Rethinking Regional Energy Policy: Towards Averting Another Energy Crisis. Do Threats Matter in The Supply and Generation Process?

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Abstract
The study investigates potential threats to energy security and sustainable electricity production from a regional perspective, after identifying a host of factors that are likely to affect sustainable energy production and supply using seemingly unrelated regression estimation, which produces efficient estimates by solving two unrelated regression simultaneously. Our results show that the identified threats to energy generation matter. Energy security which we described as the level of diversification in regional specific energy generating sources is probably being affected by regional specific level of industrialization and domestic energy consumption. Issues of over dependence on specific sources of energy supply (particularly nuclear production sources) were also found to have a negative effect on energy security and probably increase the risk of future failure in energy supply. Energy policy was also found to have a significant effect on energy security. The impacts of various constraints on electricity production were also considered. It was found that many factors affect electricity output production in regions particularly environmental factors that affect consumption and the generation process.
Keywords: Energy Security, Electricity production, Seemingly Unrelated Regression

1.0 Introduction

According to the United Nations energy report 2012, World energy consumption is likely to double by the year 2050. One of the greatest challenges for stake holders and policy makers is how to meet global -energy demands- and keep -world temperatures- from increasing by over 2 degrees Celsius through the reduction of green house gases. Promoting energy security has continually been one of top concerns, to many governments and energy security experts. According to the IEA report 2011 -energy security- can be defined as the ability to provide access to sustainable and -cheap supply- of energy for domestic consumption.

A host of threats often affect energy supply and production some include, weak energy policies, environmental constraints that affect energy supply, availability and use, regional specific industrialization rate, domestic energy consumption characteristics, regional investment in domestic innovation such as alternative energy generating sources and other climatic concerns. Over dependence on fossil fuel today also continue to remain a strong threat to achieving sustained and affordable energy for both domestic and industrial uses in countries. The convenience and advantage of using gas as a means of powering electricity turbines and for heating purposes also mean that countries particularly those in the industrialized west (e.g. particularly Europe) will continue to be highly susceptible to gas supply disruption for years to come.

Over the years, energy security experts have continued to focus on energy supply issues - particularly supplies from the Middle East and the instability in the region that can lead to a rise in crude oil prices, a constant reminder is the middle-east related world oil crisis of the 1970s. The Fukishima Nuclear disaster and the gulf of Mexico Oil spillage of 2012 are also constant reminders of how vulnerable many developed countries are to strong environmental threats that are likely to affect energy installations and in turn affect supply levels. The Russo-Ukrainian gas pipeline crises of 2005-2006 also highlights how energy markets are likely to become

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highly susceptible to disruption in gas supply lines in times of disputes. The World Economic Forum paper "The New Energy Security Paradigm 2012", mentions up to ten factors that are likely to affect energy security and how such concerns are likely to be addressed in the future, some of which include, energy generation diversification, investment in new technology, high commitment to research and development addressing market flexibility issues, the development of good relations between suppliers and users etc.

Numerous problems affect, many countries ability to provide sustainable and affordable energy for domestic and industrial use, some of these include the rapid rate of industrialization, population increase and the rise in domestic energy consumption. Lots of environmental constraints also affect their ability to access the needed energy for generation purposes, diversifying domestic generating sources will provide a great opportunity for countries to mitigate risks associated with overdependence on some specific sources. The over dependence on fossils for instance is likely to expose non producing oil countries to the high risk associated with price increases that will follow increased demand for crude oil in the global oil market.

Other issues such as pollution also associated with the use of fossil fuel also make lots countries to be vulnerable to a high level of pollution and a rise in green house gas emissions. Many other factors also affect different energy generating sources and addressing such constraints is likely to improve overall energy supply. One of the most efficient ways of reducing pollution and keeping world temperature below the projected 2 degrees Celsius increase is by depending on renewable energy sources for energy generation. The IEA report 2011 states that solar energy, a renewable energy source is likely to produce over 50% of world electricity by 2050. According to the World Energy Council Report 2013 about 1.3 billion people currently remain without electricity today. Energy policy makers also appear to have soft pedaled on issues of carbon dioxide emissions since this was probably affecting issues of energy production and utilization among the highly industrialized countries particularly the United States of America. Recent indications have also shown that the Kyoto protocol is not going to be realizable with the recent postponement of its full implementation till the year 2030 with the visible absence of the big energy consumers in the World during the 2013 Doha meeting recently. Since the introduction in 1988 with a series of inter-governmental parleys and rounds of talks, countries have not been able to realize laid-down cuts in emission rate as agreed by its various conventions.

The Middle East and Africa will continue to remain potential sources for the supply of energy to developed countries, the increase in energy demands in industrializing Asia and the gradually emerging countries in Africa and Latin America also mean that the competition for the scare available energy resources of the earth is gradually on the increase. On the other hand the adverse impact that harnessing energy reserves in many developing countries is likely to have on environmental conditions in these producing developing countries is also a matter of strong concern to many energy experts.

This paper studies the impact of various factors on energy security and electricity production in regions. Very few studies if any, have tried to address the issues of energy security from a regional perspective. Quite a few have also tried to study the various factors that affect electricity output production by addressing potential threats to electricity generation sources using regional studies. The study utilizes regional panel data for five regions, Africa, Latin America, the European Economic Area including Norway and Switzerland consisting of 27 countries, North America and South East Asia Pacific which consist of south East Asia mainland and other territories including China. The rest of the paper is divided into the scope and objective of the study, literature review, stylized facts on energy security and electricity production in regions, theory and methodology, empirical analysis and results and the concluding sections.

2.0 Scope and Objective of The Study

The study revisits the energy security paradigm and presents empirical evidence on how energy supply and generation are affected by a host of threats and investigates to what extent these threats affect energy security and electricity production in regions. The objectives of the study include:

a.) To determine to what extent does the dependence on some specific energy generation sources make countries vulnerable to energy supply failures?

b.) To determine to what extent environmental constraint associated with availability of energy supplies as well as consumption patterns in regions affect regional energy security and electricity production?

c.) To determine if industrialization rate poses a threat to future electricity production?

d.) To answer if regional investment in domestic innovation is affecting energy security and electricity production?

e.) And finally to determine to what extent has regional energy policy been affecting energy security and electricity production?

3.0 Review of Literature

Past studies (Cohen et al 2011) show that diversifying energy supply sources, particularly gas supply sources can have a positive effect on sustained and guaranteed access to energy supply for countries in the European Union even though there have not been much changes for crude oil. Causal empirical studies such as Bryce (2008) also suggest that diversification in energy has been on the increase particularly in the United States.

Lefevre (2004) have also investigated global supply of energy from the supply side of energy consumables used in generation, and suggest that global energy security in the future can be measured as the ratio of supplier exports to its domestic utilization needs. Coq and Palseva (2004) and Newman (2004,2007) state that domestic demands of oil producers are not likely to pose a threat to future energy security, on the short run arguing that consumers are likely to switch to other producers.

The 1973 energy crisis was largely responsible for the strategic blue print of many developed countries particularly the United States which according to LaCasse and Plourde (1995) was to put, energy security at the heart of energy policy agenda of industrialized countries. Rosendahl and Sagen 2009 argue that while cost of transporting gas from production point to consuming destinations have fallen over the years, the trade in natural gas has risen dramatically with spot price increase of over a factor of 10 in the last decade. Timisina and Vasetsky (2009) study the effect of inter-fuel substitution between oil and gas using cross country data and find very little inter-fuel substitution between oil and gas but find a considerable inter-fuel substitution effect, between electricity and oil. This was quite true as almost about 23% of total electricity outputs in the United States are produced from natural gas generating plants alone.

