) in combination with total factor productivity of industrial and service sectors are used. The findings of the study have shown the improvement of the real gross domestic product (GDP), output of industrial and service sectors in all simulations. Nonetheless, mixed effects have found on household consumption and trade balance. The highest growth of real GDP is registered when the investment on electricity is fully financed by domestic household and enterprise saving. However, household consumption expenditure has grown at negative rate worsening the welfare of households. Investment on electricity fully financed by foreign saving is resulted in lower growth rate of real GDP due to worsening of net export. In addition, it has benefits for households as it increases their welfare. But it is to be repaid in the future that would increase indebtedness of the country. So, financing the investment partly by domestic household saving and foreign saving would be worthwhile.

Keywords: Electricity Infrastructure, Economy, Recursive Dynamic Computable General Equilibrium Model
JEL Classifications: C6, Q4, Q43

1. INTRODUCTION

That energy is a critical economic commodity and an adequate and reliable supply of energy is a prerequisite for economic development is well appreciated (UNIDO, 2009). Compared to other parts of the world, however, energy deprivation or the lack of access to it is by far most prevalent in Africa. Energy resources of the continent remain largely underutilized. For example, only 5% of the continent's potential of hydropower and 0.6% of geothermal has been used. In addition, the gap between supply and demand in Africa has been widening over time, resulting in the lowest per capita consumption energy. Recent trends indicate that over 60% of Sub-Saharan Africans will still not have access to electricity by 2020 (UNIDO, 2009).

Ethiopia has an unused large potential for hydropower. Its generation capacity is estimated at 45,000 MW. However, so far, the utilization level has been limited to 2.2 GW, which is <4.5% of the existing potential. Similarly, solar and wind potentials have been researched and found to be considerable (Getachew and Palm, 2009; Getachew, 2011; Wolde-Ghiorgis, 1988; Mulugetta and Drake, 1996) but no considerable development has been made so far. As a result, most of the people in the country use traditional fuels such as fire wood.

The existing power capacity in the country is not able to accommodate demand. As a result, substantial potential output to be produced has been lost due to power cuts in the past years (Ermias et al., 2011). The potential losses from power disruption will also increase in the future. Demand for electricity is growing at 14% from 2005 onwards (ERG, 2009). It will grow at 17% under 10% gross domestic product (GDP) growth and 32% under 14.9% GDP growth scenarios (Zenebe and Alemu, 2011). Currently it is growing at >25%. The increase in demand reflects both the growing electrification of the country and rapid growth of electricity-intensive industries i.e., power demand will increase in the future as the economy grows and the relative contributions of the industrial sector increases. To increase supply of energy as rapidly as growth in demand, the Government of Ethiopia has given commitment to develop the electric power generating capacity of the country by investing on the available water, wind and geothermal energy resources in the country (EEPCo, 2011). Accordingly, Ethiopia is constructing large hydropower dams, wind and geothermal projects. The construction of these large dams is foreseen in the plan that aims to bring capacity to 19 GW after 2019 and further to achieve 80,000 MW of hydro, geothermal, wind and solar power in next 30 years. To meet this ambitious investment it would require average spending more than 30 billion birr per year for until 2019 (EEPCo, 2011).

Investment on large dams are not, however, free from criticisms. There are two views among scholars. One group believes that large dams are opened to political benefits with widespread debate on benefits and negative impacts such as debt burden, cost overruns, displacement and impoverishment of people (Parasuraman and Sengupta, 2001). For others, constructing large dams is the essence of civilization and effective way of government intervention for irrigation, electricity, flood control and water supply. In addition, they also believe that it contributes for economic development through creating job, promoting industrial expansion, improving export capability and generally supporting economic growth (Sambo, 2005; Aydin, 2010; Girma, 2000; Parasuraman and Sengupta, 2001).

So, the economic impact of investment on large electricity projects should be examined critically. Ermias et al. (2011) used static computable general equilibrium (CGE) analysis to show the impact of electricity shortage on economic growth in Ethiopia but is unable to account for growth or second effects since infrastructure investments are dynamic (Annabi et al., 2004). Zenebe and Alemu (2011) examined current financing mechanisms and implications of planned infrastructure investments on the country's outstanding debt by using indicator method and ratio analysis.

Analysis of the economy wide impact of investments on infrastructure for electricity involves taking into account the economy wide effects of policy because the introduction of a single shock will have impact on various economic activities as electricity is an intermediate input for almost all activities in the production process. A recursive dynamic CGE model provides good understanding of multiple linkages through which investment on infrastructure for electricity affects the economy (Dissou and Didic, 2011). It allows for analysis of general equilibrium impact of investment on infrastructure for electricity and its financing implications. Therefore, this paper aims to analyze the economy wide impact of investment on infrastructure for electricity by using a recursive dynamic CGE model which is believed to be best suited to assess the impact of investment on infrastructure for electricity. More specifically, the objective of this paper is to analyze the economy wide impact of investment on infrastructure for electricity by analyzing its impact on macroeconomic variables of interest such as GDP, real consumption, real investment, exports and imports, trade balance, sectoral indicators and household consumption under different financing options.

The rest part of this paper is organized as follows: Part two discusses theoretical, empirical literature reviews and overview of investment on power projects in Ethiopia. Part three gives methodology of the study and part four present's results and findings of the study and part five concludes and forward policy implications.

