Webology (ISSN: 1735-188X)
Volume 19, Number 3, 2022

The Impact Of Renewable Electricity Generation On Gross State Product At The State Level

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Abstract

This essay studies the impact of the REN and NREN on the real GSP per capita for a panel of 50 states over the period of 1990 to 2017. This essay uses data at the state level because each state has structurally different economies, consumption of energy, and production of energy. Moreover, this essay makes a distinction between whether a state produces oil or does not produce oil to see if the impact of REN is positive or not on both non-oil-producing states and oil-producing states.

By using fixed effect estimation with state-fixed effects and time-fixed effects to estimate the impact of REN and NREN on real GSP per capita for all states, this essay finds that REN has a statistically significant and positive impact on real GSP per capita of all states. However, NREN has a negative and statistically significant impact on real GSP per capita of the 50 states. Also, the effect of REN, when it is the only energy generation for the electricity sector in the model, is greater than its effect when there is both REN and NREN in the model. These results are consistent with this essay's assumptions.

Introduction

Dependence on fossil fuels to generate energy is the main contribution to carbon dioxide (CO2) emissions, which leads to climate change (Ferroukhi et al. 2016, 13036). Climate change causes several problems to the environment such as threatening natural systems, and increasing risk of floods and droughts (Teske 2010, 8). Moreover, CO2 emissions lead to many health problems. Reducing the reliance on fossil fuels alleviates the damaging problems associated with their use. As a result, countries started implementing more policies aimed at lowering greenhouse emissions and moving towards generating electricity from RES. RES are safe for the environment and available in a wide range when compared to conventional energy sources, which mostly come fromNRES. Furthermore, RES are not subject to fuel price instability, so they provide stable and safe earning sources for investment (Teske et al. 2015, 66).

The use of RES is significant in different sectors. However, the use of RES in the electricity sector is the highest. RES's share of the total world electricity generation was 21% in 2015, which is higher than RES's share in other sectors. In 2017, 63% of electricity generation in the U.S. came from NRES, and 17% came from RES. NRES, responsible for the emissions of CO_2 from the electric power sector, is responsible for 34% of the total U.S. energy-related CO_2 emissions (U.S. Energy Information Administration (EIA) 2018). Thus, electricity generation from RES will fulfill a significant portion of energy consumption while helping in decreasing the environmental problems with NRES production and consumption.

Many countries are working hard to meet their goals of reducing pollution and achieving their targets of replacing NRES with alternative RES. The U.S., like many countries, is taking serious steps towards increasing the use of RES, especially in the electricity sector. According to the EIA (2019), solar and wind energy sources will be the most growing energy sources of electricity generation in the U.S. in the following years; an increase for solar energy by 17% and wind energy by 14% by 2020. Using RESin the electricity sector not only has environmental benefits, but also has economic benefits. Using a panel of 174 countries from 1980 to 2012, Atems and Hotaling (2018) find that countries can replace non-renewable electricity generation (NREN) with renewable electricity generation (REN) gradually without adversely impacting economic growth of these countries. Although RES is associated with high initial fixed cost, technological advancements have considerably lowered the cost over time.

Recognizing that the 50 states have structurally different economies, and realizing that the consumption and production of energy vary in terms of uses and sources, this essay attempts to investigate the impact of increased energy production from RES in the electricity sector on states' economies. While this essay investigates the impact of investments in RES in the electricity sector, it makes a distinction between whether a state is an oil-producing or a non-oil-producing state. This essay will study the impact of REN and NREN on real GSP per capita for a panel of 50 states over the period of 1990 to2017.