Little work has been done in trying to study the impact of threats to abrupt disruption of energy supply from a regional and quantitative point of view. Few empirical studies if any have tried to examine the effects of threats to energy supply on electricity output generation and energy supply in general. The EU Green Paper 2001, states that energy security is the guaranteed supply of energy from production points to destination consumption locations. Awerbauch, Stirling, Jansen and Beurskens (2004) also define energy security in terms of portfolio diversity and green house gases (GHG) reduction concerns. They argue extensively that consumer countries should hold portfolios free of cost risk associated with the hikes in fossil fuel prices. Awerbach and Berger (2003) also argue that cost in this case determines returns, and that cost are in fact the inverse function of returns, therefore optimizing portfolio cost is not likely to affect results making cost to have no effect on the generating mix.

In tradition with past literature energy security is defined in this paper as the amount of diversity in the energy generation process in regions since diversifying energy production is likely to cause competition and drive down cost. Using a score variable for regional specific energy source dependence we study the effects of different energy generating sources such as Nuclear, renewable, coal, gas and hydro electric generating capabilities on energy security and also to identify the effects of over dependence on specific energy sources in regions.

Other possible constraints and threats to energy supply and generation mentioned by previous scholars and the IEA report 2011, such as environmental constraints, industrialization rate, domestic consumption characteristics and regional specific investment in domestic technology since the cost of acquiring technology overseas is often more expensive were also investigated, see also The World Economic Forum paper "The New Energy Security Paradigm 2012" for details and further discussion of threats to energy security.

3.0 Some Stylized Facts on Energy Security and Threats to Electricity Production

In this section we explain with facts how vulnerable regions are to threats in the generation and supply process. Consistent with past literature the level of diversity in energy generation is on the increase see Lacasse and plourde (1995) .The United States has the highest generating capacity and the most diversified energy generation system, while Europe remains the most affected by environmental limitations in the electricity generation process. Energy consumption rate is also on the increase in all regions. While energy consumption in Africa, seems to be on the increase, this increase is not significant due to huge supply disruptions attributable to the current impending infrastructural challenges in the African energy sector despite continuous investment in developing generation and supply infrastructure see Table 1 and Fig.2.

Table 1. World total installed generating capacity by region and country, 2010-2040

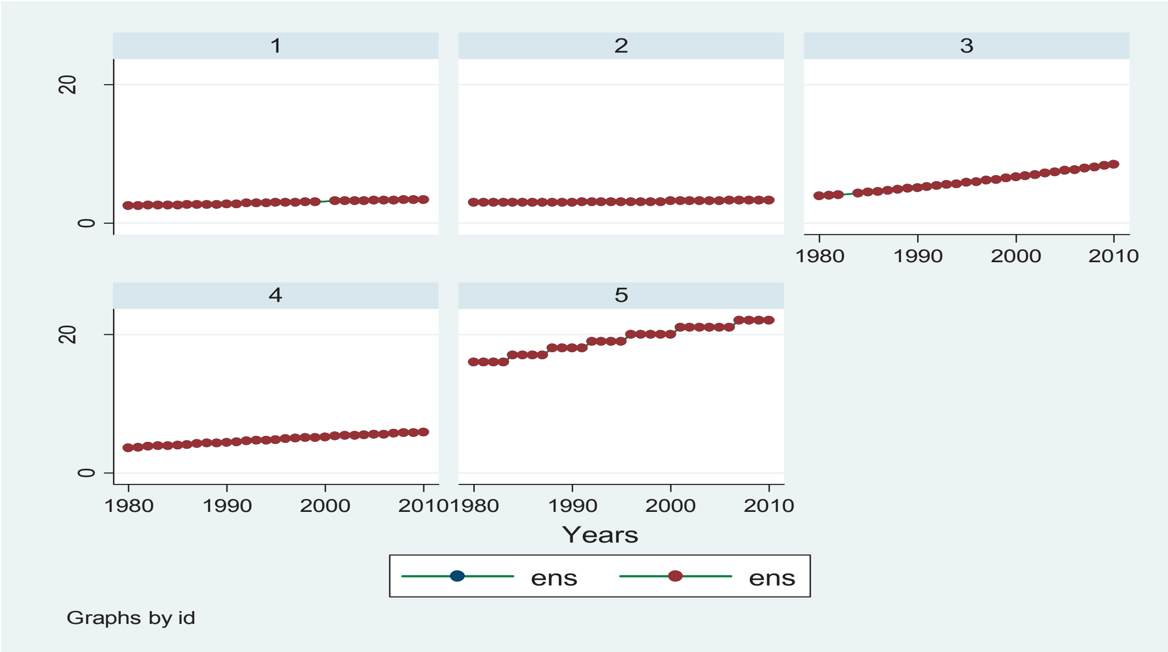
		Projections						yearly %
	2010	2015	2020	2025	2030	2035	2040	Δs
OECD								
OECD Americas	**1,248**	**1,316**	**1,324**	**1,379**	**1,456**	**1,546**	**1,669**	**1.0**
United States[a]	1,033	1,080	1,068	1,098	1,147	1,206	1,293	0.8
Canada	137	144	152	163	174	185	198	1.2
Mexico/Chile	78	93	104	118	135	155	177	2.8
OECD Europe	**946**	**1,028**	**1,096**	**1,133**	**1,159**	**1,185**	**1,211**	**0.8**
OECD Asia	**441**	**444**	**473**	**489**	**501**	**516**	**524**	**0.6**
Japan	287	275	293	300	304	309	306	0.2
South Korea	85	93	100	107	114	122	130	1.5
Australia/New Zealand	69	76	81	83	83	85	87	0.8
Total OECD	**2,635**	**2,788**	**2,894**	**3,002**	**3,116**	**3,247**	**3,403**	**0.9**
Non-OECD								
Non-OECD Europe and Eurasia	**408**	**421**	**455**	**480**	**508**	**538**	**563**	**1.1**
Russia	229	239	264	282	299	315	325	1.2
Other	179	182	191	198	209	223	239	1.0
Non-OECD Asia	**1,452**	**1,820**	**2,188**	**2,479**	**2,772**	**3,057**	**3,277**	**2.8**
China	988	1,301	1,589	1,804	2,007	2,176	2,265	2.8
India	208	241	285	327	376	440	510	3.0
Other	256	278	314	347	390	441	502	2.3
Middle East	**185**	**197**	**216**	**233**	**247**	**267**	**280**	**1.4**
Africa	**134**	**147**	**164**	**184**	**211**	**244**	**283**	**2.5**
Central and South America	**247**	**279**	**304**	**329**	**362**	**400**	**447**	**2.0**
Brazil	114	137	152	169	191	221	256	2.8
Other	134	142	152	160	171	179	191	1.2
Total Non-OECD	**2,426**	**2,864**	**3,327**	**3,705**	**4,099**	**4,505**	**4,850**	**2.3**
Total World	**5,061**	**5,652**	**6,221**	**6,707**	**7,214**	**7,752**	**8,254**	**1.6**

[a]Includes the 50 states and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.

Sources: History: Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. Projections: EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo ; and World Energy Projection System Plus (2013).