2. LITERATURE REVIEW

2.1. Theoretical Literature

There are numbers of literatures demonstrating that energy has significant positive effects on economic growth (Sambo, 2005; Stern, 2004; Mbanda et al., 2011; Morimoto and Hope, 2004; Enang, 2010). According to these literatures energy is widely considered as one of the major sources of economic growth. It improves production and hence productivity, and generates employment opportunities and income. Investment on infrastructure for energy is one of the key determinants of supply of energy. Investment on energy in turn depends on application of new technology and public acceptance of the need for new infrastructure. There are different economic growth models considering energy as an input in the production of output differently. Among them the oldest view is ecological economists view. Ecological economists stem their view of the role of energy in economic growth from the biophysical foundations of the economy. They believe that energy has a significant role in economic growth (Stern and Cleveland, 2004; Stern, 2010). They consider energy as a main factor of production directed by capital and labor (Stern and Cleveland, 2004). They focus on the material basis of the economy and consider capital and labor as intermediate inputs. The next economic growth is mainstream growth theories.

These growth theories consider capital and labor as the only primary factors of production. They focus on the fundamental primary inputs, in particular on physical capital and labor and pay little or indirect attention to the role of energy in stimulating economic growth (Stern, 2004). The starting point for almost all analysis of growth in neoclassical framework is Solow (1956) growth model. This model emphasis on three inputs (capital, labor and technology) to produce output. It gives a little attention to other inputs like land, energy and other natural resources are less important in the production process (Romer, 1996). Capital, labor and effectiveness of labor (technology) combined in the following function to produce output:

$$Y(t)=F(K(t), A(t)L(t)) \tag{1}$$

Where, $Y(t)$ - Output, $K(t)$ - Capital stock, $A(t)$ – Technology and $L(t)$ – Labor, $A(t)L(t)$ - Effective labor.

Arbex and Perobelli (2010) integrated this model and input-output analysis developed by Leontief in late 1920s to introduce energy to economic growth model for Brazil. They used the Cobb–Douglas production function that includes natural resources and integrate with input-output model. The production function is given as:

$$Y_{it} = A_{it} K_{it}^{\alpha i} L_{it}^{\beta i} T_{it}^{\delta i} \tag{2}$$

Where, Y_{it} is sectoral output, A_{it} is technology, L_{it} is labor, K_{it} is capital, and T_{it} stands for energy, αi, βi, $\delta_i > 0$ and $\alpha i + \beta i + \delta_i = 1$.

They assumed the production function displays constant returns to scale. Total factor productivity (TFP) for each economic sector changes overtime at constant rate. The TFP A_{it} for each economic sector changes over time at a constant rate, i.e., $A_{it} + 1 = (1 + g_{Ai}) A_{it}$ (Arbex and Perobelli, 2010). Where, g_{Ai} is exogenous growth rate of TFP in sector *i*.

Sectoral output is equal to aggregate demand of the economy which is the sum of aggregate consumption (C_t), aggregate investment (I_t), government consumption (GOVCON) (G_t) and net export (NE_t).

$$F_t = C_t + I_t + G_t + NE_t = Y_t \quad (3)$$

In the same way, Stern (2010) integrated different approaches and added energy as an input in the growth model by modifying Solow's model. In this setup energy can be either constraint on growth or an enabler of growth based on availability of energy and technological change. Omitting time indices, the model has two equations:

$$Y = \left[(1-\gamma)(A_L^{\beta} L^{\beta} K^{1-\beta})^{\phi} \gamma (A_E E)^{\phi}\right]^{1/\phi} \quad (4)$$

$$\Delta K = s(Y - P_E E) - \delta K \quad (5)$$

Equation (2.5) embeds a Cobb–Douglas function of capital (*K*) and labor (*L*) in a CES function of value added and energy (*E*) to produce gross output *Y*. P_E is the price of energy and γ is a parameter reflecting the relative importance of energy and value added. A_L and A_E are the augmentation indices of labor and energy. Equation (4) assumes that the proportion of gross output that is saved is fixed at *s* and that capital depreciates at a constant rate $\phi = (\sigma-1)/\sigma$, where, σ− is elasticity of substitution between energy and the value added aggregates.

For Stern (2010), economic growth that creates jobs and raises incomes depends on greater and more efficient use of energy.

2.1.1. Infrastructure investment and economic growth

Investment on productive infrastructure is important in maintaining good economic performance. Low level of investment on infrastructure is considered as partly responsible for poor growth performance in developing countries (Dissou and Didic, 2011; Foster, 2008). Power infrastructure emerges as one of the most limiting factors of growth in these countries. So, to stimulate economic growth, investment on infrastructure in the area of energy is important (Barro, 1990).

In general, there are five different ways through which infrastructure can positively contribute for economic growth. These ways are categorized in the supply and demand side.

The first way through which infrastructure affects growth is infrastructure as a direct input of production. The second way is infrastructure as a complement to other factors of production by improving productivity of other inputs and lowering production cost. The third way is infrastructure as a stimulus to factor accumulation determining accumulation of other inputs. The fourth way is infrastructure as a stimulus to aggregate demand by involving significant expenditure during construction and operation. This expenditure increases aggregate demand. In turn increasing demand may affect an economy in different ways. The fifth way is infrastructure as a tool of industrial policy. Sometimes government spend on infrastructure to guide industrial policy. Through one or all of the above channels investment on infrastructure has positive role on economic growth (Fedderke and Garlick, 2008).

