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Econometric Estimation of the Climate Change Policy Effect in the U.S. Transportation Sector

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ABSTRACT

Over the past centuries, industrialization in developed and developing countries has had a negative impact on global warming, releasing CO_2 emissions into the Earth's atmosphere. In recent years, the transportation sector, which emits one-third of total CO_2 emissions in the United States, has adapted by implementing a climate change action plan to reduce CO_2 emissions. Having an environmental policy might be an essential factor in mitigating the man-made global warming threats to protect public health and the coexistent needs of current and future generations; however, to my best knowledge, no research has been conducted in such a context with appropriate statistical validation process to evaluate the effects of climate change policy on CO_2 emission reduction in recent years in the U.S. transportation. The empirical findings using an entity fixed-effects model with valid statistical tests show the positive effects of climate change policy on CO_2 emission reduction in a state. With all the 49 states joining the climate change action plans, the U.S. transportation sector is expected to reduce its CO_2 emissions by 20.2 MMT per year, and for the next 10 years, the cumulated CO_2 emission reduction is projected to reach 202.3 MMT, which is almost equivalent to the CO_2 emissions from the transportation sector produced in 2012 by California, the largest CO_2 emission state in the nation.

Key words: *Climate Change Policy, CO_2, Entity Fixed-Effects Model, Heteroskedasticity and Autocorrelation- Consistent (HAC) Standard Errors, Transportation*

1. INTRODUCTION

The effects of global warming have been observed around the world in the form of more frequent wildfires, longer droughts, and stronger tropical storms, which can have negative impacts on the Earth's societal, ecological, and environmental systems (The National Aeronautics and Space Administration, 2014). Carbondioxide (CO_2) emissions contribute to global warming through the greenhousegas (GHG) effect by holding heat energy from the sun in the Earth's atmosphere, producing increases in global average temperatures (The U.S. Environmental Protection Agency, 2015). The Intergovernmental Panel on Climate Change (2014) reported that CO_2 accounted for 57% of total global GHG emissions in 2004 and was the largest single source of emissions. They also reported that CO_2 emissions produced by the transportation sector accounted for as much as 13% of total global GHG emissions from the combustion of fossil fuel[1].

Among the five economic sectors in the U.S. (electricity, transportation, industry, commercial and residential, and other), CO_2 emissions from the transportation sector ranked second highest, explaining 32% of total U.S. GHG emissions in 2012 (The U.S. Environmental Protection Agency, 2013). Although CO_2 emissions from the transportation sector have increased, they reached a peak in 2007 (Fig. 1). Regarding the reduction after 2007, Choi *et al.* (2014) and Choi and Roberts (2015) suggested a couple of possible factors: 1) a government policy change (stricter federal regulations for GHG emissions) to-

1) Emissions and sinks regarding land use (e.g., deforestation) are not included (The United States Environmental Protection Agency, 2013).

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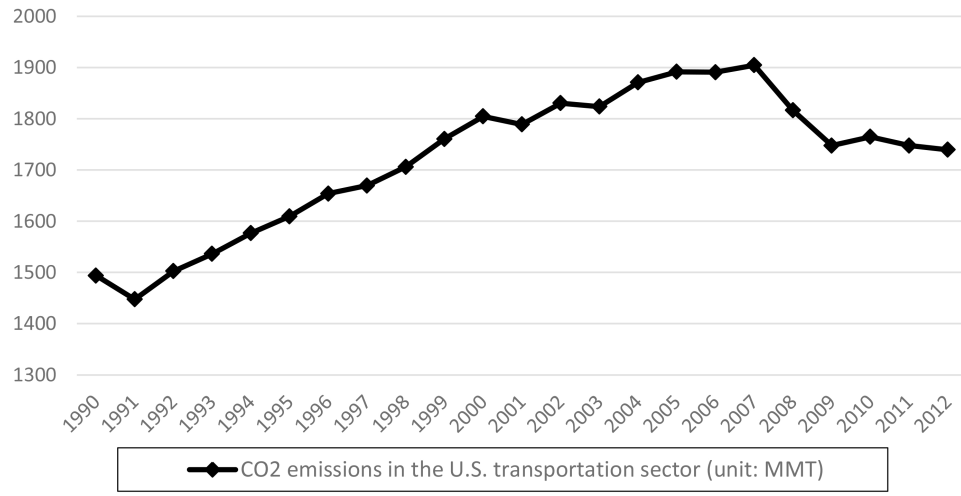

Fig. 1. CO_2 emissions from the U.S. transportation sector, 1990 to 2012.

wards CO_2 emission reduction, and 2) a decline in fuel consumption caused by higher oil prices led to increases fuel economy, production from alternative sources, and fewer miles travelled by light duty vehicles[2)].

