Would Energy Tax Policy Significantly Influence the Diffusion Rate of The Renewable Energy Portfolio in The United States?

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ABSTRACT

This paper empirically investigates the impact of tax credit to renewable energy and net energy import on renewable energy consumption in the United States. The study presents findings on the possible factors that may affect four main renewable energy consumer groups which are residential, commercial, transportation and industrial consumption. Using a linear model and time series data for the period 1985-2015. Our empirical results indicate that inward tax credit is an important vehicle for achieving renewable energy development. It clearly is seen that commercial, industrial, and transportation consumption of renewable energy significantly increase. Imposing more import barriers that discourage energy import can greatly help the domestic renewable energy consumption. However, industrial consumption of renewable energy is affected positively by the increase in the prices of industrial gas and negatively by increasing in the prices of industrial electricity. While many renewable energy studies have relied on less precise measurement factors (e.g. international oil prices the only and main energy prices that determine renewable energy consumption), our study uses direct indicators as a measurement of renewable energy consumption. We find tax credit has a significant positive impact. Other key factors that spur renewable energy consumption are co_2 emission, electricity prices, and gas prices. Thus, suggesting the federal government of United States to continue subsidizing renewable energy development which helps to decrease the prices of renewable energy(electricity for the four types of renewable energy consumers), and spur renewable energy consumption and development. Another key factor that spurs renewable energy consumption is GDP.

Key Words: Renewable energy consumption, Dynamic panel data, System-Fixed Effect, Crude Oil Prices, gas Prices, and Coal prices.

JEL classification: C36, Q2, Q42.

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1.1.Introduction

The United States economy has changed over the past several decades, leading to historically high returns in obtaining new resources for a green economy. Recently, green energy has become an important component of energy consumption. Many countries across the world are moving toward a green economy based on renewable energy. Although the United States has high fossil energy resources, it has adopted renewable energy resources such as solar, bioenergy, geothermal, hydropower, and so on.

In more recent years, the United States has become the largest consumer of electricity generated from renewable energy. Hakeem (2011) stated that countries that heavily depend on the use of fossil fuels to generate electricity will have lower diffusion rates of renewable energy. According to the IRENA, since renewable energy can provide 80% of the electricity required by the United States by 2050, the use of electricity from renewable sources should be considered when determining effects on the diffusion rate of the renewable portfolio.

Since 1985, the federal government of the United States has provided funds for the development, production, and use of fuels and energy technologies both through tax preferences and through spending programs administered by the Department of Energy. For example, the Department of Energy provides federal supports to energy in the form of tax preferences and credits for producing commodities using electricity generated from renewable sources. In 2015, renewable energy sector receives 56% of the energy related tax preferences but fossil fuels, energy efficiency, electricity from nonrenewable sources, and nuclear energy receive 24%, 17%, 2%, and 1% respectively.

To date, there are no studies examining the impact of energy tax policies on renewable energy consumption among the main four different groups of consumers in the United States.

[Figure 1 about here.]

[Figure 2 about here.]

Based on the figures above, It is clearly shown that from 2007, until 2015, the primary consumption of renewable energy is higher than the primary consumption of coal, natural gas, and petroleum. The second figure presents four main renewable energy consumer groups. It also shows the amount of consumption for each consumer group from 1995 to 2015. Industrial consumption of energy that is generated from renewable sources is the highest among the other consumption groups cross this period of time.

Since there were huge increasing in the amount of tax credit devoted to renewable energy after 2005 and fluctuations in the prices of crude oil, coal, and gas between mid-2014 and early 2016, this study involves the historical changes in these prices, tax credit impacted the consumption of renewable energy. Understanding of how energy tax policies and energy prices impact on the diffusion rate of renewable energy is an important issue of concern for consumers and policy makers.

1.2. LITURATUR REVIEW

There are two types of literatures that cover the demand side of renewable energy, which are empirical and theoretical. For the empirical type, many investigators have tested the impact of oil prices, other energy price, and trade openness, on the consumption of renewable energy. Most of the current literature attempted to identify the determinants of renewable energy consumption. Substitution of fusel fuels consumption with renewable energy helps to reduce the rate of dependency on oil, and the cost of renewable energy production gradually decreases. According to Reboredo (2015, p.32), “policy makers also need to better understand how oil prices affect the renewable energy industry, given that public expenditure aimed at progressively

reducing dependence on finite fossil fuels and carbon dioxide emissions could be reduced when oil price dynamics provide the necessary supply- or demand-side incentives to invest in the renewable energy industry".