Review of Literature

The function of renewable energy as related to economic growth has recently received increased attention. There are many studies that analyze the impact of renewable energy consumption (REC) on economic growth. These studies can be divided into two groups: (1) a group that analyzes the relationship between economic growth and REC using different approaches and data; and (2) a group that examines the relationship between CO_2 emissions, economic growth, and REC. In terms of the first group, Destek et al. (2017) cover the period of 1980 to 2012 for 17 emerging countries to investigate if there is a relationship between REC, non-renewable energy consumption (NREC), and real GDP per capita. By using bootstrap panel Granger causality method, Destek et al. conclude that for countries like Peru, Greece, and South Korea, there is either unidirectional causality from REC to economic growth or bidirectional causality between them. However, for most emerging economies there is no causal relationship between REC and economic growth (Destek et al. 2017). Yildirim et al. (2012) analyze the multivariate causality relationship between different types of renewable energy consumption sources, real GDP, real gross fixed capital formation as an indicator of investment, and employment in the U.S. for three different periods of time: 1949 to 2010,1960 to 2010, and 1970 to 2010, depending on the type of renewable energy consumptionsources. Using Yoda-Yamamoto test and bootstrap-corrected causality test, they find that biomass-waste-derived is the only energy consumption source that causes the real GDP toincrease (Yildirim et al. 2012).

As for the second group, Zrelli (2017) examines the causality relationship between REC and NREC in the electricity sector, CO_2 emissions, and real GDP using a panel data of 14 Mediterranean countries over the period of 1980 to 2011. By using the generalized method of moments dynamic model (GMM) and panel vector error correction model (VECM), Zrelli's work suggests that an important part of the economicgrowth of these countries is explained by REC. Conversely, the author finds that the long-term influence of REC on the economy is not that strong because these countries depend more on electricity consumption derived from alternative fossil fuels. Attiaoui etal. (2017) use autoregressive distributed lag model based on the pooled mean group estimation (ARDL-PMG) for 22 African countries over the period of 1990 to 2011 to study the relationship among REC and NREC, CO_2 emissions, and GDP per capita.

Based on the results of the Granger causality tests, Attiaoui et al. find that African countries must increase their use of RES because REC has a negative impact on CO_2 anda positive impact on GDP.

A new line of research focuses on the effect of electricity production instead of using electricity consumption because not all generation is used up in consumption (as inthe case of net-exporting regions). In fact, there is a loss of some electricity generation and countries have to locate the reasons for this loss, find solutions to control the production of electricity, and make sure that all produced electricity goes to consumers (Atems and Hotaling 2018, 112). Ferroukhi et al. (2016) examine the impact of increasing investments in renewable energy deployment on economic growth, welfare, trade balance, and employment in European and global regions by 2030 by using a macro-econometric model, E3ME. The base of this study is the level of crowding out of capital when investments in renewable energy are made since they are often financed by loans. Their findings show that when there is a partial crowding out of capital, investments in renewable energy have a positive impact on the economy. The opposite happens in the case of full crowding out of capital. Atems and Hotaling (2018) examine the impact of REN and NREN on the growth rate of real GDP per capita for a panel of 174 countries from 1980 to 2012 using the GMM. First, they focus on the effect of total electricity generation on the growth rate of real GDP per capita where they find a positiverelationship. Then, they disaggregate the electricity generation to REN and NREN and the results do not change. They conclude that countries can replace NREN with REN gradually and still improve the growth of their GDP.