For the last two decades, increasing interest in reducing CO_2 emissions has generated numerous studies of the major CO_2 emitting sectors (e.g., power, industry, transportation, etc.) mainly using the Laspeyres or the Divisia methods to attribute the growth in CO_2 emissions to the potential driving forces. However, those methods are limited by their inability to consider the effects of qualitative factors, such as a change in environmental policy, while leaving to speculate the effects of an environmental policy change on CO_2 emissions. In contrast, other researchers have incorporated an environmental policy factor while studying CO_2 emission changes in passenger transport, freight transport, transport land use, and highway accidents when focusing on forecasting CO_2 emissions, the effects of an environmental policy change, or revealing the relationship between CO_2 emissions and their potential driving factors (Diakoulaki *et al.*, 2007; Al-Ghandoor *et al.*, 2009; Choi *et al.*, 2010; Chung *et al.*, 2013; Barido and Marshall, 2014; Kim *et al.*, 2016; Park *et al.*, 2016; Zhang *et al.*, 2016).

Even though quantitative and qualitative analyses of CO_2 emissions have been performed, to the best of my knowledge no research has been conducted with statistical validation process since 2007 to evaluate the effects of climate change policy on CO_2 emissions produced by the U.S. transportation sector. Thus, the objectives of this study are to: I) identify whether climate change policies can reduce CO_2 emissions from the U.S. transportation sector with appropriate statistical validation tools; ii) quantify the effects of U.S. climate change policy on CO_2 emissions in the 49 contiguous U.S. states and for the nation [3)]; and iii) determine whether the effects of U.S. climate change policy are consistent states. The findings of this study will be helpful to state and federal policy planners in evaluating the effects of climate change policy within their boundaries and nation wide and will provide a base on which to improve and accelerate the trend of CO_2 emission reduction through the implementation of stricter environmental regulations all over the world.

2. BACKGROUND

2.1 Study Area

The World Bank (2015) defines the U.S. as a high-income country among the Organization for Economic Cooperation

2) "Light duty vehicles" refers to vehicles with a maximum gross vehicle weight rating of less than 8,500 pounds (TransportPolicy.net, 2013).

3) The extent of this study is limited to a macro analysis at this time, not by a state by state analysis, and thus the author focuses on major, middle, and minor groups after reviewing levels of CO_2 emissions by state.

and Development members, with gross national income per capita and total population of $53,470 and 319 million in 2014, respectively. In contrast, the U.S. transportation sector in 2011 emitted the largest CO_2 emissions of 1,629 million metrictons (MMT) in the world, which was even higher than the summation of the European Union and China, the CO_2 emissions of which were 1,535 MMT (=897+638) (The World Bank, 2015).

The CO_2 emissions from the U.S. transportation sector during the study period of 2007~2012 vary by state, but show three kinds of clusters, as presented in Table 1. The first one is the major CO_2 emission group, which includes California, Texas, and Florida, the CO_2 emissions of which contributed almost one-third of the total U.S. transportation CO_2 emissions, and if the next 6l argest states (Florida, NewYork, Illinois, Pennsylvania, Ohio, Georgia, and NewJersey) are added, then they would account for almost 50% of the total U.S. transportation CO_2 emissions. Second, the total CO_2 emissions of the other next largest CO_2 emission states, from Virginia to Kansas in Table 1, showing less than 3% but above 1% CO_2 emissions in the total CO_2 emissions, account for the other 40% of the total CO_2 emissions; for this reason, they were classified with the middle CO_2 emission group. Third, forming the minor CO_2 emission group, the rest of the states emitted less than 1% of the CO_2 emissions, occupying the bottom 10% of CO_2 emissions. Fig. 2 provides a geographic description of each group by state.