The study by Anis and Duc (2014) examined the determinants of renewable energy consumption in high, middle, and low income countries. They predicted that purchasing more energy efficient products would be the main driver of oil prices. They used panel cointegration techniques in 64 countries and found that the impact of oil on the consumption of renewable energy was smaller in middle and higher income countries because of the sharp decrease in oil prices during that period. Anis and Duc (2014) reported that CO_2 emission and trade openness are the main determinants of renewable energy consumption; oil price has a smaller and negative impact on renewable energy consumption. The authors suggested that governments around the world should subsidize renewable energy projects and tax production of fossil fuels. As a result, businesses and households would switch to renewable energy products if the price of household gas , oil, and the other fossil fuels products increased.

Sean and Zheng (2016) reported similar results to Reboredo (2015). These authors reported that the market share of oil fell by 5% from 2004 to 2014, which caused the demand for oil to decrease. However, from 2015, a negative relationship between international oil prices and the consumption of renewable energy was observed. Although these previous studies have found a substitution relationship between consumption of renewable energy and oil prices, they failed to examine the impact of energy tax policies on the consumption of renewable energy.

Another recent study focusing on renewable energy was conducted by Harry, Shuddhasattwa, and Ruhul (2015). This study investigated the impact of carbon emissions and the real GDP on renewable energy generation in China and India In addition, this study focused

on the causal relationship between CO_2 emissions and adoption of renewable energy directly and indirectly through economic growth. They found that in the long-term, increased emissions leads to more adoption of renewable energy in China but not in India. However, this study failed to find any relationship between economic growth and renewable energy adoption.

Analysis of data from South Korea suggests that the renewable portfolio influences the diffusion of renewable energy more significantly than other East Asian countries(Chul & Sung Yoon, 2017). Higher oil prices might be the main cause of the higher diffusion rate. Another study by Juan, Miguel, and Andrea (2017,p.249) reported that "the price of oil is one of the main drivers of renewable energy investment projects as it makes the substitution of exhaustible energy resources with sustainable energy resources more or less economically profitable". Thus, the literature to date suggests that the success of new renewable energy projects influences the demand for oil and the supply of energy, and consequently, oil prices.

Modeling the relationship between natural energy consumption per capita and real GDP per capita is an active area of research in emerging economics. While many studies have investigated the impact of oil prices and CO_2, a study by Perry (2009) investigated the relationship between renewable energy consumption per capita and real GDP per capita. This study utilized annual data on renewable energy consumption and real GDP per capita from 18 emerging countries. Perry (2009) reported that in emerging economies, increases in real per capita income have a significant positive impact on renewable energy consumption in the long-term. This suggests that per capita income is one of the determinants of renewable energy consumption.

The other type of literatures is theoretical. One example is a study by Dulal et al. (2013). They discussed the increasing in population in Asia and consumption of fusel fuels and

renewable energy. The aim of this study is to determine the barriers to renewable energy diffusion. Barriers in Asian countries take a form of either financial constraints, weakness in energy in technology and institutions, social and cultural choices, and governments' political leaders. Dulal et al. (2013) find out that government intervention is crucial if countries move to renewable energy sources. However, these previous studies did not address the important factor of energy tax credits; the current study addresses this potentially critical factor. Additionally, the current paper adds to the literature by providing a better empirical model specification to measure the impact of the energy prices index and other factors on renewable energy consumption.

1.3. OBJECTIVE OF THIS STUDY AND RESEARCH QUESTION

1.3.1. Objective of Study

The objective of this study was to analyze how energy tax policies influence consumption of renewable energy. Furthermore, this study investigated how the flow of different natural resources is reduced when there are multiple sources of renewable energy. This paper will fill the gap in the current literature by discussing the renewable energy consumption that leads to a well-defined constant rate at which the flow of natural resources reduces over time.