Most of the studies that analyze the impact of renewable energy on the economy use country level data. Still, there are some studies that review the impact of RES for onestate to estimate gross impact using input-output modeling methodologies that deal with local data or data for one state. H. Jo et al. (2016) analyze the impact of increasing the solar photovoltaic system by four levels of demand: 20%, 40%, 60%, and 80%, on outputand job creation in Illinois by using the Jobs and Economic Development Impact (JEDI).They find that there is an increase in both output and jobs, but this increase is because of inflation. Croucher (2012) uses the JEDI to force the same quantity of solar implementation on each state of the U.S. to see which state has the biggest economic effect. Croucher finds that total economic output of states like Pennsylvania, Illinois, Minnesota, Ohio, and Wisconsin have a huge improvement. Although Arizona and California are the richest states in solar energy, their economies have the lowest impact from installing and operating solar energy (Croucher 2012). Its report for the Solar Foundation (2013) illustrates the impact of increasing the solar photovoltaic by 1 million solar roofs on the economy and environment in Colorado by 2030. Achieving the goal leads to the creation of 10,790 jobs per year and a total output improvement of $1.42 billion. In addition, there are environmental benefits such as avoiding emissions generated by using NRES in electricity and saving a huge amount of water, which is necessary for producing electricity by NRES (the Solar Foundation 2013). By using the Regional Economic Models, Inc. (REMI) for data from Nevada, Riddel and Schwer (2004) find that increasing RES leads to an increase in both employment and GSP. Thus,a state like Nevada, which is rich in RES (solar, wind, biomass, and geothermal) should rely on these resources instead of importing energy from other states. De Silva et al. (2016) use an econometrics model to investigate the impact of improving wind capacity on income for the industry level data for the state of Texas, as a large producer of wind- generated electricity. Their work indicates a positive and significant effect of improving wind power on per capita income for Texas. Although the results of these studies vary because they cover different time periods and countries, and use different variables and models, it appears that there is a consensus among researchers that there is a strong and positive impact of renewable energy production on economic growth.

The model in this essay is based on the Atems and Hotaling (2018) model, Solow growth model. This essay uses this model because it has REN and NREN as the main independent variables. Atems and Hoteling's' model analyzes the impact of REN and NREN in the electricity sector on growth rate of real GDP per capita. Atems and Hotalings' model is appropriate to use in this essay to investigate the impact of REN andNREN on GSP for each state. Additionally, this essay also includes other control variables which are discussed by Barro (1996) and Atems and Hotaling (2018). These variables are life expectancy, higher education, and fertility rate.

Data and Methodology

The Model

A two-way fixed effects error components model with a panel-data (cross- sectional time-series data) is used to estimate the impact of electricity generation on realGSP per capita.

$GSP_{it} = \beta_1 REN_{it} + \beta_2 NREN_{it} + \beta_3 Kp_{it} + \beta_4 L_{it} + \beta_5 HK1_{it} + \beta_6 HK2_{it} + \beta_7 F_{it} + u_i + \phi_t + \varepsilon_{it}$ (2.1)

t: years(1990,1991,……2017) i:
states(1,2,……,50)

A two-way fixed effects error components model has two-way error components disturbances: $\mu_{it} = u_i + \phi_t + \varepsilon_{it}$ $i = 1,\ldots,50;\ t = 1990,\ldots,2017$

Where u_i denotes unobservable individual effects, ϕ_t denotes time effect, and ε_{it} denotesthe remainder stochastic disturbance (Baltagi 2005).