2.2. Empirical Literature

Investment on infrastructure facilitates domestic private investment and foreign direct investment by reducing production costs. It has also a positive impact on TFP and it can lead to new production and return opportunities for firms that contribute for economic development. Perrault et al. (2010) constructed a standard CGE model to explore the impact of scaling up infrastructure in six African countries. They conducted simulations on baseline non-productive investments, roads, electricity, and telecoms under different funding schemes and analyzed the most efficient funding mechanism and explored its effect on different macroeconomic and sectoral variables based on comparative analysis. For the electricity sector they conducted two scenarios. Electricity investment funded by income tax and investment funded by the value added tax. The income tax option is more favorable for some countries. In addition, Mbanda et al. (2011) analyzed the impact of public infrastructure investment in South Africa using dynamic CGE analysis under different financing options to finance public infrastructure investment. The results show that financing public infrastructure investment by direct taxation gives better results in terms of impact on aggregate output production, private investment, job creation, and household income. On the other hand, deficit financing seems to result the worst impacts on the economy in terms of above variables.

Galinis and Leeuwen (2000) used a CGE model to analyze the future of nuclear energy in Lithuania using increases and keeping limited nuclear capacity. In the first case export sector, agriculture and bulk goods industry is stimulated. In the second case economic growth is relatively low, especially in the trade (commercial and public) sectors, services, and transport. Dissou and Didic (2011) assessed the growth, sectoral and welfare implications of increased spending on infrastructure in Benin, using a multi-sector inter temporal general equilibrium model with public capital and heterogeneous agents using domestic financing through discretionary taxes and foreign financing through increased foreign aid. The results show that increased public investment on infrastructure has positive impacts on private investment for all agents in the long run irrespective of financing method.

Strzepek et al. (2006) analyzed the economic impact of high Aswan dam in Egypt. In their study, they used a CGE model of the Egyptian economy to estimate the impact of the High Aswan Dam. The results of simulations show how Egypt's economy would have performed in 1996/97 without the dam. The shock is applied to agriculture, transport, tourism, and power generation. According to their result, if the High Aswan Dam were not there, agriculture gains (especially summer crops with high value) and the burden of the shocks falls on the non-agriculture sectors, with declines in power, transportation, and tourism. Furthermore, Aydin (2010) analysed economic and environmental impact of hydropower construction in the Turkish economy and analyzed the potential long-term impacts of a hydro power expanding shock on some macroeconomic variables such as GDP, real consumption, real investment, exports, imports and trade balance under policy scenario of doubling hydro power generation. The results of the study show that such shocks have positive impacts on economic growth.

In general, this section revealed that investment on infrastructure has significant impact on economic growth. It has substantial impact on household income, job creation, investment and overall aggregate output production. Specially, improving the supply of energy has strong effects on sectoral output, trade balance, private investment and overall economic growth. Therefore, analyzing the impact of investment on infrastructure for electricity in Ethiopia using dynamic CGE model is worthwhile.

2.3. Overview of Investment on Power Projects in Ethiopia

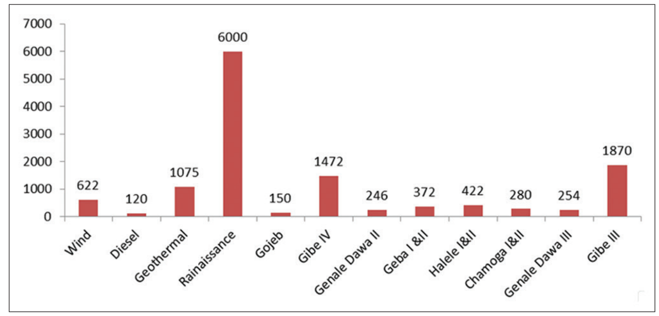
Ethiopia has been investing on mega power projects since 2008. Currently electricity generating capacity of the country is 2268 MW. In the second growth and transformation plan, government is planning (2015-2020) to increase the generating capacity of the country to 15000 MW. More than one third of total generation capacity will be from Renaissance dam which is expected to generate 6000 MW and will be completed in 2017. The dam will have 15 units each with a 350 MW capacity, On the other hand, the total electricity production from this dam is expected to be 15,128 GWH on annual basis. Next to Renaissance dam, Gibe III and IV are expected to generate more than 3000 MW power (Figure 1).

In the planned investments there are also wind and geothermal projects which are expected to generate 622 MW and 1075 MW after completion, respectively (Figure 1). Corbetti geothermal power project is the only private foreign energy project in Ethiopia. The first phase of Corbetti geothermal power project will be completed in 2022 having 500 MW generating capacity[1]. Therefore, from the mix of investment on different sources of energy one can understand there is diversification of energy sources in the planned investment which will help reduce risk and uncertainty in the time of drought.

The main challenges of this ambitious electricity investment are financing sources. The country's power infrastructure needs are massive and would require approximately 41 billion birr per year from 2011 to 2015 requiring total budget of 207 billion birr. This budget does not include Aluto Langano geothermal and MDS1 projects (Appendix A). 62% of the budget is planned to finance capital expenditure and 38% of it is to finance operation and maintenance costs and administrative salaries (will be financed by EEPCo's internal financing sources). In addition, for the coming

1 http://www.rg.is/en/frettir/bloomberg-reykjavik-plans-to-start-2-billion-ethiopian-power-project.

Figure 1: Planned investment projects and their generating capacity in MW



Source: EEPCo, 2013

5 years (2015-2020) 410 billion birr is planned to be injected to power sector. From the projects, Renaissance Dam will require 79 billion birr and expected to be financed domestically through domestic grants and bond selling since there are no financing sources from abroad. Almost all other projects are going to be financed through foreign loans.

