Renewable and Sustainable Energy Reviews 57 (2016) 1260–1269

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Ghanaian energy economy: Inter-production factors and energy substitution

Boqiang Lin [a,*], Philip Atsagli [b], Kingsley E. Dogah [c]

[a] Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, Xiamen University, Fujian, 361005, PR China
[b] The School of Economics, China Center for Energy Economics Research, Xiamen University, Xiamen, Fujian, 361005, PR China
[c] Wang Yanan Institute for Studies in Economics, Xiamen University, Xiamen, 361005, China

ARTICLE INFO

Article history:
Received 24 November 2014
Received in revised form
26 September 2015
Accepted 17 December 2015
Available online 8 January 2016

Keywords:
Energy economy
Energy substitution
Factor substitution
Ghana

ABSTRACT

Industries in Ghana depend highly on petroleum to fuel their operations which has brought immerse environmental threat from greenhouse emission gas (GHG). This study tried to investigate potential substitutability of factor inputs and fuel inputs among capital, labor, petroleum and electricity in Ghana by adopting the translog production and cost function approach. We used Ridge regression technique to estimate the parameters after our data show possibility of multicollinearity. Our result shows that, all inputs are substitutes with their relative technological progress also showing evidence of convergence. This suggests that, redirecting resources into the improvement of technology towards cleaner energy production like electricity will be a success over time and this will mean that the fueling of the economy will be done in a cleaner environment and mitigating mitigate CO_2 emissions as well. The improvement of electricity production and the promotion of its use require government policies that will enable industries to adjust to the switch from one input to the other through capital subsidies and tax rebates. Also, energy-labor and capital-energy being substitutes in our findings suggest that, removal of all energy subsidies will reduce the use of energy and increase capital and labor intensiveness. Input switch by industries will promote merger of smaller firms with bigger firms that have cost advantage during the switch period and requires a clear government merger control policies.

In a nutshell, our findings provide an insight into policies to promote the use of renewable energy, energy intensity and merger policies.

Contents

* Corresponding author at: Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, Xiamen University, Fujian, 361005, PR China. Tel.: + 86 5922186076; fax: +86 5922186075.
E-mail addresses: bqlin@xmu.edu.cn, bqlin2004@vip.sina.com (B. Lin), atsaglip@yahoo.com (P. Atsagli), dogah.kingsley@yahoo.com (K.E. Dogah).

http://dx.doi.org/10.1016/j.rser.2015.12.160
1364-0321/

1. Introduction

All socio economic activities in Ghana are propelled by energy which promotes commercial and industrial activities with the aim of delivering basic social services. Indeed, energy is an important contributor to Ghana's economy and provides not only an immerse contribution to the gross domestic product (GDP) of Ghana but also provides vital support to some key sectors of the economy which includes transportation, agriculture, health, education, tourism, fiscal revenue, food security, regional development and employment.

Notwithstanding the dominance of petroleum products in the Ghanaian energy mix, currently driven by the discovery of oil in commercial quantities, poses serious environmental concerns. For instance, the energy consumption mix in the industrial sector in 2010 was estimated to be about 85% petroleum products and electricity accounting for only 15% (Source; UN report on Ghana 2010) [1]. This has led to an increase in the level of energy-related CO_2 emissions (see Fig. 1). The amount of CO_2 emissions increased from 2.227 million tons in 1980 to 9.005 in 2011 representing 304.4%. (Source; international energy statistics, US Energy Information Administration EIA) [2]. Since 2005, average CO_2 emission growth rate from petroleum has been about 5.2% p.a. (Source; EIA) which has called for an urgency to control energy related emissions. Given the continuous growth of the Ghanaian economy (ADB 2013) [3], coupled with the increase in petroleum and electricity use (from 3,800,000billion British Thermal Unit (BTU) and 14,027.47 billion BTU respectively, in 1987, to 129,000,000 billion BTU and 28,740.873 BTU in 2012 representing 3294.7% and 104.8% increase respectively) (EIA), the rate of CO_2 emissions is expected to further increase. Though Ghana's emission contribution to global warming is less than the international standards, the country could be proportionately affected should climate change continue looking at the indicators of Ghana.