In Eq. 2.1, the left hand side variable is the real gross state product (GSP) per capita of state i in period t. The following are the variables on the right hand side: REN denotes renewable electricity generation of state i in period t measured in megawatt hours (Mwh), non-renewable electricity generation (NREN) of state i in period t measured in Mwh, capital stock (Kp) per capita of state i in period t measured in chained 2009 dollars,labor force participation rate (L) of state i in period t which is measured in the percentageof the civilian non-institutional population 16 years and older that are employed or searching for a job (BLS), number of students who enroll in public elementary and secondary schools (HK1) (as a proxy for human capital) of state i in period t, life expectancy (as another proxy for human capital) (HK2) of state i in period t which measured average number of years that a newborn is expected to live if current mortality rates remain the same, and fertility rate (F) of state i in period t measured in live births per 1,000 women 15 to 44 years of age, u_i denotes unobservable state-fixed effects (a dummy variable for each state multiplied by its regression coefficient, and one base state is excluded), ϕ_t denotes year-fixed specific effect (a dummy variable for each year multiplied by its regression coefficient, and one base year is excluded), and ε_{it} denotes the remainder disturbance. The weights, $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$, $\beta 6$, and $\beta 7$ are the regression coefficients and theslopes of REN, NREN, Kp, L, HK1, HK2, and F respectively. They are a measure of how strongly each independent variable impacts the dependent variable, and the higherthe β value the greater the impact of the predictor variable on the dependent variable. For example, for given state, as REN changes over time by one Mwh, GSP would increase or decrease by $\beta 1$. This essay uses STATA software to estimate the model.To choose the right estimator for the model, pooled Ordinary Least Squares (OLS) estimation is used first to examine the impact of REN and NREN on real GSP percapita for each state. After estimating the model using Pooled OLS estimations, fixed effect estimations are used. Fixed effectestimations were used for several reasons. Fixed effect estimations have two important assumptions. The first assumption is that the state effect error u_i is correlated with the regressors to control for state effect. Thus, the fixed effects models do not have biased coefficients. The second assumption is that the error term and constant term (which captures state characteristics) are not correlated to keep each state different from other states. F-test for fixed effects is used to compare pooled OLS and fixed effect estimations. The null hypothesis is that all dummy parameters are all zero, and the alternative hypothesis is that at least one dummy parameter is not zero. The results of F- test of joint significance of all state dummies shows that all state dummies are significantwhich leads to conclude that the pooled OLS model is biased and inconsistent because it omits these state dummies (Baltagi 2005). The model is then estimated by random effect estimations. To decide between fixed effect estimations and random effect estimations, the Hausman Test is applied. The null hypothesis is that individual effects are uncorrelated with any regressors in the model, and therefore random effect estimation is appropriate (Baltagi 2005). The test’s result shows that the null hypothesis is rejected, which indicates that fixed effect is more appropriate to estimate this model. Also, there is a result for the fixed effects model with time-varying state effects model where the model has both state-fixed effects and time- fixed effects. The results reject the null hypotheses that the coefficients for all years are jointly equal to zero; therefore time-fixed effects are required in this model. Thus, the impact of REN and NREN on real GSP per capita is estimated by fixed effect estimation with both state-fixed effects and time-fixed effects.There are some tests to confirm the goodness of fit of the fixed effect estimation with both state-fixed effects and time-fixed effects. First, F test result shows that all coefficients of the model are not equal to zero. Second, the result of Pesaran's test of cross sectional independence shows that the null hypotheses cannot be rejected and thereis no serial correlation in the model. As it is known, serial correlation causesbias in the standard errors which affects the efficiency of the model's results (Drukker 2003). Third, Levin-Lin-Chu unit-root test's result shows that the time series are stationary and does not have unit root. This means that time series have constant mean and variance. Moreover, to control for heteroskedasticity, the regressions standard error value in the model is tested and it is robust.

Data

This sectionexplains each variable in details. The per capita real gross state product (GSP) is the dependent variable in thispaper, and is measured in chained 1997 dollars. The data comes from the Bureau of Economic Analysis (BEA).The two-key independent variables are renewable electricity generation (REN) and non-renewable electricity generation (NREN). They are both measured in Mwh. REN production includes hydroelectricity, geothermal, wind, solar thermal and photovoltaic, other biomass, pumped storage, and wood and wood derived. NREN production contains coal, natural gas, other gases, uranium (nuclear energy), and crude oil (petroleum). The hypothesis in this essay is that increasing production of REN improves the economy for each state. Finding another source of energy increases production, which leads to economic improvements (Atems and Hotaling 2018).

Moreover, this essay assumes that NREN has a negative impact on growth. This assumption is built on the fact that unstable oil prices adversely affect economic activitiesbecause they delay investments and add uncertainty to economic projections (Rentschler 2013, 16). By using data from 1986 to 2011 for different countries including developing, developed, net-oil-exporter, and net-oil-importer countries, Rentschler (2013) finds that price volatility has a negative impact on GDP of all these countries. Data of REN and NREN comes from the U.S. Energy Information Administration (EIA).