As the supply of electricity increases (power outages decreases), TFP of the firms increase because investment on electricity has positive externality to the industrial and service sectors. In general, infrastructure contributes some 53% of TFP of firms in Ethiopia (Eberhard et al., 2011; Foster and Morella, 2010). According to Escribano et al. (2009), 20% improvement in infrastructure in Ethiopia leads to improvement of average productivity of firms by 6.3%. From infrastructure contribution to TFP of private firms, electricity covers almost 80%. Therefore, it is difficult to think of any firm in either industry or services that would not rely on electricity. Looking at the demand section of the activity level in the 2005/06 Ethiopian SAM in Appendix A, the industrial and services' sectors are the main users of electricity (EDRI, 2009). Agricultural activities, fetching water and real estate activities do not use electricity in the production.

3. METHODOLOGY AND DATA

3.1. Data

The CGE model follows the SAM disaggregation of activities, commodities, factors and institutions (Lofgren et al., 2002). This study has used the updated 2009/10 SAM and introduced policy shock until 2018/19. The updated SAM is produced in different level of aggregations. It is disaggregated into 113 activities (with 77 agricultural activities by agro ecological zones), 64 commodities, 16 factors, and 13 institutions including 12 households (EDRI, 2009). To see economic impact of investment on infrastructure for electricity, we used elasticity of TFP with respect to electricity investment estimated by Eberhard et al. (2011) in Mali based on comparisons of delay to obtain electricity, power outages for firms and share of firms that use their own generator in 2006 with Ethiopia (WDI, 2009).

3.2. Method of Analysis

A recursive dynamic CGE model is used for this study because this model is based on adaptive expectation which is more relevant for developing countries. It is also best suited to assess the long run energy infrastructure investment impact (Palstev, 2004). It also offers an economy-wide assessment of policies, including the concurrent effects of policy-changes (Thurlow, 2004). Investment demand and saving investment balance of the model is adjusted to go well with this study. Quantity of fixed investment (FIXINV) demand represented by $QINV_c$ in the model was disaggregated to investment demand in electricity sector ($QINV$E0[C]) and non-electricity sectors (all sectors except electricity) ($QINV$NE0[C]). So, investment shock in electricity sector directly flows to capital accumulation of the sector because the capital accumulation equation was also adjusted in the same way. In line with disaggregation of investment, financing options were also adjusted. The policy shocks are introduced in in saving – investment balance equation and current account balance (in foreign currency).

Saving – investment balance equation:

$$\sum_{i \in INSDNG} MPS_i (1 - TINS_i).YI_i + GSAV + EXR.\overline{FSAV} = \sum_{c \in C} PQ_c.QINV_c + \sum_{c \in C} PQ_c.qdst_c \tag{6}$$

Where, $TINS_i$ is direct tax rate for institution i, YI_i is income of institution i, MPS_i is marginal propensity to save of institution I, $GSAV$ is government saving, EXR is exchange rate, $FSAV$ is foreign saving, PQ_c is composite commodity price, $QINV_c$ denotes quantity of FIXINV demand for commodity and $qdst_c$ represents the quantity of stock changes (Thurlow and Van Sevnter, 2002).

Current account balance equation:

$$\sum_{c \in CM} pwm_c.QM_c + \sum_{f \in F} trnsfr_{rowf} = \sum_{c \in EC} pwe_c.QE_c + \sum_{i \in INSD} trnsfr_{irow} + \overline{FSAV} \tag{7}$$

Where, $\overline{FSAV}$ denotes foreign saving (in foreign currency unit), PWM_c is domestic import price of commodity c is the product of world import price of c, pwe_c is free on board export price, QM_c is quantity of commodity import, QE_c is quantity of commodity export, $trnsfr_{irow}$ is transfer from the rest of the world and $trnsfr_{rowf}$ transfer to the rest of the world.

4. SIMULATIONS AND RESULTS

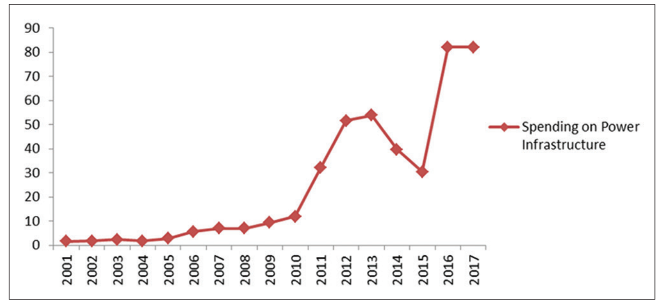
4.1. Descriptions of Simulations

The investment spending on infrastructure for electricity has been growing at 30% on average for each year compared to 2009[2]. This growth rate is computed from Figure 2. So, 30% increase in investment in electricity results with above financing rate and improvement in TFP of industrial, service and construction sectors in a given period of time (Table 1).

Accordingly, Simulation 0: The base case scenario is established to serve as a reference in an absence of any policy shock and serves as a benchmark for policy evaluation (assumes the status qua continues).

2 It does not include spending expected to be financed by EEPCo own sources.

Figure 2: Spending on power infrastructure (in billion birr)



Source: From EEPCo, 2013 and African Utility Weak, 2015[3]

Simulation 1: If domestic household and enterprise saving and other investment (non-electricity investment) grow at base line rate, to finance investment in electricity foreign saving rate grows at 26% each year (Table 1).

Simulation 2: If foreign saving rate and non-electricity investment grows at base rate, domestic household and enterprise saving rate has to grow at 12.7% (Table 1).