The rapid industrialization in Latin America, South East Asia and also in some emerging African countries starting in the early 2000s, see graphs 3,4 and 5 respectively in Fig 3, also means that the competition for the world resources is on the increase despite the slowdown in the industrialization development of the highly developed countries in Europe and North America. See graphs 1 and 2 in Fig. 3. Investment in domestic technology in regions is also ongoing with a steady rate of investment in Europe and North America and continuous improvement for Latin America and Africa. North America particularly the United States and Canada have some of the largest number of Wind generating plants in the World after China (Renewable Global Status 2006 – 2012 report). Asia is presently experiencing a slowdown from the massive investment of the 1990s in generation technology, but still maintaining steady investment in the development of improved generation sources.

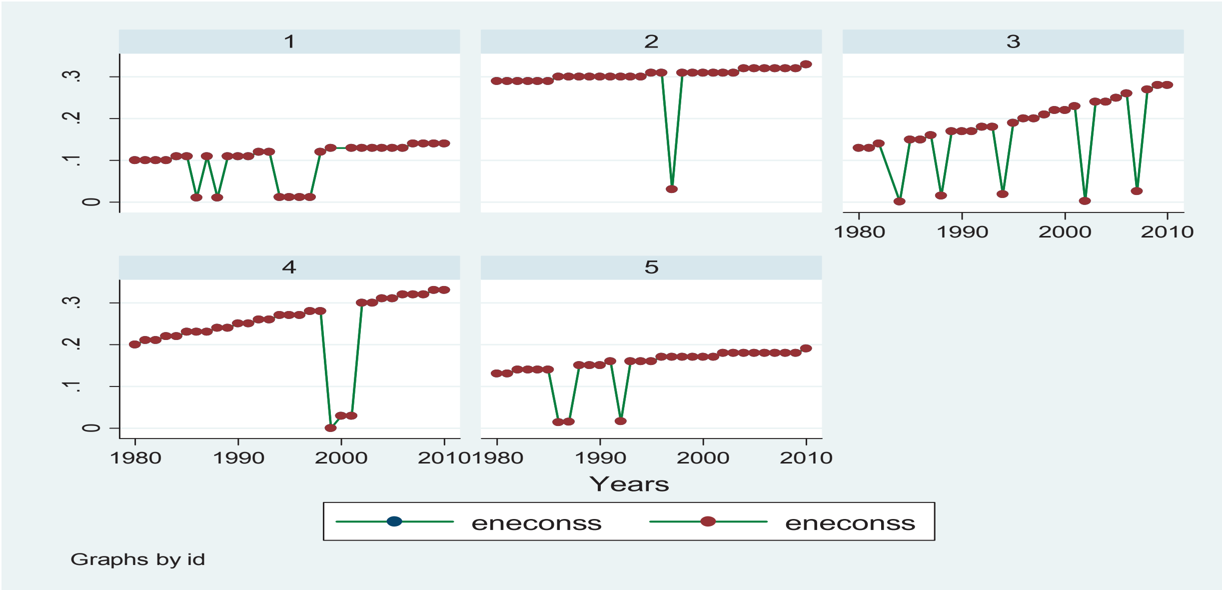
Fig. 1 Energy security in regions



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

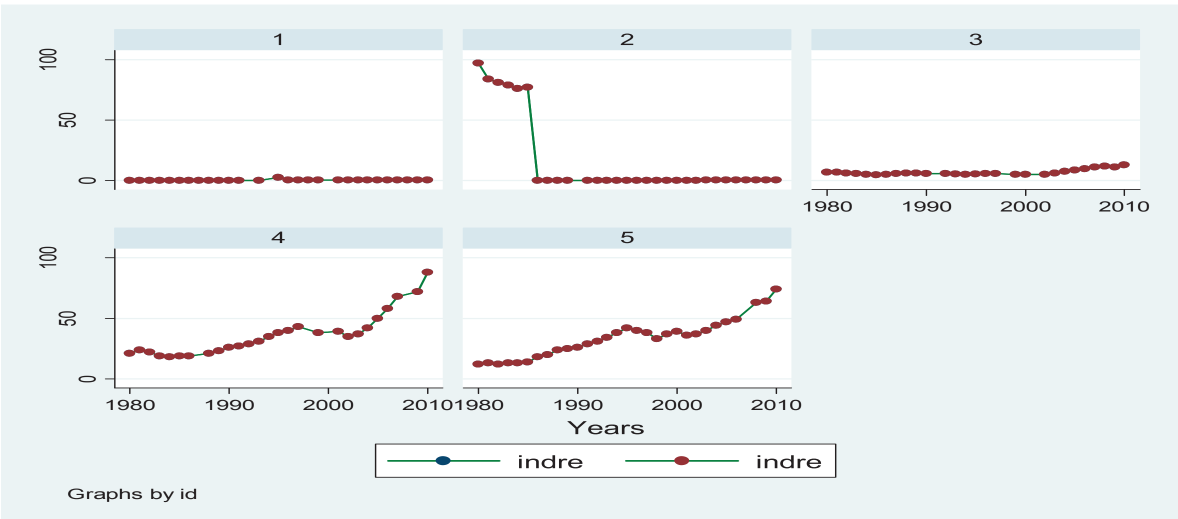
While energy diversification concerns in Europe and North America have reached advance stages other regions are beginning to improve the level of diversification as can be seen from fig.1 above with noticeable increases in Africa, Latin America and South East Asia.

Fig.2 Domestic Energy Consumption patterns in regions



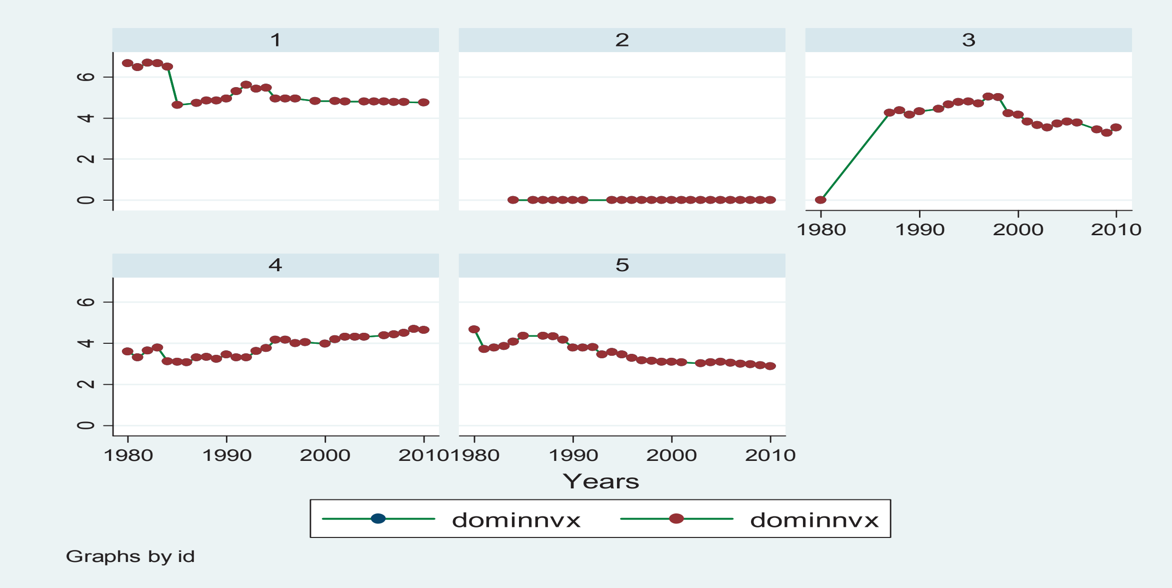
Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. Domestic consumption pattern for Africa has the highest fluctuation rates owing disruptions in supplies attributable to infrastructural challenges. This was also noticeable for north America obviously due to adverse weather conditions that often affect energy infrastructure such as typhoons and hurricanes. Major reduction in supply for Europe in the mid 200s is likely to be attributable to the Russo-Ukrainian gas crisis.