2.2 Air Pollution Regulations including a Climate Change Action Plan

The first federal act regarding air pollution was initiated with the Air Pollution Control Act of 1955 to protect public health from disease caused by air pollution. Congress enacted the Clean Air Act in 1970 to establish national air quality standards and made major revisions in 1977 and 1990. Since the 2000s, with the Energy Policy Act in 2005, Energy Independence and Security Act in 2007, and presidential proclamations for CO_2 emission reduction in recent years, the USEPA has established stricter air pollution regulations.

For the state-level climate change policy, Table 2 shows when the GHG inventory and/or climate change action plan was completed in each state. Of the 49 U.S. states, 31 (29)

Table 1. CO_2 emissions by state, percentage and cumulative percentage of the total CO_2 emissions from the U.S. transportation sector in 2012, and group classification

State	CO_2 emissions (MMT)	Percentage	Cumulative percentage	Group
California	203.93	11.29	11.29	Major
Texas	197.31	10.93	22.22	Major
Florida	102.08	5.65	27.87	Major
New York	69.78	3.86	31.74	Major
Illinois	64.81	3.59	35.33	Major
Pennsylvania	63.95	3.54	38.87	Major
Ohio	63.18	3.50	42.37	Major
Georgia	58.92	3.26	45.63	Major
New Jersey	57.90	3.21	48.84	Major
Virginia	51.15	2.83	51.67	Middle
Michigan	48.43	2.68	54.35	Middle
North Carolina	46.33	2.57	56.92	Middle
Louisiana	45.87	2.54	59.46	Middle
Washington	42.73	2.37	61.82	Middle
Indiana	41.84	2.32	64.14	Middle
Tennessee	41.61	2.30	66.44	Middle
Missouri	38.35	2.12	68.57	Middle
Alabama	33.19	1.84	70.41	Middle
Minnesota	32.76	1.81	72.22	Middle
Oklahoma	31.56	1.75	73.97	Middle
Kentucky	31.30	1.73	75.70	Middle
Arizona	31.08	1.72	77.42	Middle
Massachusetts	30.36	1.68	79.11	Middle
South Carolina	30.25	1.68	80.78	Middle
Wisconsin	29.20	1.62	82.40	Middle
Maryland	29.19	1.62	84.01	Middle
Colorado	28.64	1.59	85.60	Middle
Mississippi	25.19	1.40	87.00	Middle
Oregon	21.02	1.16	88.16	Middle
Iowa	20.77	1.15	89.31	Middle

Table 1. Continued

State	CO_2 emissions (MMT)	Percentage	Cumulative percentage	Group
Arkansas	19.32	1.07	90.38	Middle
Kansas	18.40	1.02	91.40	Middle
Utah	16.86	0.93	92.33	Minor
Connecticut	15.55	0.86	93.19	Minor
New Mexico	14.20	0.79	93.98	Minor
Nevada	14.04	0.78	94.76	Minor
Nebraska	13.76	0.76	95.52	Minor
West Virginia	11.75	0.65	96.17	Minor
North Dakota	9.22	0.51	96.68	Minor
Idaho	9.17	0.51	97.19	Minor
Wyoming	8.24	0.46	97.65	Minor
Maine	8.02	0.44	98.09	Minor
Montana	8.00	0.44	98.53	Minor
South Dakota	6.97	0.39	98.92	Minor
New Hampshire	6.88	0.38	99.30	Minor
Delaware	4.36	0.24	99.54	Minor
Rhode Island	3.87	0.21	99.76	Minor
Vermont	3.34	0.19	99.94	Minor
District of Columbia	1.08	0.06	100.00	Minor

Notes: The CO_2 emission data for 2012 were obtained from the U.S. Environmental Protection Agency (The United States Environmental Protection Agency, 2014); the total U.S. CO_2 emissions in 2012 for the 49 states were 1,838.71 MMT.

have completed a climate change action plan (GHG inventory) within their boundaries. A climate change action plan contains specific policy recommendations to address and reduce GHG emissions in various sectors, including transportation. Transportation-related emission reduction strategies are as follows: Low carbon fuel standard, trip reduction programs, heavy-duty vehicle anti-idling measures, clean vehicle purchase incentives, vehicle emissions standards, pay as you drive insurance, or others (Morrow *et al.*, 2010; Choi and Roberts, 2014).

