Sectoral carbon emissions and economic growth in the US: Further evidence from rolling window estimation method

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ABSTRACT

The Environmental Kuznets Curve Hypothesis (EKC) which argues that an inverted U-shaped relationship exists between economic growth and environmental degradation has been examined by numerous studies for different countries or country groups. However, the validity of the EKC hypothesis at the sectoral level is mostly ignored. In addition, most of these studies have modeled the nexus between per capita income and CO_2 emissions based on the assumption of non-linearity. Unlike previous studies, the main purpose of this paper is to investigate the validity of EKC hypothesis for sub-elements of carbon dioxide emissions (i.e. total CO_2 emission, commercial CO_2 emission, electrical CO_2 emission, industrial CO_2 emission, residential CO_2 emission and transportation CO_2 emission) in the United States for the annual data of 1973-2015. In doing so, the rolling window estimation procedure is employed to observe the effect of per capita income on sectoral CO_2 emission for each sub-sample period instead of the non-linear assumption. The results of the rolling window coefficients show that inverted U-shaped EKC hypothesis is valid for total CO_2 emission, industrial CO_2 emission, electrical CO_2 emission and residential CO_2 emission. However, the inverted U-shaped relationship between economic growth and CO_2 emission is not supported for commercial and transport sector of the US.

Keywords: Sectoral CO_2 emission, economic growth, EKC hypothesis, rolling window estimation.

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1.Introduction

Since industrial revolution, the pressures on environment have been increased and environmental awareness has begun to arise after these pressures reached to global dimension such as global warming and climate change. In addition, human-induced greenhouse gas emissions have reached to the highest levels in the recent period and economic development is accepted as the main reason of climate change and greenhouse gas emissions (IPCC, 2014). Therefore, the link between economic growth and environment degradation has gain attention from policymakers and researchers. However, the effect of economic growth on carbon dioxide has still been a controversial issue in the field of environmental economics. In this regard, the mostly accepted explanation called as Environmental Kuznets Curve (EKC) hypothesis is that environmental degradation is increased with the first stages of economic growth to a turning point, and after this point, economic growth leads to decrease in environmental degradation by increased environmental sensitivity.

Although many researchers examined the effect of economic activities on environmental quality, it is mostly ignored that environmental effects of sectoral activities. According to the US Energy Information Administration (EIA), commercial sector, electrical sector, industrial sector, residential sector and transportation sector are responsible for 13.01 %, 26.66 %, 20.06 %, 14.48 % and 25.81% total carbon dioxide emissions of the US in 2015, respectively. The annual share of these sectors for the period of 1973-2015 is illustrated in Fig 1. As a shown in Fig 1, CO_2 emission sourced from transportation, electrical and commercial sector is increased for the period from 1973 to 2015 in the United States. However, it can be said that as a result of using eco-friendly technologies, environmental damage of industrial and residential sector has been decreased.

[INSERT FIGURE 1 HERE]

Based on above reasons, the main aim of this study is to investigate the validity of EKC hypothesis for different sectors by examining the relationship between economic growth and environmental degradation indicators (i.e. total CO_2 emission, commercial CO_2 emission, electrical CO_2 emission, industrial CO_2 emission, residential CO_2 emission and transportation CO_2 emission) for the period from 1973 to 2015 in the United States. For this aim, we used the rolling window estimation methodology which can be used to detect the causal relationships and coefficients for sub-sample periods. In addition, the previous studies which investigate the validity of EKC hypothesis examined the possible non-linear relationship between economic growth and CO_2 emission with using both the real GDP and the square of the real GDP as explanatory variables. However, in this study, used methodology gives us a chance to determine whether the non-linear relationship is valid by computing each coefficient for all sub-sample periods.

The contribution of this study is fivefold. First, this is the first study which examines the relationship between economic growth and CO_2 emission in the US using with rolling window procedure. Second, using rolling window causality method leads to determine the possible changes in causality between environmental degradation indicators and economic growth. Third, the effects of economic growth on environmental degradation indicators can be observed for each sub-sample period. Fourth, used bootstrapping technique minimizes the distortions sourced from small samples therefore obtained findings will be reliable for policy implications. Fifth, examining the relationship for sectoral level leads to a more detailed observation of the success of eco-friendly policies in which sectors and gives us a chance on more detailed policy implications based on this observation.