Simulation 3: In the case mix of foreign and domestic households and enterprise savings are used they have to grow at 15% and 7.9%, respectively (Table 1).

4.2. Effects on Macroeconomic Variables

In Table 2 we present the summary of the results from our simulation exercise for the major macroeconomic variables. These variables are real GDP at factor cost (GDPFC2), FIXINV, private consumption (PRVCON), GOVCON, real exports and real imports.

In all simulations, the macroeconomic variables have shown positive changes. In Simulation 1, a real GDPFC reveals 1.31% increase from base line simulation. It grows by 11.95%. This is largely driven by rising in real investment and PRVCON. Real investment and PRVCON increase by 6.06% and 1.52% compared to base line simulation, respectively.

Compared to the other simulations in this study, the growth rate of consumption is highest. This might be due to the fact that, inflow of additional resources to the economy from the rest of the world increase domestic consumption. When electricity investment is financed through increased foreign saving rate (loan), it increases financial inflow to the country which in turn leads to a raise PRVCON. Increase in PRVCON in turn contributes more to GDP growth.

In Simulation 2, as shown in Table 2, real GDPFC grows at 1.56% more than base line simulation. It is the highest growth rate compared to Simulation 1 and 3. Increase in growth rate of GDP, in this case, is explained by an increase in real investment and real

3 http://www.african-utility-week.com/industrynews?page=2.

exports though there is a lower growth rate of real PRVCON. Real FIXINV and real export increase by 5.98% and 4.32% compared to the base line simulation, respectively. So, increase in real export and FIXINV offsets decrease in PRVCON and leads to increase in growth rate of real GDPFC. The lowest growth rate of PRVCON is, however, registered in this simulation. It grows at negative rate (0.15% less than base line simulation) since part of disposable income to be spent on consumption goes down that explains the decrease in the real PRVCON.

Finally, in Simulation 3, real GDPFC increases by 1.49% compared to the base line simulation. The reason for increase in growth rate of real GDP is an increase in growth rate of FIXINV and real export. It results in better GDP growth rate than investment fully financed through increased foreign saving rate. Similarly, real PRVCON grows at positive growth. It has risen by 0.64% compared to base line simulation.

4.3. Impact on Trade Balance

In Simulation 1, as it is explained in section 5.3, the real export increases by 0.27% compared to base line simulation. It is the least growth rate compared to Simulation 2 and Simulation 3. This might be due to an appreciation of real exchange rate. Increase in foreign loan to the economy appreciates the real exchange rate by raising price of non-tradable goods as the increased financial resources inflow increases spending on non-tradable goods and services. In fact, the real exchange rate appreciates by 3.93%. Appreciation of the real exchange rate may reduce competitiveness of the trade sector. Since there is an inflow of funds, we import more and export less. In other words, export firms become less profitable because their revenue declines as they sell at the world market price (in dollars) and their costs measured (in local currency) rise. As a result, economic resources may move from the tradable to the non-tradable sector resulting in a contraction of the tradable sector and expansion of the non-tradable sector. As can be seen from Appendix B, the real exports of all activities have declined. However, real exports of leather, textile, chemicals, chat, crops, dairy and pulse, among the others, have declined at the highest rate. Though the real exchange rate is appreciated, the real export grew at a positive rate. This could easily be attributed to the TFP effect of investment in electricity on industrial and service sectors that improves their output. So, positive supply side effects of this investment on the productivity of the private sector overcome the possible negative impact of the appreciation of the real exchange rate. Unlike the real export, the real import has registered the greatest growth rate in this simulation. It increases by 4.08% compared to base line simulation. This may be partly explained by increase in resource inflow that increases domestic demand. According to Appendix C, real imports of machinery, leather, dairy, crops, wheat and non-metallic commodities have risen more than other commodities.

In Simulation 2, real export grows by 4.32% more than the baseline simulation. It is the greatest growth rate compared to other simulations because possible combined effects of increase in factor productivity and the least appreciation of the real exchange rate improve real export. Import has, however, the least growth rate in this simulation with a growth rate of 15.13%. In Simulation 3, the growth rate of real export is greater than that obtained in Simulation 1 because the appreciation of the real exchange rate is lower. It has grown by 2.38% more than Simulation 1. Real exchange rate has appreciated by 2.12%. So, the possible combined effect of increase in TFP and lower appreciation of the real exchange rate result in positive growth of real export.

Using percentage change in real exports and real imports from simulation results we can analyze the impact of investment on electricity on percentage change of trade balance of the country. In all simulations, the average growth rate of exports is greater than average growth rate of imports. This will lead improvement in average growth rate of trade balance. As we can see from Figure 3, there is improvement in the growth rate of trade balance in the case of Simulation 2. Financing investment on electricity by using domestic household and enterprise saving increase percentage change of trade balance than financing investment on electricity through increased foreign saving (foreign loan).