1.3.2. Research Questions

Did the energy tax policy help to spur renewable energy consumption in the United States?
Did the net energy import influence the diffusion rate of the renewable energy portfolio in the United States?

1.4. METHODOLOGY

Taking the above discussion in the introduction into account, the empirical model that we built is consistent with the past literature that determines the consumption of renewable energy. I

study the impact of energy tax policy (tax credit to renewable energy) and the other factors that may determine the rate of renewable energy consumption in the United States. Movement toward more consumption of produces that were produced using renewable energy required attracting federal fund toward the renewable energy activities. I developed the determinants of consumption units of renewable energy using the following formulae:

$$CRE=F\ (GDP, CO2, Poil, Pgas, Pcoal, Egim, Taxcredit, Pelectricity) \quad (1)$$

Where CRE_t is the renewable energy consumption at time t. GDP_t is gross domestic products. $Poil_t$ is the oil prices index at time t. $Pgas_t$ is the gas prices index at time t. $Pcoal_t$ is the coal prices index at time t. $CO2_t$ is the co_2 emission at time t. $Pelectricity_t$ is the prices of electricity index.$Egim_t$ is the net energy import at time t. $Taxcredit_t$ is the tax credit to renewable energy development at time t. ε is the error term. The subscript t indicates the time period 1985 to 2015 in the United States. We will repeat this linear model four multiple times for each type of renewable energy consumers in the regression part, and coefficients will be shown clearly on the table section. Furthermore, we are interested to test the impact of gas and electricity prices for these four type of renewable energy consumers. For example, we are testing the impact of commercial prices of gas, commercial prices of electricity, and other control variables on commercial renewable energy consumers.

We chose this period of time based on information that provided by the energy department in the United States regarding the year that actively the energy development program started. We tested economic activity from the demand for renewable energy for four major renewable energy consumers. Since our empirical analysis involved time series, the equation can be written in a time series form. The usual approach for modeling energy consumption is to find

a model that relates energy consumption to crude oil prices, GDP, and coal prices(see for example, Sadorsky Perry, 2009). In this study, since we are focusing on renewable energy consumption, we add prices of electricity, net energy import, and tax credit to renewable energy development. Furthermore, renewable energy consumption, the dependent variable, for each type of renewable energy consumers is a composite variable. It reflects total consumption of sources of renewable energy, which are, solar, wind, and geothermal. A linear relationship between natural renewable energy consumption and the explanatory variables exists and equation1 can be written in a linear form as follows:

$$CRE_t=\beta_0+\beta_1 GDP_t+\beta_2 Poil_t+\beta_3 Pgas_t+\beta_4 Pcoal_t+\beta_5 Pelectricity_t+\beta_6 CO2_t+\beta_7 Egim_t+\beta_8 Taxcredit_t+\varepsilon_t \quad (2)$$

1.5.MEASURE AND DATA

Crude oil price is not exactly the same as gas prices and coal prices in the U.S., therefore we use gas prices and coal prices in the U.S. to study the consumption of renewable energy. Electricity price from renewable and nonrenewable sources is almost the same; therefore, we use it to measure the impact of electricity from renewable energy prices on the consumption of renewable energy. I also include the import of energy to measure the impact of international trade of energy on the consumption of renewable energy in the U.S. variables description and measurement for this model are as follow:

[Table 1 about here.]

Consumption of renewable energy for each type of consumptions is measured in trillion British thermal unit (Btu). Prices of coal are measured by dollar per short ton. GDP is measured by the constant 2010 U.S. dollar. Crude oil prices are measured by the U.S. dollar per barrel. Net

energy imports are measured in oil equivalents. The price of gas for each type of consumptions is measured by dollar per thousand cubic feet. CO_2 emissions are measured by kiloton (kt). The price of electricity for each type of consumptions is measured by cents per kilowatt hour. Tax credit to renewable energy is measured by billions of US dollars.

GDP data, net import data, and CO_2 emissions are collected from World Bank Development Indicators. International crude oil prices data is collected from the BP Statistical Review of World Energy. Data for prices of coal, prices of gas, prices of electricity and the consumption of renewable energy, are collected from U.S. Energy Information Administration. Lastly, renewable energy tax credit data is collected from Congressional Budget Office.