This essay assumes that a capital stock per capita (Kp) has a positive impact on the real GSP per capita, as it is a driver for economic growth. There are two main methods to estimate capital stock. The first method of estimating capital stock is a direct measurement, and the main problem of this method is the difficulties of finding completedata and valuation of assets (Young et al. 1980, 43). There is no well-defined data for Kpat the state level (Garofalo and Yamarik 2002; Garcia-Mila et al. 1993). The second method to estimate capital data is the Perpetual Inventory Method (PIM) (Young et al. 1980). Barro (1996) and Berlemann and Wesselhöft (2014) use gross investment rates asa proxy for capital stock by using PIM. However, PIM is difficult to use at the state level because investment data at the state level is founded only for the manufacturing sector, and as it is known that estimation of capital stock needs the whole state's economy (Munnell

1990). There are some contributions to create capital stock dataset at state levelby using different approaches and data. Munnell (1990a) creates capital stock data for each state by using data of three industries from 1972 to 1987. Munnell's method depends on apportioning BEA's data on capital stock of each industry at the national level to the state level. Garofalo and Yamarik (2002) and Yamarik, (2013) create new private capital dataset by apportioning capital stock at the national level to state level andby using income data. They use annual data and one-digit industry data to create capital stock from 1990 to 2007. Garofalo and Yamarik (2002) explain that their approach and data are better than Munnell (1990) because Garofalo and Yamarik (2002)'s data is annual data which will be more accurate than data collected every five years. Moreover, Garofalo and Yamarik (2002) use economic value not book value data as in the case of Munnell (1990). Moreover, Garofalo and Yamarik (2002) suggest that their data provide actual information by using a regression of the states' income to capital ratio on ratio of income to capital for the nation, which strengthens their data. Furthermore, they found that the income to capital ratio for each state differs than the income to capital ratio for the nation, and the absolute value of the growth rate for more than half of the states is greater than that at the national level. El-Shagi and Yamarik (2018) update Garofalo and Yamarik (2002) capital stock data to cover the period from 1950 to 2016 and they use Cobb-Douglas and Solow growth model to assess their data. This essay borrows state level capital stock data from (El-Shagi and Yamarik 2018) which is measured in chained 2009 dollars.

The labor force participation rate (L) is assumed to have a positive impact on eachstate's economy (Shahid 2014). Increasing labor force participation rate causes an increase in production, which leads to improvements in the economy of each state. Thelabor force data by state comes from U.S. Bureau of Labor Statistics (BLS). This essay calculates labor force participation rate by dividing the labor force data by civilian non-institutional population for each state.

Consistent with Barro (1996), this essay includes other control variables. These variables are life expectancy, education, and fertility rate. Education and health are the best indicators for human capital. This paper will use total enrollment in public elementary and secondary schools (HK1) as a measurement for education and life expectancy (HK2) as a proxy for health. As in Barro, this essay assumes that education has a positive impact on real GSP per capita. Enrolment in public elementary and secondary schools data comes from the National Center for Education Statistics (NCEC).Empirical literature finds a positive effect of life expectancy on GDP (Barro). Life expectancy data for the years from 2010 to 2015 comes from National Center for Health Statistics (U.S. 2018) and the data for 2009 comes from Henry J Kaiser Family Foundation. Moreover, data for the years 1990, 1991, and for the years from 1999 to 2001 is downloaded from Center for Disease Control and Prevention (CDC). The rest of the years are estimated by taking the average because there is no big difference between the numbers over the whole period for each state.

This essay assumes a positive effect of fertility rate (F) on real GSP per capita,which means more workers who improve the economy of each state. Fox et al. (2015)examine the relationship between fertility and economic growth on 20 European countries over the period of 1990 to 2012. They find that for few countries, such as France and Austria, there is a positive relationship between fertility and economic growth, while most countries have a negative relationship, but this relationship changedto be positive by 2012 for half of these countries. Data on fertility rate is measured in live births per 1,000 women 15 to 44 years of age, and it is collected from CDC. The fertility rate's data definition for 2017 differs than fertility rate from 1900 to 2016.