Table 1: Simulation values

Simulations	Household and enterprise saving growth rate (%)	Foreign saving growth rate (%)	TFP for industry (%)	TFP services (%)	TFP construction (%)
Simulation 0 (BASE)	4	6			
Simulation 1 (FSAV)	4	26	3	1.65	2.25
Simulation 2 (HESAV)	12.7	6	3	1.65	2.25
Simulation 3 (BOTH)	7.9	15	3	1.65	2.25

Own computation from EEPCo Data, 2013, TFP: Total factor productivity

Table 2: Impact on macroeconomic variables

		Average % change per year			
Variables	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
PRVCON	338.61	9.20	10.72	9.05	9.84
FIXINV	85.49	12.45	18.51	18.43	18.47
GOVCON	31.82	5.70	5.70	5.70	5.70
EXPORTS	52.14	20.07	20.33	24.39	22.71
IMPORTS	−126.51	12.39	16.47	15.13	15.71
GDPFC2	354.95	10.64	11.95	12.20	12.16
REXR	1	−1.59	−3.93	−2.12	−2.87

Source: Simulation results, GDP: Gross domestic product factor cost, PRVCON: Private consumption, FIXINV: Fixed investment, GOVCON: Government consumption

4.4. Sectoral Effects of Investment on Electricity

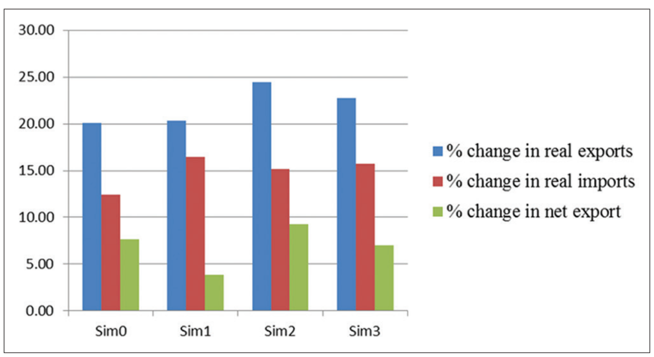
Average percentage change in output from base line simulation of all sectors is depicted in Table 3. Output of all activities in the agricultural, industrial and service sectors are aggregated to get total output of the sectors. Then average percentage change in output for each sector is calculated from aggregate output growth. Accordingly, among the sectors, the largest expansion is shown by the industrial sector. This is because the industrial sector is one of the major users of electricity as an intermediate input in its production. Therefore, TFP of industrial sector improves more following investment on electricity shock and it explains expansion of the output in the sector. Among the activities in the sector, output of metal, machinery, vehicles, electronic equipment and paper manufacturing have recorded the fast growth rates. The highest growth rate of output is, however, expected in metal manufacturing (Appendix D).

Service sector is the second in growth. Among the subsectors the construction, transport and whole sale and retail trade registered higher growth rate. The largest output growth rate is, nevertheless, registered by the construction sector (Appendix E). The investment on electricity, on the other hand, has the least effect on the agricultural sector because agricultural sector does not use electricity as an intermediate input in its production processes.

4.5. Impact on Household Consumption Expenditure

As shown in Table 4, compared to the base line simulation, household consumption has improved more in Simulation 1. It has increased by 1.55%. However, it has recorded negative growth in Simulation 2. Total average consumption of all households in both rural and urban areas has declined by 0.16%. Decline in their consumption in general is due to increase in marginal propensity to save. The urban non-poor and rural poor households have recorded negative growth. Decrease in consumption of the urban non-poor households is due to increase in saving rate while decrease in the consumption of the rural poor may be due to decrease in income of agricultural labor. Therefore, household consumption raises more with investment on electricity that is financed through increased foreign savings than in the case where it is financed through increased domestic households' and enterprises saving, since financing investment on electricity through increased foreign saving increases resource inflow to the country. Nevertheless, as foreign savings are in the form of loans that are to be repaid, it may increase consumption for the short time (temporary). Thus, household consumption may be chosen as the preferred indicators for the more enduring gains from increased foreign savings.

Figure 3: Average % change in trade balance



Source: Simulation results

It also affects consumption expenditure of household by affecting their consumption. Consumption expenditure is the product of commodity consumed by households and average output price. In Simulation 1, consumption expenditure of all households records a positive growth. The negative growth rate of aggregate consumption expenditure is, however, recorded in Simulation 2 partly due to increase in saving rate and decrease in income of some groups of households. Except for urban non-poor, consumption expenditure of all households' has risen in Simulation 3.

Overall, compared to the other simulations consumption expenditure has grown at the highest rate in Simulation 1 (Table 5).

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study is attempted to examine economy wide impact of investment on infrastructure for electricity using a recursive dynamic CGE model. The study used an updated version (2009/10) of the 2005/06 EDRI social accounting matrix. We used three simulations to evaluate economy wide impact of this investment.

Table 3: Sectoral impact of investment on electricity

	Sectoral impact (average % change per year)			
Sectors	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Agriculture	7.20	7.49	7.09	7.39
Industry	13.9	16.01	17.01	16.41
Service	13.4	15.4	16.0	15.8

Source: Own computation from simulation results

Table 4: Impact on household consumption

	Average % change per year				
Households	Initial (billion birr)	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Rural poor	70.18	9.67	10.29	9.11	9.68
Rural non-poor	237.96	9.19	10.35	9	9.65
Urban poor	3.43	8.24	9.54	7.92	8.71
Urban non-poor	27.04	6.31	7.31	3.55	5.43
Total	338.61	9.2	10.75	9.04	9.95

Source: From simulation results

Table 5: Impact on aggregate house consumption expenditure (% change from Simulation 0)

Households	Initial (in billion birr)	Share (%)	Simulation 1	Simulation 2	Simulation 3
Rural poor	70.18	20.7	0.62	−0.56	0.01
Rural non-poor	237.96	70.3	1.16	−0.19	0.46
Urban poor	3.43	1.0	1.30	−0.32	0.47
Urban non-poor	27.04	8.0	1.00	−2.76	−0.88
Total	338.61	100	1.05	−0.47	0.26

Source: Simulation results from CGE model, CGE: Computable general equilibrium

Such as, investment on electricity fully financed with increased foreign saving rate (loan), investment on electricity fully financed through increased domestic households' and enterprise savings rate and investment on electricity financed partly by increased domestic saving and partly by increased foreign savings rate (50% of spending by domestic household and enterprise saving and 50% of it by foreign loan) to assess impact of investment on electricity on aggregate macroeconomic variables, trade balance, sectoral output and household consumption. The results of model reveal that investment on infrastructure for electricity would be valuable to ensure faster economic growth in all scenarios.