1.6. EMPIRICAL RESULT

We started our analysis by indexing the energy prices which are: oil, gas, coal, and electricity. The rest of the variables are stationary and they inter the model in level form. Descriptive Statistic is provided.

[Table 2 about here.]

[Table 3 about here.]

[Table 4 about here.]

Results from the ordinary least square (OLS) regression model indicate that tax credit to renewable energy development has a significant effect on commercial, industrial, and transportation consumption of renewable energy in the United States at the 5%, 10%, 1%level respectively. The coefficients' magnitude of 2.512, 14.08, and 34.9 mean that an increasing in 1 billion of tax credit will increase commercial, industrial, and transportation consumption of renewable energy by 2.512, 14.08, and 34.9 trillion British thermal unit (Btu) respectively, which

prove the fact that a stronger impact on renewable energy development in the United States. The negative significant coefficients of net energy import imply that an increasing in 1 barrel of oil will decrease commercial and transportation consumption of renewable energy by 9.35 and 24 trillion British thermal unit (Btu) respectively. The positive significant coefficients of CO_2 emission implies that an increasing in 1 kiloton (kt) of emission will increase commercial consumption of renewable energy by less than trillion British thermal unit (Btu).

The positive significant coefficients of GDP imply that an increasing in GDP by 1 US dollar will increase industrial and commercial consumption of renewable energy by 0.06 and 0.11 trillion British thermal unit (Btu). Lastly, the positive significant coefficients of industrial gas prices imply that an increasing in industrial gas prices by 1 dollar per thousand cubic feet will increase industrial consumption of renewable energy by 3 trillion British thermal unit (Btu). However, the negative significant coefficients of industrial electricity prices imply that an increasing in industrial electricity prices by 1 cents for per kilowatt hour will decrease industrial consumption of renewable energy by 21 trillion British thermal unit (Btu).

From the analysis above, tax credit have positive significant impact on commercial, industrial, and transportation consumption of renewable energy. Net energy import has a significant negative impact commercial and transportation consumption of renewable energy. an increasing in CO_2 emission encourage the department of energy in the United States to reduce the development fund of household gas that causes CO_2 emission. Clearly we can see that commercial consumption of renewable energy increase. Industrial consumption of renewable energy is effected positively by the increasing in the prices of industrial gas and negatively by increasing in the prices of industrial electricity.

Although the net energy import has a negatively impact lower impact on the commercial

and transportation consumption of renewable energy, governments who set policies or trade tax to discourage energy import admitted to more energy imports. We did not find any significant impact of oil prices on renewable energy consumption in any of the four groups of consumers. These findings are opposite to those in related earlier work by Omri and Nguyen (2014).

1.7. CONCLUSION AND IMPLICATIONS

This paper investigates the impact of tax credit on renewable energy consumption in the United States. We asked the question, did the energy tax policy help to spur renewable energy consumption in the United States? Our main finding over the period 1985–2015 shows that: (i) tax credit have positive significant impact on commercial, industrial, and transportation consumption of renewable energy. We also asked the question, did the net energy import influence the diffusion rate of the renewable energy portfolio in the United States? (ii) Net energy import has a significant negative impact commercial and transportation consumption of renewable energy. We suggest that in the United States, the federal government subsidies associated with more import barriers that discourage energy import can greatly help the domestic renewable energy consumption. With federal tax credit, switching to green energy sources in commercial, industrial, and transportation consumption of renewable energy is possible. We did not see any impact of tax credit on residential consumption.