Fig. 3. Industrialization trends in regions



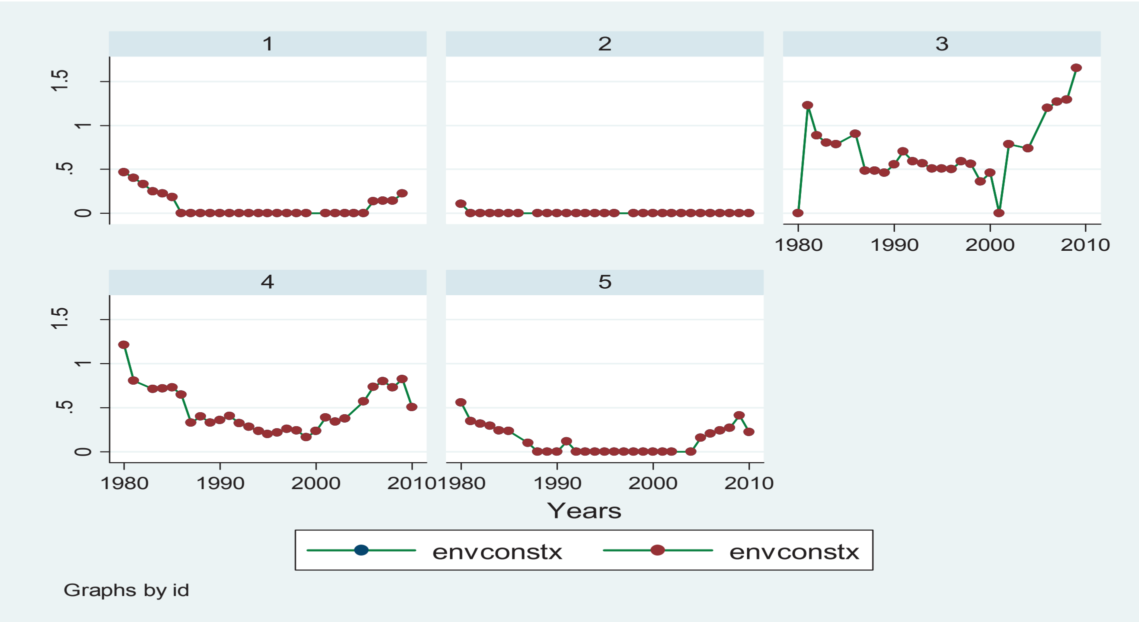
Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. Latin America and Asia, are currently experiencing industrialization growth although this has also be noticed for Africa since the early 2000s that of Africa has not been quite significant.

Fig. 4 Investment in domestic innovation in regions



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. Domestic innovation is particularly on the increase in Latin America, this likely to be as a result of significant investment in Brazil most especially in the development of alternative renewable energy production sources.

Fig.5 Environmental associated threats to energy production



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. Average world temperatures used as proxy for environmental constraints show that north America, Europe and Asia are likely to be most adversely affected by environmental associated threats to energy production. While Latin America and particularly are most likely to be the least affected. Their position of one strategic advantage due to their proximity to natural resources and solar energy availability, since they are most likely to be the highest beneficiaries of the solar energy production technologies of the future.

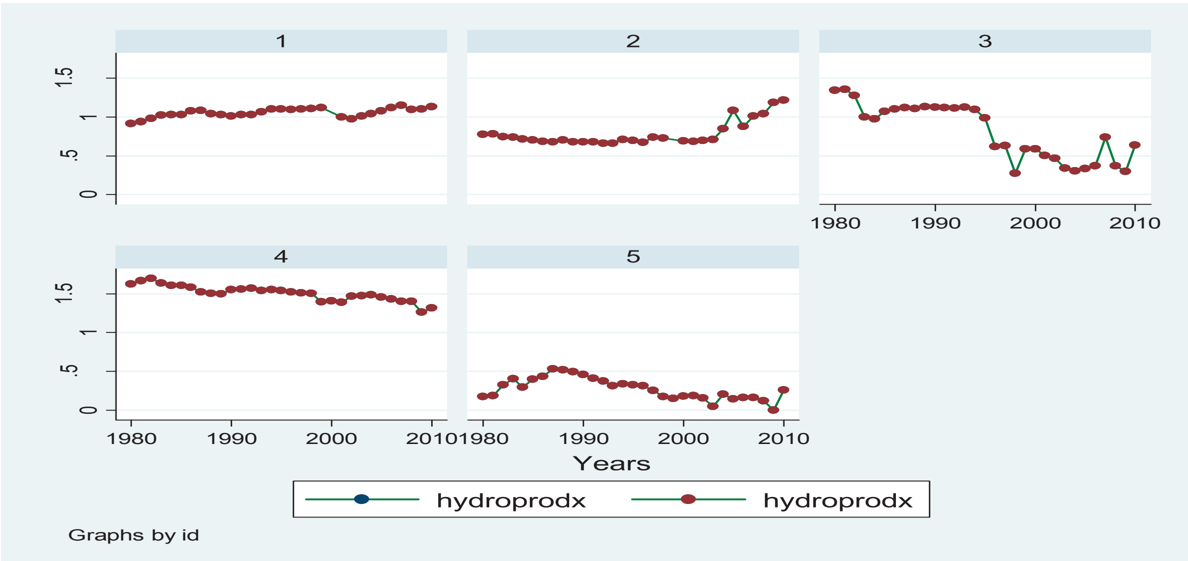
Availability of energy resources and access to interruptible energy generation supplies is likely to hit Europe most owing to extreme cold winter temperatures and dependence on gas supply from Russia and other external sources. Conditions in North America seem to be improving slightly in the 2000s with President Obama's recent approval in 2011/2012 of more drilling rights particularly on the US soil. Facts show that about 19% of the world electricity production comes from renewable energy sources with hydro electricity production alone accounting for about 16% of world electricity production (see International Energy Agency Report 2011), even though we also separate hydro electricity production as a production unit to examine its impact on energy security and total output production in this paper. Hydro electricity production is also on the increase in North America, Europe and Latin America particularly, with decreases recorded for Asia and Africa see Fig. 6. Production from renewable energy sources has been on the increase due to its relatively cheapness in recent times see Fig. 7, even though we record sharp declines for Latin America and South East Asia Pacific in the late years of the last decade. Wind energy sources currently supply about 238000MW of electricity worldwide, (see IEA Report 2011) making continuous improvement in renewable energy a strategic issue for regions.

Nuclear generation has been on the decline this can probably be attributed to the presence of other safer and less hazardous ways of producing electricity see Fig. 8. Europe in particular has continued to diversify its electricity generation capabilities away from nuclear sources with a dramatic decrease in production from the mid 2000s this can be attributable to need for relatively cheaper methods of production and the relative cheapness in recent renewable energy technologies.