Numerous efforts by interest groups calling for emissions control have not been very successful. In Ghana there have been various policies enacted to control some of the emission issues and also to switch to a cleaner energy to fuel the economy (see in Table 1). Though all these policies are in place, some have actually not been implemented with others in the process of implementation.

The success of initiating these policies will largely depend on the extent of the amount of substitutability going on between different factors of production and fuel types. Inter-fuel substitution, sustainability of energy and other factors of production are greatly influenced by the effects of output growth and changing fuel prices on the demand for energy. These issues have generated numerous debates and have drawn a large attention to the number of energy demand studies with the greater number of these research studies focusing on developed economies.

Carrying out this research study on Ghana is very timely and significant for various reasons. First, due to the increasing demand for energy inputs and classical factor as the economy grows and expands; there is the need to match future demand forecast with the necessary future supply. In matching these future demand and supply forecasts, much attention should be given to both energy consumption and the level of inter-fuel and inter-factor substitution possibilities over time. To be precise, results of future forecasts for energy demand are more reliable when the demand models consider elasticity of substitution taking place over time. Second, to construct computable general equilibrium (CGE) model for Ghana's energy economy, the previous estimate could be of importance. There is a slight variation between general CGE models and CGE models that focus on energy. While the general one uses production function through constant elasticity of substitution (CES) forms where output is made up of (CES) combination of energy and non-

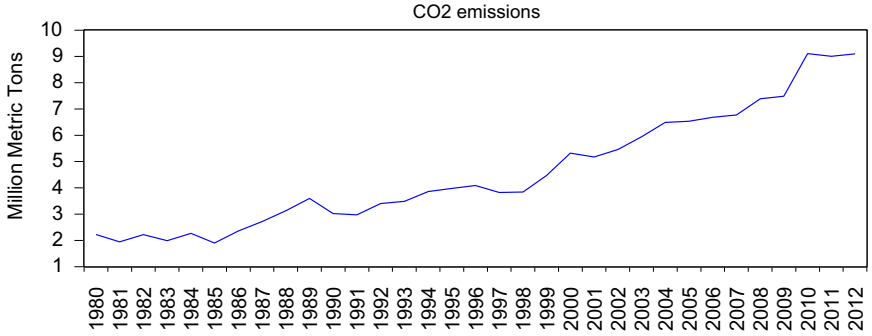

Fig. 1. CO_2 emissions from petroleum consumption in Ghana (Million Metric Tons) Source US EIA database.

Table 1
Policies put in place by government to promote the use and development of cleaner energy sources. (Source: Ghana energy commission and UNDP).

Year	Policy
1990	National LPG program (instituting a pricing scheme called uniform petroleum price fund where taxes on gasoline sales are used to cross subsidize LPG and also offering incentives for sales of LPG at locations more than 200 km from the Tema oil refinery)
1999	Renewable energy service program – RESPRO (direct investment into energy infrastructure for solar and solar photovoltaic).
1998	Renewable energy tax and duty exemption program (duty free and tax relief for all renewable energy inputs and equipment and tax relief for renewable energy investments).
2005	National renewable energy policy (accelerating the development and utilization of renewable energy so as to achieve 10% penetration of electricity and supplementing petroleum supply from biodiesel).
2006	Strategic national energy plan – SNEP (supporting strategic plans for multiple renewable energy sources)
2007	Ghana energy development and access project – GEDAP (providing grants, subsidies tax reliefs and economic instrument for private investment into wind, solar and solar photovoltaic projects).
2007	National electrification scheme – NES (promoting research and development with financial incentives for wind, solar generation for electricity)
2010	Ghana national energy policy (promoting hydropower, solar, geothermal, and biofuel for transportation and electricity generation)
2011	Renewable energy act – Act 2011, act 832 (provide physical incentives and regulatory framework to encourage private sector investment into renewable energy projects)