Thus, this essay uses the same number of 2016 for the data of 2017.This essay uses an oil production dummy variable, which helps to distinguish between the states that produce oil and states that do not produce oil by assuming that a state is non-oil producing if its oil production equals zero for the most of the years in theperiod. A state is oil-producing, value of one, if its oil production is greater than zero most years during the time period of this study. This assumption allows examining whether the impact of REN on real GSP per capita for oil-producing states is the same as non-oil-producing states. In this essay, the assumption is that the impact of REN on real GSP per capita for both oil-producing states and non-oil- producing states is positive. The impact of REN for non-oil-producing states on GSP is also more than the impact of REN for oil-producing states because states that don not produce oil will benefit from increasing their dependency on RES. Moreover, the increase of using RES in the electricity sector, as another source of energy, increases production which leads to an economic growth for non-oil-producing states (Atems and Hotaling 2018). There are 19 states that do not produce oil. And there are 31 oil- producing states. This essay uses primary energy production estimation for crude oil inthousand barrels from EIA for oil production data.

Results

Descriptive Statistics

From this essay's sample, which includes all 50 states from 1990 to 2017, there are 1,400 observations. The dependent variable real GSP per capita has a minimum value of

$17,392, while a maximum value of $79,894. The mean real GSP per capita is $42,780,and the standard deviation is $12,767. For the independent variables, REN has a minimum value of zero and a maximumvalue of 1.05e+08 Mwh, while NREN has a minimum value of 4,549 Mwh and a maximum value of 4.03e+08 Mwh. These results are expected since NRES are the main source of energy in the electricity sector for a long time, and later on RES came in as an energy source for the electricity sector. Moreover, Kp as one of important component in GSP model has a minimum value of $0.032 and a maximum value of $0.588. L, as another important component in GSP model, has minimum value of 0.5143 % of the civilian non-institutional population 16 years and older that are employed or searching fora job, and maximum value of 1.618%. The minimum of HK1 is 84,409 students and the maximum is 644,1557 students. The minimum of HK2 is 73.03 years and the maximum is 82 years. Finally, F's minimum is 48.5 births per 1,000 women and its maximum is94.4 births per 1,000 women.

Results of Pooled OLS Regression for All States

The results shows that the relationship between real GSP per capita and REN over time for all states is negative. REN does not impact real GSP per capita during the time period of the study. However, NREN does have a statistically significant impact on real

GSP per capita. When NREN increases over time by one Mwh, real GSP per capita would decrease by $0.00001. When divided the states to oil-producing and non-oil-producing by using oil production dummy variable.

Results of Fixed Effects Estimations for all States

A) The Impact of Renewable and Non-Renewable Electricity Generationon Real GSP Per Capita Using Fixed Effects Estimations.

The impact of REN and NREN on real GSP per capita of each state over the period from 1990 to 2017 is estimated using Eq. (2.1). The results of this estimation show that the value of u_i has a statistically significant impact on real GSP per capita. This means that there are unobserved heterogeneity and the unobserved variables have a statistically significant impact on real GSP per capita and they are not assumed in this regression (Rahman 2017). When the value of u_i increases by one unit, then real GSP per capita decreases by $226,518. For the independent variables, the increase of REN by one Mwh leads to an increase of real GSP per capita by $0.00014 while holding other variables constant. Stated differently, it takes a 7,143 Mwh increase in REN to increase real GSP per capita by $1. REN has a positive and statistically significant impact on real GSP per capita, which is consistent with the assumptions of this essay. On the other hand, NREN has a negative and statistically significant impact on real GSP per capita, which also supports this essay's assumptions. Increasing of NREN by one Mwh leads to a reduction in real GSP per capita by $0.00005 while holding other variables constant. Stated differently, it takes a 20,000 Mwh increase in NREN to decrease real GSP per capita by $1. HK2 and F have positive and statistically significant impacts on real GSP per capita. Increase in HK2 by one-year leads to an increase in real GSP per capita by $2,938. Increase in F by one live birth leads to an increase in real GSP per capita by $374. Kp, L, and HK1 are not statistically significant,

but they have a positive relationship with real GSP per capita, which supports the assumptions in this essay.