The use of gas production plants is also on the increase in South East Asia partly due to the industrialization growth in China leading to high domestic electricity consumption rate. The industrialization rate in Asia and emerging countries in Africa and Latin America mean that competition for World fossils derived energy resources is on the increase. This has strong implication for Asia which is most likely to be affected by cuts in gas supply in the years to come (see Fig. 9).

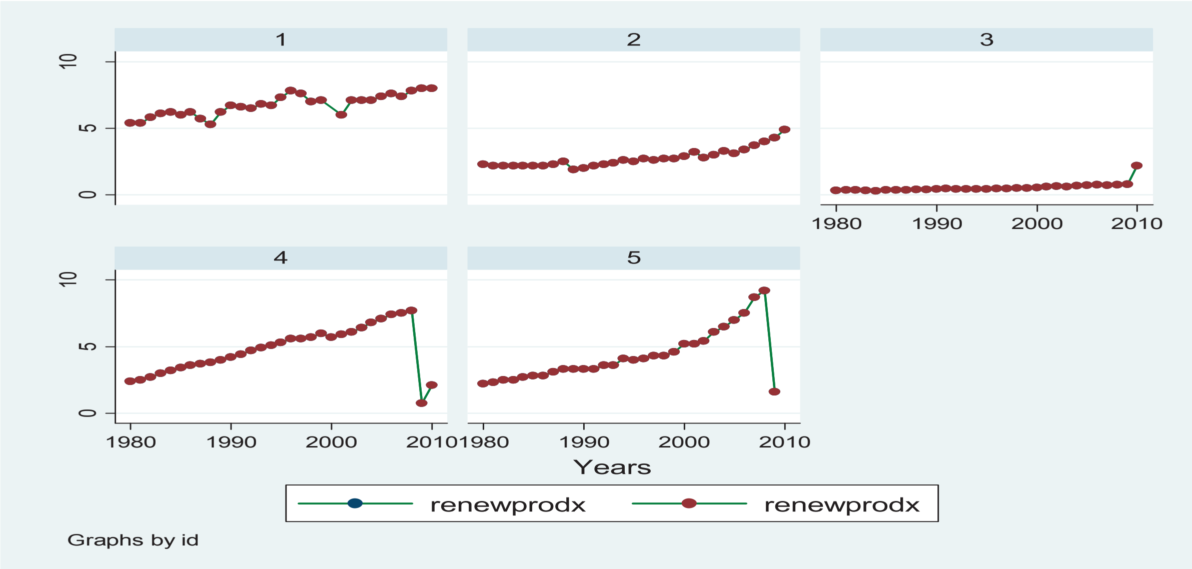
The use of coal producing plants is also on the increase in Africa see Fig 10. Asia still depends quite substantially on coal electricity production while North America and Europe seem not to be increasing the use of coal in their generating capabilities in recent times.

Fig. 6 Hydro generation output



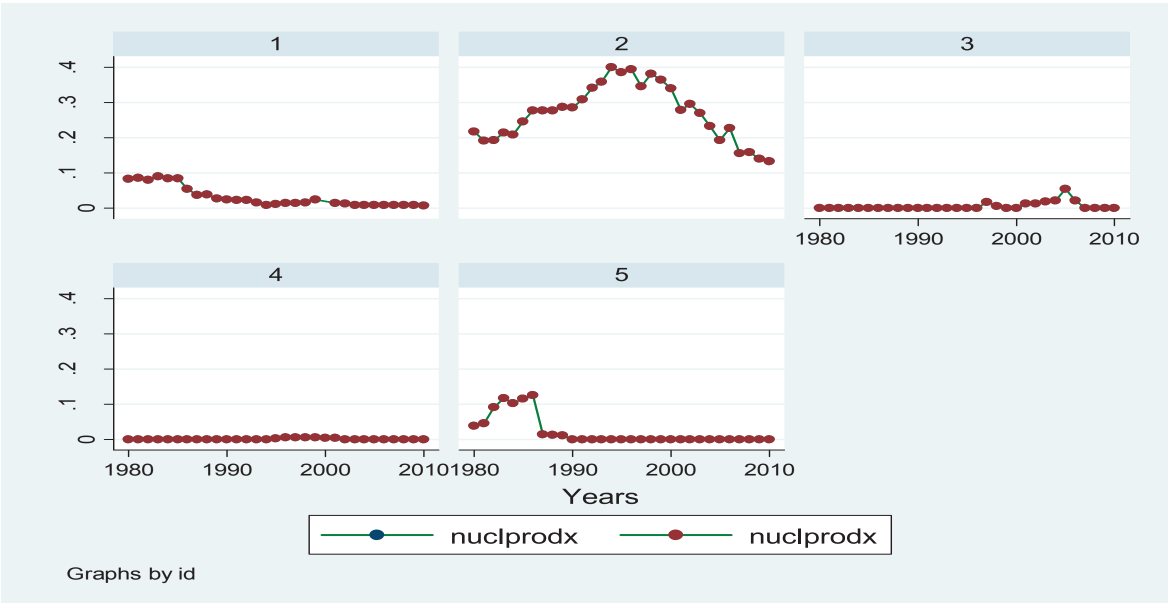
Note: The regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. The use of hydro electric generation capabilities is on the increase in North America and Europe, while a steady decline has been recorded for Africa, Latin America and South East Asia.

Fig.7 Renewable energy generation sources output



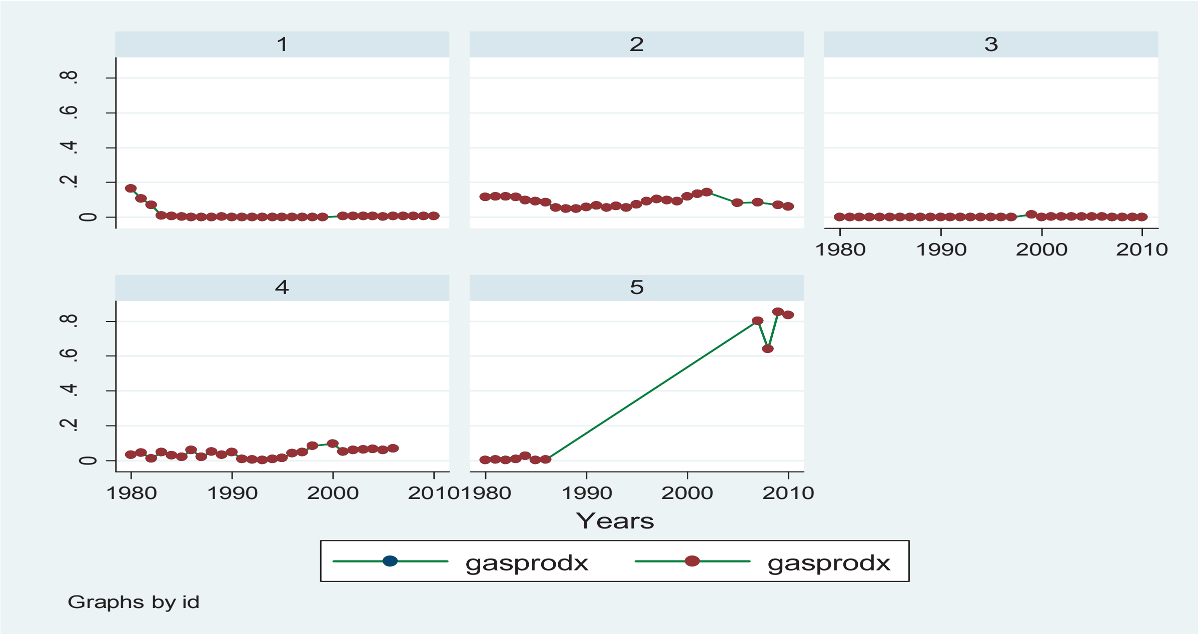
Note: The regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. North America and Europe seem to maintain steady use of renewable generation sources and of late Africa is beginning to increase the use of this source even though not in a significant manner. Drastic drops have been recorded for Latin America and South East Asia in recent times particularly the late 2000s.