3. DATA AND METHODOLOGY

Various independent variables[4)] in the literature were taken into account to explain the factors of CO_2 emission reduction in the transportation sector; therefore, the seven in dependent variables, including the implementation of a climate change policy, were all initially examined by a stepwise regression even though the effects of such apolicy are of primary interest in this study. The stepwise regression automatically selected the most important in dependent variables for modeling the mean dependent variable based on a *t*-test, and the brief procedures used are explained as follows: 1) all possible one-variable models of a linear form were fitted; 2) the best two-variable model of the form was selected through there maining $(k-1)$, where k is the number of independent variables; and 3) the researchers checked for the third independent variable and this process continued until further independent variables did not appear to contribute to a significant *p*-value with the variables already in the model (Mendenhall and Sincich, 2011).

After the procedures, the four independent variables (fuel consumption, regulation of CO_2 emissions, VMT, and GDP in the transportation sector, ordered by the lower *p*-value and statistically significant at the 10% level) remained. However, due to the high possibility of multicollinearity between the four variables, the variance inflation factor (VIF) was tested for each variable. Excluding the regulation of CO_2 emissions, the three variables were highly correlated, showing a VIF greater than 10 (Mendenhall and Sincich, 2011); thus, only the variable of fuel consumption, which is directly connected to CO_2 emissions, remained and the others were dropped. Finally, the two independent variables (fuel consumption and regulation of CO_2) were selected. The former variable was obtained from the online data base of the U.S. Energy Information Administration (2015) and was measured in billion Btu. The latter variable was produced through a qualitative

4) The independent variables examined are as follows: 1) all petroleum products consumed by the transportation sector; 2) all petroleum products' average price in the transportation sector; 3) population; 4) GDP in the transportation sector; 5) number of employees working for the transportation sector; and 6) vehicle mileage traveled (VMT).

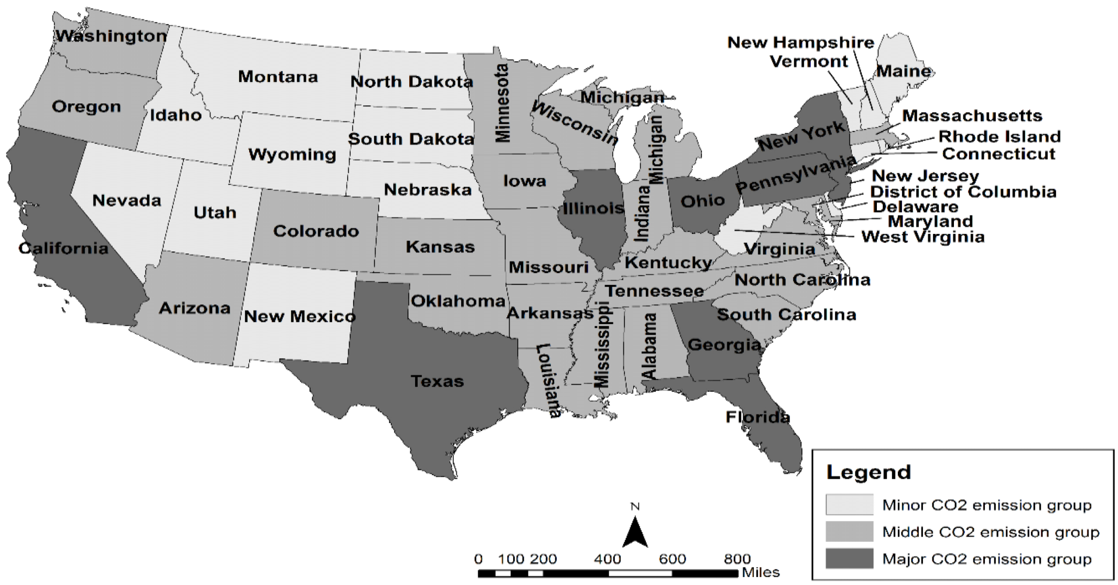

Fig. 2. Study area by groups.