B) The Impact of Renewable Electricity Generation on Real GSP Per Capita Using Fixed Effects Estimations.

To see the impact of REN alone on real GSP per capita of each state, the following regression is estimated:

$$GSP_{it} = \beta_1 REN_{it} + \beta_2 Kp_{it} + \beta_3 L_{it} + \beta_4 HK1_{it} + \beta_5 HK2_{it} + \beta_6 F_{it} + u_i + \phi_t + \varepsilon_{it} \quad (2.2)$$

The results of fixed effect estimation for this regression show that the value of u_i has a negative and statistically significant impact on real GSP per capita. If the value of u_i increases by one unit, real GSP per capita decreases by$234,344. As for the other independent variables, when REN increases by one Mwh, realGSP per capita increases by $0.00017 while holding other variables constant. Stated differently, it takes a 5,882 Mwh increase in REN to increase real GSP per capita by $1. REN has a positive and statistically significant impact on real GSP per capita. Like the basic model with REN and NREN, HK2 and F both have a statistically significant impacton real GSP per capita. Kp and L both have a positive but not statistically significant impact on real GSP per capita, which supports the assumptions of this essay. However, HK1 has a negative but not a statistically significant impact on real GSP per capita.

Barro (1996) finds that elementary education has a negative and insignificant impact on GSP, but there is a significant and positive impact of higher-level education.

C) The Impact of Non-Renewable Electricity Generation on Real GSP Per Capita Using Fixed Effects Estimations.

To see the impact of NREN alone on real GSP per capita of each state, the following regression is estimated:

$$GSP_{it} = \beta 1\ NREN_{it} + \beta 2\ Kp_{it} + \beta 3\ L_{it} + \beta 4\ HK1_{it} + \beta 5\ HK2_{it} + \beta 6\ F_{it} + u_i + \phi_t + \varepsilon_{it} \qquad (2.3)$$

The results of fixed effect estimation for this regression show that there is an increase u_i by one unit decreases real GSP per capita by $216,274. NREN has a negative and statistically significant impact on GSP. An increase in NREN by one Mwh shrinks real GSP per capita by $0.00007 while holding other variables constants. Stated differently, it takes a 14,286 Mwh increase in NREN to decrease real GSP per capita by $1. For control variables, HK2 and F both have a positive and statistically significant impact on real GSP per capita. Kp, L, and HK1 have positive andinsignificant impacts on real GSP per capita.

2.4.1. Results of Fixed Effects Estimations for Oil-Producing States

By using Eq. (2.2) to estimate the impact of REN on real GSP per capita of oil- producing states, the results show that REN has a positive and statistically significant impact on real GSP per capita. An increase of REN by one Mwh improves the real GSP per capita of oil-producing states by $0.00017. Stated differently, it takes a 5,882 Mwh increase in REN to increase real GSP per capita by $1.This result is important because it is consistent with the assumption of this essay that RES have a positive impact on the economy, even in the case of oil-producing states. Asfor the variables F, L, Kp, and HK2, they have a positive and statistically significant impact on real GSP per capita, which is consistent with the assumptions of this essay.However, HK1 has a negative and insignificant effect on GSP of oil-producing states.

By using Eq. (2.3) to estimate the impact of NREN on real GSP per capita of oil-producing states, the results show that when NREN increases by one Mwh, the real GSP per capita of the oil-producing states drops by $0.00005. Stated differently, it takes a 20,000 Mwh increase in NREN to decrease real GSP per capita by$1. This is consistent with this essay’s assumption that NREN has a negative impact on real GSP per capita of all states. The explanatory variables F, L, HK1, Kp, and HK2 have a positive and statistically significant impact on real GSP per capita of these states.