Fig. 8 Nuclear source generation



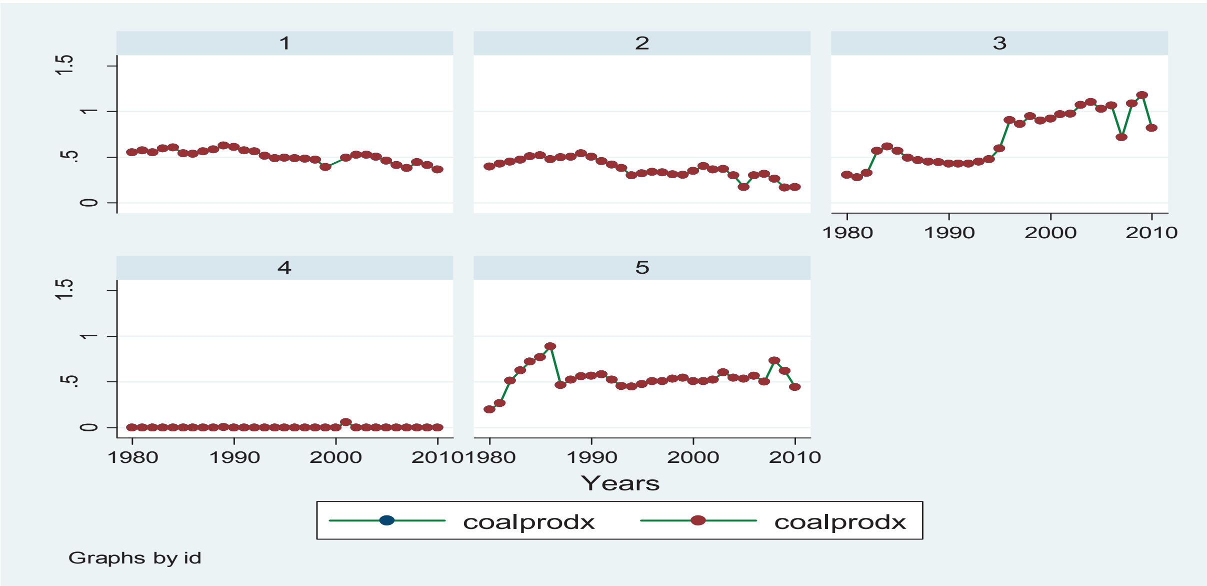
Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. Significant drop in the use of nuclear dependable sources are on the drastic decline in North America and particularly for Europe.

Fig. 9 Gas plants generation



Note: the regions are graphed by identity(id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. While the use of gas generating sources remains steady for North America and Europe, a significant demand for the use of gas generating plant is particularly noticeable for South East Asia.

Fig 10 Coal generation source production



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia. The use of coal generating plants appears to be on the increase in Africa and the steady use is quite noticeable in Asia, North America and Europe.

4.0 Theory and Methodology

Past studies have relied on different methods of evaluating country specific vulnerabilities to energy supply and generation efforts. The paper by Cohen Joutz and Loungani (2007) use a set of self constructed diversification index to measure energy diversification for OECD countries using country net production of energy as a function of net total exports by adjusting for country size and political risks that are likely to lead to energy supply disruptions using the international country risk guide (ICRG) measures for instability in countries. Blyth and

Lefevre 2004; Le Coq and Paltseva 2008, 2009; Gupta 2008 and Rubbelke 2010b, use Herfindahl-Hirschmann index (HHI) to measure energy diversification. Knox-Hayes, Brown et al 2013 attempt to study the effect of cross country energy policy on energy security from country specific respective attitude, to energy vulnerability aversion, using a multivariate linear regression model they find that energy security is affected by country specific domestic consumption and reliance on specific sources for energy generation. However only few energy scholars if any have tried to measure energy security in a quantitative manner using regional specific number of electricity generating sources as score for energy security as we try to do in this study.

This study tries to examine the extent to which electricity sources often depend on host of factors such as mineral and natural resources which are often scarce for production purposes etc. for instance nuclear energy relies on substantial supply of uranium for the enrichment process for nuclear reactors to operate, while gas generating electricity sources have now become one of the dominating method of electricity output production besides the use of nuclear reactors. Other sources such as renewable energy sources (which in this case, refer to biogas, wind, solar energy sources and at times this include hydro electricity sources which was separated in this paper) remain highly significant in the electricity production capability of many countries. Other major factors that are likely to affect energy security are country specific consumption behavior, domestic innovation and environmental constraints. Environmental constraints are likely to affect energy security and productive capacities in two ways, first temperate regions are likely to consume more electricity during winter periods owing to the need for sustained heating capacities and secondly, the presence of mineral resources in regions and the potential threats they pose to the environment when exploited is also likely to affect energy security and electricity generation.

The theory presented is one in which country specific energy utilization will affect energy security and guide how countries utilize a variety of generating sources for electricity generation. Our method of identification is based on the premise that energy security will depend on individual regional generating sources ***(GS),*** energy consumption rate ***(EC)*** in regions, industrialization rate ***(IR),*** regional specific environmental constraints ***(EVC)*** and energy policy ***(EP).*** While electricity generation in regions will depend on countries in regions specific energy policy, energy consumption rate, industrialization rate and domestic innovation. Our model specification captures major factors that affect the dynamics of energy supply and production allowing us to investigate the dynamics of sustainable energy supply and production and the potential threats that are likely to affect energy availability.

Environmental constraints can now be expressed as access to energy generation sources ***(AEGS)*** since availability of generation sources are often dependent on natural resource endowment, regional size (RS) since the bigger countries or regions are the more the length of energy transmission lines leading to energy losses in transmission lines, and weather conditions (WC) that are likely to affect both the consumption and generation process expressed below in equation 1.

(1.) EVC= AEGS+RS+WC

Energy consumption rate will also be a function of industrialization rate in regions captured using gross domestic product ***(GDP)*** across regions, since this will capture the level of domestic activity in regions and population growth ***(POP)*** since this will also reflect the domestic demand in energy across regions expressed below in equation 2 as

(2.) EC=GDP+POP

Aggregate energy generation can be expressed as an increasing function of three factors which will include the number of energy generating sources ***(NGS),*** domestic investment in technology ***(DI)*** which is a factor of cost and stability since it will be cheaper to access technology domestically than externally, and regional energy policy ***(EP)*** which could account for diversity in generation sources as well as efficiency and reliability of such sources. It will also be a decreasing function of two factors which will include environmental constraints which will have a negative effect on energy generation ***(EVC)*** and energy consumption demands ***(EC)*** expressed in equation 4 as

(3.) AG = (NGS+DI+EP)/(EVC+EC)

Energy security ***(ES)*** will be guaranteed by sustained and uninterruptible supply of energy, therefore energy supply will be an increasing function of three factors aggregate energy generation ***(AG)*** (which will capture diversity in supply generation), total generation cost ***(GC)*** which will be a function of efficiency since regions will be cost averse and regional specific energy policy ***(EP)***. It will also be a function of four decreasing functions which will include aggregate domestic consumption ***(DC)*** across regions, environmental constraints