Financing the investment on electricity by foreign saving has a positive impact on real GDPFC. Real GDPFC has increased by 1.31% compared to the base line simulation (business as usual). Sectoral effects also confirm increase in output. Nevertheless, the growth rate of real GDP is lower compared to investment on electricity that is financed by increased domestic household and enterprise saving and a combination of domestic (household and enterprise) and foreign savings due to slower growth in real export. It has also a positive highest impact on household consumption compared to Simulation 2 and 3. However, a scheme of investment on electricity that is fully financed by increased foreign saving deteriorates the average growth rate of trade balance by appreciating the real exchange rate and leads to contraction of real exports.

The largest growth rate of real GDP is revealed in the case of investment on electricity financed by increased domestic household and enterprise saving (Simulation 2). It has risen by 1.56% compared to base line simulation. This is due to the fact that increases in growth rate of real export and FIXINV offset decrease in real PRVCON. Moreover, this investment has positive effects on output of the industrial and service sectors. However, it affects household consumption negatively and deteriorates the welfare of households. In the last simulation, where the investment on infrastructure for electricity is financed partly by domestic household and enterprise saving and partly by foreign saving, GDPFC has grown at positive rate. It has increased by 1.52%. Average aggregate household consumption and consumption expenditure have also grown at positive rate. Investment financed by increased foreign saving (foreign loan) will be associated with appreciated real exchange rate contributing to slower growth in real export even though it increases welfare of households. In addition, since foreign loan is expected to be repaid, it will raise probability of indebtedness of the country. On the other hand, meeting the full financing requirements of this investment through mobilizing domestic household and enterprise saving is difficult. So, financing the investment on infrastructure for electricity partly by increased domestic household and enterprise saving rate and partly by increased foreign saving rate would be worthwhile.

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APPENDIX A

Appendix A: Electricity use in different activities of industry and service sectors

Activities	Electricity use ('000000 birr)
Industrial activity	
Mining and quarrying	37.876
Grain mill production	13.291
Other food manufacturing	37.076
Beverage manufacturing	17.698
Tobacco manufacturing	769.2
Sugar manufacturing	5.383
Wood manufacturing	1.927
Vehicle manufacturing	1.202
Wearing apparel	1.425
Leather manufacturing	11.327
Textile manufacturing	37.223
Electrical equipment	0.055
Machinery and equipment manufacturing	0.095
Chemicals manufacturing	26.229
Basic metal manufacturing	12.916
Mineral products manufacturing	58.749
Paper products manufacturing	12.695
Sugar refining	5.388
Tea processing	1.872
Service sector activities	
Education	35.611
Communication	4.656
Transport	24.74
Hotel and catering	99.21
Whole sale and retail trade	187.01
Trade	
Construction	7.282
Business services	0.744
Public administration	169.05
Other private services	4.842
Milling services	93.721

APPENDIX B

Appendix B: Average % change in real exports

Commodity	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Pulse	0.35	2.77	−3.25	1.51	−0.52
Coils	2.73	5.53	4.9	5.53	5.27
Vegetable	0.1	1.33	−2.77	0.5	−0.89
Fruits	0.08	5.85	0.54	5.35	3.38
Chat	0.97	−8.5	−21.14	−9.37	−14.65
Coffee	5.48	5.95	2.62	5.8	4.48
Flower	0.34	4.66	4.58	4.68	4.64
Crops	0.56	−0.16	−8.68	−1.17	−4.45
Cattle	0.66	−7.03	−11.33	−7.37	−8.77
Milk	0.02	−16.42	−24	−16.9	−19.56
Poule	0.05	−3.27	−5.97	−3.54	−4.33
Vegetable protein	0.32	−1.32	−4.83	−1.55	−2.73
Fish	0.15	2.41	0.01	2.05	1.22
Dairy	0.03	−16.35	−24.38	−16.78	−19.62
Milling	0.66	18.93	14.05	20.64	17.59
Sugar	0.07	30.16	9.79	30.82	24.16
Tea	0.06	1.23	−3.74	1.58	−0.89
Food	0.16	−2.55	−7.68	−2.32	−4.86
Beverage	0.14	28.43	25.37	30.82	28.91
Tobacco	0.05	34.51	33.21	39	36.83

Cond...

Appendix B: ***(Continued...)***

Commodity	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Textile	0.84	−0.17	−4.44	−0.2	−1.97
Cloth	0.11	50.43	47.43	61.64	55.5
Leather	1.02	1.14	−10.79	1.57	−3.41
Wood	0.01	19.95	14.29	22.97	19.28
Paper	0.35	31.54	35.09	39.35	37.62
Chemical	0.5	29.19	21.95	28.98	26.05
Metal	2.87	25.65	29.6	35.43	33.08
Vehicle	0.4	14.5	18.2	19	18.73
Electrical equipment	0.65	16.29	20.64	22.1	21.52
Trade	1.15	14.01	15.89	17.15	16.65
Hotel	1.51	9.95	11.03	9.98	10.53
Transport	19.08	25.95	27.42	30.48	29.2
Communication	1.45	14.98	14.88	17.32	17.03
CFSRV	0.91	13.8	15.35	16.12	15.86
Business service	1.41	27.52	27.16	34.18	31.05
Real state	0.37	13.05	12.73	13.13	13.03
Other services	0.22	10.41	11.97	12.39	12.28