2.4.1. Results of Fixed Effects Estimations for Non-Oil-Producing States

By using Eq. (2.2) to estimate the impact of REN on real GSP per capita of non- oil-producing states, the results show that REN has a positive and statistically significantimpact on real GSP per capita of non-oil-producing states. The results show that there is an increase in the use of REN by one Mwh causes an increase in real GSP per capita of non-oil-producing states by $0.00006.Stated differently, it takes a 16,667 Mwh increase in NREN to increase real GSP percapita by $1.

By using Eq. (2.3) to estimate the impact of NREN on real GSP per capita of non-oil-producing states, the results show that an increase in the use of NREN by one Mwh causes a reduction in real GSP per capita of non-oil-producing states by $0.00012. Stated differently, it takes a 8,333 Mwh increase in NREN to decrease real GSP per capita by $1. Non-oil-producing states are the most vulnerable to NREN because of price fluctuations of non-renewable energy sources, and also due to thefact that significant state resources are devoted to importing oil. Therefore, investments in REN should leave a long-term positive impact on their economies.

Conclusion

This essay studies the impact of the REN and NREN on the real GSP per capita for a panel of 50 states over the period of 1990 to 2017. This essay uses data at the state level because each state has structurally different economies, consumption of energy, andproduction of energy. Moreover, this essay makes a distinction between whether a state produces oil or does not produce oil to see if the impact of REN is positive or not on bothnon-oil-producing states and oil-producing states. The reasons that this essay differs from most other renewable energy studies, which analyzed the relationship between economic growth and electricity consumption from RES, is that this essay uses data at thestate level and uses electricity production but not consumption to avoid the electricity loss because of transmission and distribution.The benefits of using RES instead of NRES on health and environment are obvious. However, the impact on the economy is inconspicuous for many people. Thereis a belief that fossil fuels are better for economies, especially for oil-producing states.This makes the transition to use RES very slow. Finding new research that approves the positive effect of RES on the economy, especially for each state in the U.S., will speed upthe steps towards an increase in RES use.Economic data is available at the national level, but some data is not available at the state level. There is no data for stock capital at the state level, thus this essay borrows state level capital stock data from El-Shagi and Yamarik (2018). Another restriction is that some data is not found for 2017 because the data will be published in 2020. Thus, oil production and stock capital are assumed to have the same values for 2016 to 2017

REN, which is the main variable in this essay data, is available from 1990 to 2017, which makes it difficult to get accurate results because it is better if there is more observation to examine the impact of variables and to have perfect results.By using fixed effect estimation with state-fixed effects and time-fixed effects to estimate the impact of REN and NREN on real GSP per capita for all states, this essay finds that REN has a statistically significant and positive impact on real GSP per capita ofall states. However, NREN has a negative and statistically significant impact on real GSP per capita of the 50 states. Also, the effect of REN, when it is the only energy generation for the electricity sector in the model, is greater than its effect when there is both REN and NREN in the model. These results are consistent with this essay’s assumptions. These results apply also for oil-producing states. An increase in REN improves real GSP per capita for oil-producing states, and an increase in NREN causes a reduction in real GSP per capita of oil-producing states.All the outcomes of this essay encourage taking serious steps in accelerating the use of RES in the electricity sector as a first stage. Then, this use has to expand to cover the most important sectors in the U.S. economy. These results are valid for all countries regardless if they are oil exporter countries or not. RES protects the environment from pollution, saves people's health from diseases caused by pollution, and improves the economy. RES are available all the time, which encourages countries to depend on theminstead of fossil fuels, which are threatened with depletion and have unstable prices.

Furthermore, future research could apply this model on oil exporter countries like Saudi Arabia, which depends on oil in its economy as the only source of energy.

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