2. Literature review

Since the pioneer studies of Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992) and Panayotou (1993), many studies investigate the existence of EKC hypothesis. Although the validity of EKC hypothesis is searched for total CO_2 emission by many researchers, the studies on the relationship between economic growth and sectoral CO_2 emission is relatively limited. Therefore, the literature section is categorized with two parts. In first part, the recent studies on the relationship between economic growth and total CO_2 emission are summarized with obtained results on the validity of EKC hypothesis. The literature on EKC hypothesis for total CO_2 emissions is illustrated in Table 1.

As a seen in Table 1, different results are found based on using methodology and observing time period for same countries. For instance, Fodha and Zaghdoud (2010) utilized with Johansen cointegration and VECM Granger causality method to examine the existence of EKC hypothesis for the period from 1961 to 2004 in Tunisia and the findings supported the inverted U-shaped EKC hypothesis. Similarly, Shahbaz et al. (2014a) and Farhani et al. (2014b) confirmed the inverted U-shaped relationship between real GDP and environmental pollution. However, Jebli and Youssef (2015) examined the validity of EKC hypothesis in Tunisia and found the evidence of U-shaped relationship between real GDP and environmental pollution for same country. In addition, in case of Malaysia, Saboori et al. (2012a) investigated the existence of EKC hypothesis using with ARDL bound test approach for 1980-2009 period and confirmed the inverted U-shaped connection between real GDP and CO_2 emission. On the other hand, Begum et al. (2015) searched the real GDP-emission nexus for same country and also used same methodology for the period from 1970-2009 but found the U-shaped relationship between real GDP and CO_2 emission. Moreover, Dogan and Turkekul (2016) used ARDL bound test approach to examine the validity of EKC hypothesis in the US for the period from 1960 to 2010 and concluded that the U-shaped relationship exists between real GDP and environmental pollution. However, Atasoy (2017) examined the relationship between real GDP and CO_2 emission in 50 US states for the same period and used panel data methodology. This study found that there is inverted U-shaped relationship between economic growth and environmental pollution in the US.

[INSERT TABLE 1 HERE]

In second part, the studies on the relationship between economic growth and disaggregated CO_2 emission are given in detail. Alper and Onur (2016) examined the validity of EKC hypothesis for different environmental pollution indicators (i.e. gaseous fuel pollution, liquid fuel pollution, solid fuel pollution, residential buildings and commercial and public services pollution, industrial pollution, transportation pollution and electricity and heat pollution) using with fully modified OLS method for the period of 1977-2013 in China. The results show that the evidence of EKC hypothesis is found for gaseous, liquid, solid and transportation pollution.

Congregado et al. (2016) investigated the existence of the EKC hypothesis for sectoral CO_2 emissions (i.e. total CO_2 emission, commercial, electrical, industrial, residential and transport) using with dynamic OLS method under structural breaks spanning the quarterly period of 1973:1 – 2015:2 in the United States. The results supported the EKC hypothesis for all sectors excluding industrial sector.

Wang et al. (2017) probed the validity of EKC hypothesis for mining, manufacturing, electricity and heat sectors utilizing with semi-parametric panel fixed effect estimator for the period from 2000-2013 in 30 provinces of China. The results show that inverted U-shaped EKC hypothesis is confirmed just in electricity and heat sector. Pablo-Romero and Sanchez-Braza (2017) examined the existence of EKC hypothesis for residential sector for the period from 1990 to 2013 using with multilevel mixed-effect model in EU-28 countries. It is concluded from this study is that the EKC hypothesis is valid for residential sector.

To sum up, it can be concluded from previous studies that using different methodology or utilizing different control variables (urbanization, trade openness, population, energy consumption, renewable energy consumption etc.) may lead to obtain different results for both the same countries and the same periods. Additionally, most of these studies constructed the empirical model in quadratic or cubic form based on the assumption of non-linear relationship between real GDP and CO_2 emission for full-sample period. Unlike previous studies, we used the rolling window estimation method to examine the validity of non-linear relationship between real GDP and CO_2 emission without the assumption of non-linearity by computing the coefficient for each sub-sample period.