Sources: Simulation results from CGE model. CGE: Computable general equilibrium

APPENDIX C

Appendix C: Average % change in real imports

Commodity	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Wheat	6.65	16.88	25.55	17.89	21.32
Pulse	1.16	14.04	21.36	14.86	17.71
Teal	0	34.89	38.04	34.93	36.49
Tobacco	0.13	23.39	25.01	26.03	25.62
Crop	0.85	16.38	24.95	17.3	20.7
Poul	0.02	16.58	21.59	16.66	18.7
Fish	0.01	12.28	15.9	12.07	13.8
Coal	0.02	20.27	17.67	20.59	19.35
Gas	0.07	9.18	11.97	8.69	10.18
Mineral	1.86	11.22	18.41	17.95	18.2
Dairy	0.44	32.2	44.82	32.77	37.51
Vegetable protein	1.9	10.05	12.2	10.01	11.02
Grain mill	0.28	3.13	7.65	2.29	4.79
Sugar	0.8	21.33	23.92	22.25	22.96
Tea	0	16.76	23.26	16.51	19.71
Food	1.43	14.89	20.4	14.74	17.4
Beverage	0.56	7.18	9.57	6.88	8.12
Tobacco	0.22	7.98	10.79	7.69	9.12
Textile	4.38	13.11	16.53	13.96	15.04
Cloth	3.07	5.91	8.9	5.13	6.84
Leather	0.5	15.07	23.56	15.33	18.81
Wood	0.97	10.69	16.21	14.22	15.11
Paper	2.27	9.12	11.09	10.49	10.76
Petrolem	20.92	15.63	18.59	19.34	19.04
Fertilizer	4.74	8.21	8	7.96	8.03
Chemical	12.42	10.76	13.38	11.95	12.59
Metal	5.27	9.72	17.11	15.73	16.34
Metal works	13.08	13.48	17.49	18	17.79
Machinery	8.88	12.41	18.47	18.36	18.42
Vehicle	8.78	11.52	15.69	15.15	15.4
Electrical equipments	10.68	10.36	13.96	11.86	12.81
Construction and manufacturing	1.66	5.99	9.85	5.86	7.57
Trade	0.2	11.79	14.83	14.62	14.69
Hotel	1.28	9.84	11.61	9.89	10.71
Transport	22.42	11.28	13.95	13.65	13.8
Communication	0.97	9.7	12.94	10.82	11.58
CFSRV	1.23	9.74	13.08	11.63	12.27
Business services	5.09	11.89	14.28	14.39	14.34

Sources: Simulation results from CGE model. CGE: Computable general equilibrium

APPENDIX D

Appendix D: Impact on real output of industrial sector (percentage change)

Activity	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Mineral	2.57	13.36	15.08	15.08	15.08
Dairy	12.05	5.32	5	5.26	5.36
Vegetable protein	0.02	8.24	9.26	8.23	8.69
AGMLL	2.05	13.55	11.72	14.51	13.13
Milling service	2.32	15.56	18.78	16.57	17.62
Sugar	2.74	6.42	5.78	6.08	5.94
Tea	0.41	7.78	8.53	7.76	8.11
Food	6.66	5.81	5.79	5.82	5.81
Beverage	5.05	12.85	14.13	13.43	13.81
Tobacco	0.64	18.3	19.66	20.51	20.17
Textile	4.6	5.12	4.43	5.42	4.99
Cloth	1.17	27.44	27.54	33.56	30.79
Leather	2.69	5.42	1.48	5.72	3.99
Wood	0.32	14.74	15.09	17.98	16.79
Paper	2.06	21.84	24.86	27.12	26.2
Chemical	3.15	20.31	17.69	20.63	19.38
Non-metal	2.29	16.37	15.56	17.24	16.57
Metal	7.08	21.14	25.49	29.45	27.81
Machinery	0.03	13.57	19.04	19.35	19.26
Vehicle	0.81	13.72	17.55	18.02	17.87
Electrical equipments	0.81	15.8	20.1	21.37	20.87
Construction and manufacturing	6.12	11.52	14.27	12.65	13.42

Sources: Simulation results from CGE model. CGE: Computable general equilibrium

APPENDIX E

Appendix E: Impacts on real output of service sectors (percentage change)

Activity	Initial	Simulation 0	Simulation 1	Simulation 2	Simulation 3
Electricity	3.58	14.65	16.91	15.58	16.25
Water	3.92	11.59	13.65	12.97	13.56
Construction	85.1	12.21	17.51	17.38	17.45
Trade	90.02	12.91	15.37	15.89	15.68
Hotel	40.9	9.9	11.31	9.93	10.62
Transport	24.6	24.88	26.4	29.32	28.09
Communication	4.03	13.42	14.27	15.43	15.42
AFSRV	10.5	11.96	14.32	14.08	14.23
Business service	1.41	27.52	27.16	34.18	31.05
Real state	37.01	11.61	12.98	12.15	12.56
Other services	6.86	10.6	12.67	11.87	12.28
Administration	20.64	5.77	5.82	5.78	5.8
Education	11.08	6.29	7.08	6.8	6.93
Health	3.23	6.81	7.75	7.34	7.54

Sources: Simulation results from CGE model. CGE: Computable general equilibrium