(EC), industrialization rate **(IR)** across regions and finally environmental constraints ***(EVC)*** which can be expressed below in equation 5 as

(4.) ES= (AG+GC+EP)/(DC+EC+IR+EVC)

We can write energy security and electricity output production in regions as a function of these factors as expressed below

$$\boldsymbol{Energy\ Security\ = f(GS, DI, DC, EC, IR, EVC, EP\ )}$$ and

$$\boldsymbol{Electiricity\ Production = f(\ EC, DI, DC, IR, EVC, EP)}$$

In light of the foregoing analysis, the following prepositions shall be considered in the study;

i.) Regions are likely to diversify their sources of energy generation to stem energy supply failures and drop in electricity output production;

ii.) Investment in domestic technology such as alternative energy generating sources is likely to reduce vulnerability to energy supply failures and improve output electricity; an

iii.) And finally regions are likely to consider both efficient generation methods as well as diversify energy production to stem off treats to energy production and supply.

In stating the model for the study, it is assumed that energy security depends on individual generating sources, with the number of dependable generating sources potential lowering the risks to failure in energy supply (i.e. increasing energy security) $\frac{\partial ES_i}{\partial GS_i} \geq 0$. Then energy supply can be said to depend on domestic investment (DI), domestic consumption rate(DC), industrialization rate (IR)**,** environmental constraint EC, and economic policy (EP).

$$(5.)\quad \frac{\partial ES_i}{\partial GS_i} = \frac{\partial ES}{\partial DI_i}\frac{\partial DI_i}{\partial GS_i} + \frac{\partial ES_i}{\partial DC_i}\frac{\partial DC_i}{\partial GS_i} + \frac{\partial ES_i}{\partial IR_i}\frac{\partial IR_i}{\partial GS_i} + \frac{\partial ES_i}{\partial EP_i}\frac{\partial EP_i}{\partial GS_i} + \frac{\partial ES_i}{\partial X_i}\frac{\partial X_i}{\partial GS_i}$$

With domestic consumption and industrialization rate having potential to lower energy security $\frac{\partial ES_i}{\partial DC_i}\frac{\partial DC_i}{\partial GS_i} \leq 0$**,** $\frac{\partial ES_i}{\partial IR_i}\frac{\partial IR_i}{\partial GS_i} \leq 0$ and domestic investment having the potential to increase energy security $\frac{\partial ES}{\partial DI_i}\frac{\partial DI_i}{\partial GS_i} \geq 0$ as stated earlier. For the purpose of estimation, the original model will be expressed in a reduced form as follows:

$$(6.)\quad \boldsymbol{Energy\ Security_{i,t} = \alpha_0 + \alpha_1 GS_{i,t} + \alpha_2 X_{i,t} + u_{1i,t}}$$

$$(7.)\quad \boldsymbol{Electricity\ Generating\ Source\ _{i,t} = \lambda_0 + \lambda_1 EC_{i,t} + \lambda_2 X_{i,t} + u_{2i,t}}$$

Where $GS_{i,t}$ will be the energy generation sources (e.g. coal, gas hydro, nuclear and renewable sources) and $EC_{i,t}$ is the aggregate domestic electricity consumption for countries in regions. $X_{i,t}$ is the list of other explanatory variable included in the regression, that are likely to affect energy security and electricity output production in general while other omitted variables are captured, by the error term in our model specification. This assumption is based on the premise that if the error terms $u_{1i,t}$ and $u_{2i,t}$ are correlated using seemingly unrelated regression estimation method is likely to produce more efficient estimates reducing bias in the regressions results since the error term of the first regression equation is reduced through its interaction in a simultaneous linear regression with that in the second equation.

5.0 Data and Sources

Regional panel data were obtained for five regions, these include Africa, North America, European Union, South East Asia Pacific and Latin America, spanning for a period of 1980 to 2010 thirty years. All data are obtained from data market of Iceland unless otherwise stated. See table 2 below for all data used in this paper. The dependent variables are energy security which we measure using score values assigned to regions, based on the level of diversification and infrastructure in renewable energy sources in regions with North America particularly the United States having stronger capabilities towards averting energy interruptions.

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Table-2 Descriptive Statistics Used in the Study

Variable	Observations	Mean	Std. Dev	Min	Max
Energy Security	155	2.96	0.84	2	5
Total Energy Production in Regions	109	6790000	1260000	3300000	43000000
Production from Hydro Sources	155	8861	4464	26	16960
Production from Gas Sources	125	570	1391	0	8528
Production from Coal Sources	155	4266	2797	0	11750
Nuclear production Sources	155	660	1111.9	0	4006
Production from Renewable Sources	124	3820000	243000	310000000	920000000
Industrialization Level	154	1867753	226528.5	10000000	300000000
Energy Policy	155	1.4	0.57	1	3
Domestic Energy Consumption	154	1915535	947609.8	28.8	3300000
Level of Domestic Innovation	132	3369.689	1812.66	-4.32	6694
Environmental Constraint	144	2750.256	30.56	-0.06	16541

Note: Descriptive statistics is derived from author's dataset obtained from data market of Iceland

Electricity Output generation by source was captured from each generation source such as nuclear plants, renewable energy sources (particularly wind energy and biogas productions), coal powered electric plants, gas driven turbines and hydro electric production which even though classified as renewable was separated from what was called renewable in this study due to strong dependence on hydro electric generating plants all measured in kilowatts hours (KWH). The list of explanatory variables were environmental constraints measured using number of dams, regional size and average regional temperatures that are likely to affect electricity transmissions and consumption particularly for temperate regions were used to generate an index for environmental constraint.

Regional specific investment in domestic innovation was measured using total investment in research and development in regions in constant US dollars. While regional industrialization rate was regional specific GDP per capita in constant USD which will be high for highly industrialized countries. Energy consumption rate was measured using total domestic consumption for countries in regions in Kilowatt hour and finally regional specific energy policy was measured using score values for regional specific participation and implementation of the Kyoto protocol starting from 1998 when the first inter government panels were set up to 2010 when commitment towards emission reduction and implementation plans were emphasized also using score values of 1 to 3 depending on regional level of implementation and using consumption patterns in the pre Kyoto protocol years.

6.0 Empirical Analysis and Results

6.1 Do Threats Matter in the Energy Supply and Generation Process?

In this section the study tries to answer to what extents do the threats identified in the literature affect energy supply and generation process in general? The empirical analysis of the study is conducted with the view of ascertaining the following objectives: a. Overdependence on specific sources of energy generation is likely to affect guaranteed supply of energy in regions significantly; b. Regional specific investment in domestic innovation will increase energy security and access to cheap and more sustainable methods of energy production in regions; c. Energy policy is likely to affect energy supply and production in a positive manner as to improve energy security and reduce cost overall generation process in regions; d. Regional industrialization rates are likely to have a negative effect on energy security and energy output generation on regions; e. Environmental constraints and regional specific energy consumption rates is likely to have a significant effect on energy supply and production in regions.

6.2 Results

Results for the energy security as well as for the electricity production output equations are presented below in - tables 2 and 3- below. Our results show that renewable energy and gas production had a significant effect on energy security and were mitigating threats to energy supply failures in regions contributing 34 and 16 percentage points to energy availability and supply efficiency respectively (see - table 2 - columns 3 and 4). Nuclear energy also had a negative significant effect on energy security reducing energy generation diversification in regions by 19 percentage points (see -table 2 -column 5).