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II. Tables

Table 1 Variables Description

Variable	Level- Differentiated	Data Source	Description	Expected Sign
Renewable energy consumption	Level	U.S. energy information administration	is measured in trillion British thermal unit (Btu).	Dependent Variable
Federal Tax Credit	Level	Congressional Budget Office	is measured in Billions of Dollars.	(+)
Crude oil price	Index	BP Statistical Review of World Energy	measured by the U.S. dollar per barrel	(-)
Net energy imports	Level	World Bank Development Indicators	estimated as energy use less production, measured in oil equivalents	(-)
Price of gas	Index	U.S. energy information administration	measured by dollar per thousand cubic feet	(+)
Prices of coal	Index	U.S. energy information administration	measured by dollar per short ton	(+)
CO2 emissions	Level	World Bank Development Indicators	Measured by kiloton (kt)	(+)
GDP	Level	World Bank Development Indicators	GDP is measured by the constant 2010 U.S. dollar	(+)
Electricity Prices	Index	U.S. energy information administration	cents per kilowatt hour	(-)

Table 2 Descriptive Statistic

	Mean.	Standard Deviation	Minimum	Maximum
Growth of Renewable Energy Consumption	**2.567**	**285.8**	**-2441.6**	**.1720.7**
Growth of Electricity Prices	**.0219**	**.7762116**	**-5.67**	**1.39**
Growth of Gas Price	**. .011056**	**1.217**	**-4.88**	**3.25**
Growth of Coal Price	**. -.013033**	**1.911**	**-5.75**	**5.22**
Growth of Oil Price	**-.0684**	**16.38**	**-47.26**	**. 31.21**
Growth of Net Energy Import	**-.0198**	**2.865**	**-5.44**	**6.1342**
Growth of CO2	**6233.53**	**. 171991.8**	**-766723.9**	**204152.9**
Growth of GDP	**72.176**	**1433.3**	**-8877.73**	**. 540.025**
Growth of Tax Credit	**.053**	**2.4338**	**-6.5**	**9.7**

Table 3 Result of the unit root test for the variables.

	Level		Growth		Growth-Growth	
	Statistic	**P-value.**	**Statistic**	**P-value.**		
Renewable Energy Consumption	**4.2322**	**0.8356**	**68.9128***	**0.0000**		
Electricity Price	**0.4542**	**0.9999**	**33.8496***	**0.0000**		
Gas Price	**3.5645**	**0.8941**	**68.4636***	**0.0000**		
Coal Price	**4.2100**	**0.8377**	**9.2204**	**0.3240**	**85.2693***	**0.0000**
Crude Oil Price	**4.4333**	**0.8161**	**33.7832***	**0.0000**		
Net Energy Import	**1.3371**	**0.9951**	**11.2632**	**0.1872**	**177.4515***	**0.0000**
CO2	**15.2107**	**0.0552**	**69.7030***	**0.0000**		
GDP	**0.6368**	**0.9997**	**32.5576***	**0.0001**		
Tax Credit	**1.8152**	**0.9862**	**31.6743***	**0.0000**		

***Statistic significant at the 1% level.**

Table 4 regression result.

	Residential	Commercial	Industrial	Transportation
Coal Prices	**2.63(4.31)**	**-.734(1.09)**	**-.457(5.18)**	**1.73(2.67)**
CO2	**-.00018(.0003)**	**.00015(.00003)*** **	**-.169(.550)**	**-.163(.304)**
Net Energy Import	**-9.35(13.77)**	**-7.22 (1.92)*** **	**-16.58(14.58)**	**-24.04(8.03)*** **
Crude Oil Prices	**.599 (.851)**	**.107 (.226)**	**.994(1.154)**	**.756(.57)**
Tax Credit	**2.67 (12.90)**	**2.51 (1.30)***	**14.08(8.0570)***	**34.94(4.58)*** **
GDP	**-.024 (.053)**	**-.006(.033)**	**.0609(.032)***	**.113(.0185)*** **
Electricity Prices	**11.29 (57.38)**	**-1.32(2.49)**	**-20.94(10.060)** **	**.383(2.707)**
Gas Prices	**.791 (2.42)**	**.242 (.571)**	**3.095(1.79)***	**.559(.884)**
Constant	**1555.3 (1469.06)**	**-379.07(198.7)***	**3620.48(875.43)*** **	**-651.16(399.78)***