Table 2. GHG inventories and climate change action plans by state

State	GHG inventories	Climate change action plans
Alabama	N/A	N/A
Arizona	2006	2006
Arkansas	2008	2008
California	2007	2006
Colorado	2007	2007
Connecticut	2006	2005
Delaware	N/A	N/A
District of Columbia	N/A	N/A
Florida	2008	2008
Georgia	N/A	N/A
Idaho	N/A	N/A
Illinois	2007	2007
Indiana	N/A	N/A
Iowa	2011	2008
Kansas	2008	N/A
Kentucky	N/A	2011
Louisiana	N/A	N/A

Table 2. Continued

State	GHG inventories	Climate change action plans
Maine	N/A	2004
Maryland	N/A	2008
Massachusetts	2009	2004
Michigan	2005	2007
Minnesota	2008	2008
Mississippi	N/A	N/A
Missouri	N/A	N/A
Montana	2007	2007
Nebraska	N/A	N/A
Nevada	2008	2008
New Hampshire	N/A	2009
New Jersey	2008	2008
New Mexico	2006	2006
New York	2010	2009
North Carolina	N/A	2008
North Dakota	N/A	N/A
Ohio	2011	2011

Table 2. Continued

State	GHG inventories	Climate change action plans
Oklahoma	2002	N/A
Oregon	2011	2010
Pennsylvania	2006	2009
Rhode Island	N/A	2002
South Carolina	N/A	2008
South Dakota	2007	N/A
Tennessee	N/A	N/A
Texas	2002	N/A
Utah	2007	2007
Vermont	2007	2007
Virginia	2008	2008
Washington	2007	2008
West Virginia	2003	N/A
Wisconsin	2007	2008
Wyoming	N/A	N/A

Notes: Information was obtained from the U.S. Environmental Protection Agency (The United States Environmental Protection Agency, 2014); N/A means that a state has not completed a GHG inventory or a climate change action plan.

variable technique based on information regarding a climate change action planfrom Table 2. For the dependent variable, CO_2 emissions were derived from the USEPA and measured in MMT (The U.S. Environmental Protection Agency, 2014). All the data ranged from 2007 to 2012 by state.

An entity fixed-effects panel regression model was utilized to estimate the effects of climate change policy on CO_2 emission reduction in the U.S. transportation sector. The empirical econometric model for the pooled data and each group is as follows (Pindyck and Rubinfeld, 1997; Stock and Watson, 2011):

$$y_{it} = \beta_0+\beta_1X_{1it}+\beta_2X_{2it}+y_3D2_i+y_4D3_i+\cdots+y_{n+1}Dn_i+u_{it} \quad (1)$$

where, β_0, β_1, β_2, y_3, $\cdots$; y_{n+1} are unknown coefficients; X_{1it} is the implementation of a climate change policy by state i in year t; X_{2it} is the transportation sector fuel consumption by state i in year t; $D2_i$ is a qualitative variable that equals 1 when i = 2 and 0 otherwise; $D3_i$ is a qualitative variable that equals 1 when i = 3 and 0 otherwise, and so on; u_{it} and is an error term.

$n-1$ qualitative variables were used to avoid the dummy variable trap by omitting the first qualitative variable, $D1_i$. The rest of the qualitative variables take care of the effects of all the omitted variables that are not the same from each state to another but are constant over time. To summarize, the processes of the model performed in this study are as follows. First, the author extracted the appropriate regressors for the model by the stepwise regression and multicollinearity test. Second, the author tested whether the entity fixed-effects regression model is the best among other possible panel models, such as the time fixed effects, one-way random effects, and two-way random effects, by using F statistics and comparing the overall model fit and the estimated coefficients' statistical significance. Third, a couple of statistical tests for verifying the serial correlation and heteroskedasticity were processed by the Durbin-Watson test and the Breusch-Pagan test, and the problems found were fixed by heteroskedasticity and autocorrelation-consistent (HAC) standard errors. Fourth, the author regressed the panel model and then analyzed the regression results based on the estimated coefficients' p-values at the 10%, 5%, and 1% significance levels.