Other factors such as environmental constraints which involve regional temperature which affect domestic consumption, regional size which affect transmission of electricity and distribution, availability and proximity to natural and mineral resources for electricity generation and temperature constraints had a negative effect on energy security except for the regression where we use nuclear generating source as a variable for generating source, which is particularly interesting, (see -table 2 -columns 1 to 5 where environmental constraints reduce energy security by 8,9,7,4 and 1 percentage points respectively).

Industrialization rate had a strong negative effect on energy security using all generating sources; this was particularly serious for nuclear generating sources since this was increasing dependence on nuclear sources in developed countries with nuclear generating energy plants (see -table 1 -columns 1 to 5 where industrialization rate was reducing energy security by 22,20,26,19 and 35 percentage points respectively). Domestic innovation and regional specific energy policy were also having a positive effect on energy security. Differences in yearly energy productions due to maintenance or supply cut issues from various generating sources were probably making regions depend more on renewable energy sources since the control for annual difference only held for renewable energy generating sources.

Table 2 Regression for energy security

Variables	(1) Energy security	(2) Energy security	(3) Energy security	(4) Energy security	(5) Energy security
Hydro energy generation	-0.09				
	(0.06)				
Coal generation		-0.04			
		(0.08)			
Gas generation			0.16***		
			(0.04)		
Renewable energy generation				0.34***	
				(0.05)	
Nuclear energy generation					-0.19***
					(0.05)
Energy consumption	-0.01	-0.03	-0.08	-0.07	-0.03
	(0.06)	(0.07)	(0.07)	(0.05)	(0.06)
Domestic Innovation rate	0.29***	0.31***	0.35***	0.19***	0.16***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)
Environmental constraint	-0.08***	-0.09***	-0.07***	-0.04***	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Industrialization rate	-0.22***	-0.20***	-0.26***	-0.19***	-0.35***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)
Energy policy	0.95***	1.11***	0.90***	0.71***	0.85***
	(0.16)	(0.18)	(0.18)	(0.14)	(0.18)
Year Effect	No	No	No	Yes	No
Observations	112	92	73	112	68
R-squared	0.71	0.67	0.79	0.80	0.77

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Renewable generation sources had the strongest positive effects on energy security contributing 34 percentage points to energy supply while gas sources were also exerting 16 percentage points on energy security. Nuclear generation sources were having negative effects on energy security increasing the risk of supply disruption by 16 percent across regions. Industrialization was also increasing risk of supply disruption across regions by 35 percent. Invest in domestic invest had strong and meaning results for energy security improvements contributing 16 percentage point to energy supply improvements across regions.

The results where the potential threats to electricity output generation from sources were considered are also reported in -table 3. They show that energy consumption had no significant effect on electricity generation from all sources. Industrialization rate had a negative effect on electric output generation in regions for hydro and nuclear energy sources, it was likely that energy infrastructure were not been adequately developed to meet with industrial development rates in regions.

Domestic innovation had a negative effect on gas output productions and was reducing the use of nuclear energy generating sources since, it was likely that regions were developing new alternative technologies and were probably aware of the dangers and difficulties associated with the operation of nuclear facilities and the risk associated with the disposal of nuclear wastes. It also affected renewable energy generating sources positively; the greatest impediments to renewable energy generation were probably environmental constraints since the availability of resources for renewable energy generating capabilities were often an issue.

Table 3 Regressions for electricity generating sources

Variables	(1) Hydro production	(2) Coal production	(3) Gas production	(4) Nuclear energy production	(5) Renewable energy production
Energy consumption	0.09	0.03	0.26	-0.18	0.15
	(0.10)	(0.09)	(0.18)	(0.16)	(0.10)
Domestic Innovation rate	-0.06	0.06	-0.46***	-0.54***	0.30***
	(0.05)	(0.05)	(0.11)	(0.09)	(0.06)
Environmental Constraint	0.06**	0.0003	0.20***	0.20***	-0.12***
	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Industrialization rate	-0.16***	-0.03	0.10	-0.49***	-0.04
	(0.04)	(0.04)	(0.08)	(0.07)	(0.04)
Energy policy	-0.35	-0.11	0.37	0.23	0.76***
	(0.27)	(0.25)	(0.49)	(0.44)	(0.26)
Year effect	No	No	No	Yes	No
Observations	112	92	73	68	112
R-squared	0.178	0.08	0.55	0.77	0.28

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Domestic innovation had the most singular effects for renewable energy sources since most investment were probably channeled towards new technologies in sustainable and environmental friendly energy generation process. Energy policy was also most useful for renewable energy sources since; countries in regions were probably more concerned cheaper and more efficient ways on energy generation. Industrialization rate in regions were also causing strain on hydroelectric and nuclear sources across regions.

Here, a summary of the results of our empirical investigations are presented as follows:

a.) The assertion that overdependence on specific sources of energy generation is likely to affect guaranteed supply of energy in regions significantly was probably true since reliance on nuclear generating sources were probably affecting energy diversification in a negative manner
b.) Regional specific investment in domestic innovation had a positive effect on energy diversification (our measure of energy security) and also improved access to cheap and more sustainable methods of energy production in regions. This was particularly true since it reduced overdependence on gas and nuclear generation sources significantly (see - table 2).

c.) Energy policy affected energy generation diversification in a positive manner but had no effect on individual energy generating sources except for renewable energy sources showing the likely priorities of regional governments.
d.) Regional industrialization rates had a negative effect on energy security and energy output generation on regions. This was likely true since increasing industrialization in regions were increasing demands for consumption of energy and causing a strain to energy generating capabilities in countries in regions
e.) Environmental constraints had a negative effect on energy security and were probably affecting energy generation diversification in regions; however domestic energy consumption rate had no significant effect on energy diversification. This was probably true as industrial units were likely to consume more energy than domestic units.

7.0 Conclusions

In this paper an attempt was made to answer some specific questions that were introduced earlier in the study, they are: to what extent does overdependence on specific generating sources affect energy diversification which was the measure used for energy security in regions? It was found that nuclear, coal and hydro generating plants were probably reducing regional energy security. This study also investigated if domestic industrialization rate and environmental constraints pose a threat to future electricity supply and generation in regions. It was discovered that industrialization rate does pose a threat to both energy supply and generation in regions since it had a negative significant effect on both. Environmental constraints were found to have a negative effect on energy security and on renewable energy generating sources but had no effect coal powered plants

The policy implication of this paper is that another energy crisis can be conveniently averted through continuous investment in renewable energy technology and increased diversification of the energy production sector in regions. It was also found that countries in regions most probably the developed countries were now depending more on renewable energy sources to mitigate risk of supply disruptions, thereby supporting past finding by Coq and Palseva (2004) and Newman (2004, 2007) who state that increasing needs of consumers is not likely to affect energy security on the short run since they are likely to secure alternative energy sources. The implication of the findings are that, the identified threats to supply and generation process matter as posited by past literature and that the emerging countries in Latin America, Africa and Asia and the developed countries in Europe and North America are likely to be most susceptible to supply disruption.

The results also support IEA report 2011 which encourages the use of cheaper, cleaner and more efficient methods of electricity generation which will be useful for many developing countries, which are likely to benefit most from the relative cheapness of renewable energy technologies in the near future.

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