***Significant at or below 1 percent.
**Significant at or below 5 percent.
*Significant at or below 10 percent

III. Figures

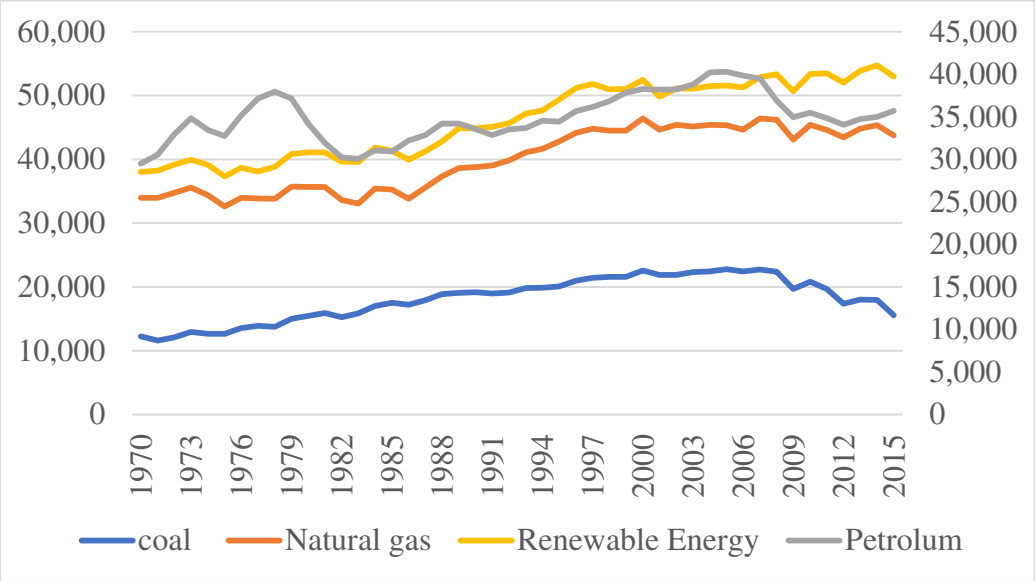

Figure 1 primary energy consumption in the United States: Trillion British thermal unit (Btu).
Sources: U.S. Energy Information Administration(U.S. EIA).

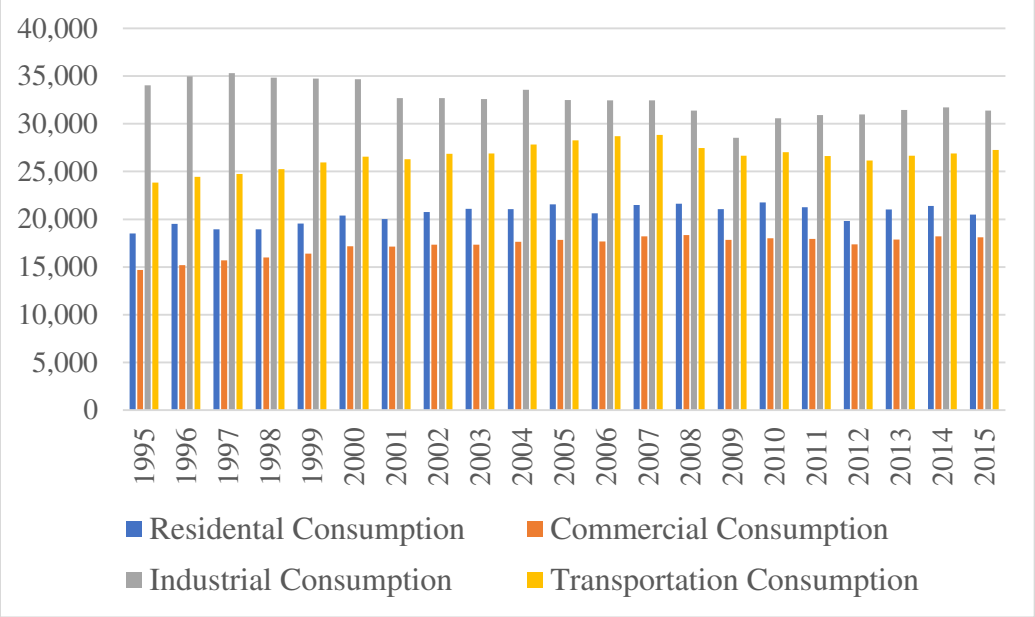

Figure 2 renewable energy consumption groups in United States: Trillion British thermal unit (Btu).
Sources: U.S. Energy Information Administration(U.S. EIA).