4. EMPIRICAL RESULTS

The empirical findings regarding the effects of climate change policy on CO_2 emission reduction in the U.S. transportation sector from 2007 to 2012 are summarized in two parts-pooled data and each group-in Table 3 and Table 4. In both tables, the F statistic's null hypothesis, which is no fixed effects, was rejected at the 1% level of significance. A couple of OLS regression assumptions were tested and the test results are shown with the existence of positive serial correlation and heteroskedasticity since the Durbin-Watson tests were less than 2 and the null hypothesis of homoskedasticity in the Breusch-Pagan tests were rejected at the 5% significant level, respectively.

Table 3. Regression results for the entire U.S

Regressors	Coefficients and p-values
Intercept	−1.537 (0.064)*
Fuel consumption	0.000077 (0.000)***
Climate change action plan	−0.413 (0.002)***
$\overline{R}^2$	0.99
Number of observations	245
F statistic	20.01 (0.000)***
Breusch-Pagan test	80.39 (0.000)***
Durbin-Watson test	1.74

Notes: *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively. The coefficients on all the cross-sectional dummies and control variables have been omitted. The null hypothesis of the Breusch-Pagan test is homoskedasticity, and the F statistic's null hypothesis is no fixed effects.

To address these problems, HAC standard errors were used in the entity fixed-effects models. The HAC standard errors functioned to make the regression errors remain randomly correlated within a grouping and uncorrelated across groups (Stock and Watson, 2011). Additionally, to consider the potential omitted variable bias arising from omitting both technological advancements in fuel efficiency and the U.S. economic recession, the two control variables[5)] were utilized in the regression models. The concept of a control variable replaced the first least squares assumption of exogeneity with conditional mean in dependence[6)] to prevent the estimated causal effect of interest from suffering from endogeneity (Wooldridge, 2012). As Stock and Watson (2011) explained in 2011, this study distinguished between regressors for which we have an interest in estimating a causal effect and a control variable. By establishing the alternative assumption, "the OLS estimator of the effect of interest was unbiased, but the OLS coefficients on control variables were in general biased and did not have

Table 4. Regression results for each group

Regressors		Major	Middle	Minor
Intercept		−2.943 (0.115)	−0.734 (0.321)	0.048 (0.518)
Fuel consumption		0.000076 (0.000)***	0.000080 (0.000)***	0.000077 (0.000)***
Climate change action plan		−0.718 (0.089)*	−0.260 (0.017)**	−0.059 (0.064)*
CO_2 emissions	Avg.	97.9	33.4	9.1
	S.D.	59.6	9.5	4.6
$\overline{R}^2$		0.99	0.99	0.99
Number of observations		45	115	85
F statistic		10.50 (0.000)***	34.20 (0.000)***	55.89 (0.000)***
Breusch-Pagan test		80.39 (0.000)***	10.42 (0.015)**	22.44 (0.032)**
Durbin-Watson test		1.70	1.55	1.66

Notes: *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively; the p-values are in parenthesis. The coefficients on all the cross-sectional dummies and control variables have been omitted. The null hypothesis of the Breusch-Pagan test is homoskedasticity, and the F statistic's null hypothesis is no fixed effects.

5) The two control variables represent the U.S. economic recessions from 2007 to 2009 and the technological advancements for fuel economy in vehicle fleets. The variable of the U.S. economic recessions was constructed using a qualitative variable technique. The variable of advances in fuel efficiency was constructed using the summation of vehicles sold in the U.S. from electric hybrid vehicles, flex-fuel vehicles on E85, and hydrogen vehicles and was obtained from the online database of the USEIA (The United States Energy Information Administration, 2013).

a causal interpretation" (Stock and Watson, 2011, p. 231).

In Table 3, an overall effect of a climate change action plan on CO_2 emission reduction in the U.S. transportation sector across the 49 U.S. states was estimated and its coefficient shows a negative value of −0.413. If a state's policy plan of CO_2 emission reduction took effect during the period of 2007~2012, then it on average has reduced the CO_2 emissions per year by 0.413 MMT. Since the 31 states have completed such a CO_2 emission reduction policy plan through a climate change action plan, their total reduced CO_2 emissions reached 12.803 MMT in 2012, which was bigger than the entire transportation CO_2 emissions of West Virginia in 2012, 11.75 MMT. As the author expected, the fuel consumption in the transportation sector has had a positive impact on CO_2 emissions, technically 1 billion Btu in fuel consumption by transport in a state per year on average, increasing the CO_2 emissions by 0.000077 MMT.

Table 4 provides the effects of the climate change policy on CO_2 emission reduction in the three groups. Overall, the stability of average and standard deviation of CO_2 emission by each group would not seem to be deteriorated when considering the difference of the levels of CO_2 emission. The major group shows the most significant CO_2 emission reduction through the climate change action plan, followed by the middle and minor groups. The policy plan of CO_2 emission reduction in a state in the major group on average has almost three times as powerful a CO_2 emission reduction effect than that of the middle group, while a state in the minor group has on average only one-tenth of the CO_2 emission reduction effect compared with the major group. Since a climate change action plan exerts different effects within the groups, if the time and financial resources available are limited in the nation, then it is recommend to focus on letting the federal government first support the states in the major and middle groups[7] rather than the minor group.

5. CONCLUSIONS

The human activities for industrialization have been accelerating and raising the global temperature for centuries, due to the increasing CO_2 emissions released into the atmosphere by most of the economic sectors in a nation. As a result, we are unexpectedly experiencing severe natural disasters in many areas worldwide more frequently than in the past and thereby more people are being exposed to danger to their life and property.

A positive environmental policy change will be an essential factor in protecting public health and the coexistent needs of current and future generations; as Benjamin Franklin (Sussman, 2006) emphasized in 1963 at the University of North Dakota, the environment is an important public policy concern. In the U.S., such a change to relax the current high-level global warming and reverse it to a moderate level of around 1990 has been evident in various social and economic sectors; among them, the transportation sector, which emits one-third of the total CO_2 emissions in the U.S., has been quickly adapting by implementing a climate change action plan to reduce its CO_2 emissions.

This study revealed how effectively a climate change policy can function in the U.S. transportation sector by estimating the quantified climate change policy impacts not only for the national level, but also for the major, middle, and minor CO_2 emission groups. The empirical findings using an entity fixed-effects model with various valid statistical tests shows an evidently positive effect of the existence of a climate change policy in a state on decreasing its CO_2 emissions, even in the case of the minor CO_2 emission group. If all of the 49 states can implement climate change action plans, the U.S. transportation sector can reduce its CO_2 emissions by 20.2 MMT per year, and for the next 10 years, the cumulated CO_2 emission reduction will reach 202.3 MMT, which is almost equivalent to the CO_2 emissions produced by the transportation sector in 2012 in California, the largest CO_2 emitting state in the nation. All of this finally suggests the importance of implementing a climate change policy to reduce CO_2 emissions in the transportation sector.

6) Conditional mean independence is mathematically shown with the equation $E(u_i \mid X_{1i}, X_{2i}) = E(u_i \mid X_{2i})$, where X_{1i} is the variable of interest, X_{2i} is the control variable, and u_i is the error term. Including X_{2i} makes X_{1i} uncorrelated with u_i, and therefore OLS can be used to estimate the effect on Y_{it} of a change in X_{1i} [65].

7) The states that have not implemented any climate change action plans are as follows: Georgia and Texas in the major group and Alabama, Indiana, Louisiana, Mississippi, Missouri, Oklahoma, and Tennessee in the middle group.

6. STUDY LIMITATION

The author tried to find out scientific proofs regarding implementing effective climate change policies in the transportation sector as using an econometric tool which was well known in the econometrics. We probably think that decrease of fuel consumption will step out of CO_2 emissions in the air more and more, but regardless of intuitive awareness, evident proofs need to be revealed. In this study, the author macroscopically found out the CO_2 reduction effect of climate change policies, but in the next study microscopic effects of each climate change policy needs to be reviewed for the detailed policy effect analysis.

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REFERENCES

Al-Ghandoor A, Jaber JO, Samhouri M, Al-Hinti I. 2009. Analysis of aggregate electricity intensity change of the Jordanian industrial sector using decomposition technique. International Journal of Energy Research 33:255-266.

Barido DP, Marshall JD. 2014. Relationship between urbanization and CO_2 emissions depends on income level and policy. Policy Analysis 48:3632-3649.

Choi M, Kim J, Lee HJ, Jang YK. 2010. Estimation of greenhouse gas emission from off-road transportation. Journal of Climate Change Research 1:211-217.

Choi J, Roberts DC. 2015. How does the change of carbon dioxide emissions change affect transportation productivity? A case study of the U.S. transportation sector from 2002 to 2011. Open Journal of Social Science 3:96-106.

Choi J, Roberts DC, Lee E. 2014. Forecast of CO_2 emissions from the U.S. transportation sector: Estimation from a double exponential smoothing model. Journal of Transportation Research Forum 53:63-81.

Chung Y, Cho H, Choi K. 2013. Impacts of freeway accidents on CO_2 emissions: A case study for Orange County, California, US. Transportation Research Part D 24:120-126.

Diakoulaki D, Mavrotas G, Orkopoulos D, Papayannakis L. (2006). A bottom-up decomposition analysis of energy-related CO_2 emissions in Greece. Energy 31:2638-2651.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Impacts, adaptation, and vulnerability. Retrieved January 5, 2015, from http://www.ipcc.ch/report/ar5/wg2/

Kim M, Yoon YJ, Han J, Lee HS, Jeon EC. 2016. Analysis of GHG reduction potential on road transportation sector using the LEAP model. Journal of Climate Change Research 7:85-93.

Mendenhall W, Sincich T. 2011. A second course in statistics: Regression analysis. Pearson, London.

Morrow WR, Gallagher KS, Collantes G, Lee H. 2010. Analysis of policies to reduce oil consumption and greenhouse-gas emissions from the US transportation sector. Energy Policy 38:1305-1320.

Pindyck RS, Rubinfeld DL. 1997. Econometric models and economic forecasts. McGraw-Hill, New York.

Park YS, Lim SH, Egilmez G, Szmerekovsky J. 2016. Environmental efficiency assessment of US transport sector: A slack-based data environment analysis approach. Transportation Research Part D: Transport and Environment.

Stock JH, Watson MW. 2011. Introduction to econometrics. Addison-Wesley, Boston.

Sussman G. 2006. The Environment as an important public policy Issue. Retrieved January 9, 2015, from http://ww2.odu.edu/ao/instadv/quest/Environment.html

The National Aeronautics and Space Administration. 2014. The current and future consequences of global change. Retrieved January 5, 2015, from http://climate.nasa.gov/effects/

The United States Energy Information Administration. 2013. Alternative Fuel Vehicle Data. Retrieved January 7, 2015, from http://www.eia.gov/renewable/afv/users.cfm#tabs_charts-2

The United States Environmental Protection Agency. 2013. Global greenhouse gas emissions data. Retrieved January

5, 2015, from http://www.epa.gov/climatechange/ghgemissions/global.html

The United States Environmental Protection Agency. 2014. Greenhouse gas inventory data explorer. Retrieved January 3, 2015, from http://www.epa.gov/climatechange/ghg-emissions/inventoryexplorer/#transportation/allgas/source/all

The United States Environmental Protection Agency. 2015. Climate change & air quality. Retrieved January 5, 2015, from http://www.epa.gov/airquality/airtrends/2011/report/climatechange.pdf

The World Bank. 2015. CO_2 emissions from transport. Retrieved January 6, 2015, from http://data.worldbank.org/indicator/EN.CO2.TRAN.MT/countries?display=graph

Wooldridge JM. 2012. Introductory econometrics: A modern approach. Cengage Learning, Boston.

Zhang H, Chen W, Huang W. 2016. TIMES modelling of transport sector in China and USA: Comparisons from a decarbonization perspective, Apllied Energy 162:1505-1514.