3. Data and methodology

The data used in this study consists of annual observations from 1973 to 2015 for the United States. The real gross domestic product (GDP) is measured in constant 2009 US dollars. There are some reasons to use the total GDP instead of the sectoral value added as an indicator of economic development. The response of sectors to emission reducing pressure is in different directions and these reactions are not solely dependent on the output from that sector. Because different sectors have different energy intensities and some sectors generate more emissions due to the production structure (Bowden and Payne, 2010; Congregado et al., 2016). In this case, high-cost production innovations in the direction of reducing emissions may change depending on the proportional share allocated from the national income or technological developments in the other sectors. Based on these reasons and following the studies of Hamit-Haggar (2012), Xu and Lin (2015), Alper and Onur (2016), Congregado et al. (2016), Pablo-Romero and Sanchez-Braza (2017) that utilized with the data of total GDP and sectoral emissions to examine the validity of EKC hypothesis, we also used the total gross domestic product as proxy for economic development. Environmental pollution indicators are measured in million metric tons of carbon dioxide. In addition, the environmental pollution indicators are distinguished by total CO_2 emission (TCO), CO_2 emission of commercial sector (COM), CO_2 emission of electrical sector (ELC), CO_2 emission of industrial sector (IND), CO_2 emission of residential sector (RES) and CO_2 emission of transportation sector (TRA). The data of GDP is sourced from US Bureau of Economic Analysis (BEA) and environmental pollution indicators are retrieved from US Energy Information Administration (EIA). Moreover, all variables are used natural log form for empirical analyses. The descriptive statistics of included variables are illustrated in Table 2. EViews 9 software is used for empirical analysis.

In order to investigate the validity of Environmental Kuznets Curve hypothesis, we utilized with rolling window estimation methodology developed by Balcilar et al. (2010). The rolling window estimation method is mainly based on bootstrap causality test of Hacker and Hatemi-J (2006). In the first step of bootstrap causality method is as following;

$$y_t = \varphi_0 + \varphi_1 y_{t-1} + \cdots + \varphi_p y_{t-p} + \varepsilon_t, \quad t = 1,2, \dots, T$$
(1)

where p is the lag order, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is zero mean white noise process with covariance matrix Σ. y_t is splited in two vectors; CO (y_{1t}) and GDP (y_{2t}) and finally obtain;

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \varphi_{10} \\ \varphi_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11}(L) & \varphi_{12}(L) \\ \varphi_{21}(L) & \varphi_{22}(L) \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$
(2)

where $\varphi_{ij}(L) = \sum_{k-1}^{p} \varphi_{ij,k} L^k$, $i, j = 1,2$ and L is the lag operator. The null hypothesis of real GDP (GDP) does not Granger-cause environmental pollution (CO) can be examined by imposing zero restrictions $\varphi_{12,i} = 0$ for $i = 1,2, \dots, p$ and the null of environmental pollution (CO) does not Granger-cause real GDP (GDP) can be computed by imposing zero restrictions $\varphi_{21,i} = 0$ for $i = 1,2, \dots, p$. Furthermore, the critical values of test are obtained from bootstrap testing procedure of Efron (1979).

In empirical analysis, researchers call different methods (splitting the sample into pieces, using dummy variables etc.) to determine the structural changes. This study uses rolling window causality method of Balcilar et al. (2010) to consider the changes of causal relationship between economic growth and environmental pollution for sub-sample periods. Balcilar et al. (2010) utilized above methodology of Hacker and Hatemi-J (2006) and developed a causality method to investigate the bootstrap causality in rolling window sub-samples for $t = \tau - 1 + l, \tau - 1, \dots, \tau, \tau = l, l + 1, \dots, T$, where l is the rolling window. Possible changes in the causal connections between growth and CO_2 emissions are determined with computing the bootstrap *p*-values of LR-statistic rolling through T-1 sub-samples. Furthermore, the effect of economic growth on environmental pollution is calculated as $B^{-1}\sum_{k-1}^{P}\hat{\varphi}_{21,k}^{*}$ with $\hat{\varphi}_{21,k}^{*}$ obtained from bootstrap estimation of vector autoregressive (VAR) model by Eq.2 and B is the bootstrap repetition number. Similarly, the effect of environmental pollution on economic growth is computed as $B^{-1}\sum_{k-1}^{P}\hat{\varphi}_{12,k}^{*}$ where $\hat{\varphi}_{12,k}^{*}$ is obtained from bootstrap estimation of VAR model by Eq.2 and B refers to bootstrap repetition number.

4. Empirical results and discussion

In order to examine the existence of EKC hypothesis, we first test the stationary level of variables using with Phillips-Perron (PP) unit root test. The results of unit root test are illustrated in Table 3. As a shown in Table 3, the null of unit root process is not rejected of the level form of variables. However, all variables become stationary in first differenced forms due to the null hypothesis is rejected.

[INSERT TABLE 2 HERE]

The main argument of this study is that full sample estimation methods may not give reliable information about the validity of EKC hypothesis because of the assumption of stable parameters. Before this procedure, we utilized with Schwarz Information Criteria (SIC) to determine optimal lag order of vector autoregressive (VAR) model. We sequentially increase the lag of VAR model and the optimal lag order is selected 2 which minimize the SIC value. Therefore, this study examines stability properties of long-run parameters of cointegrated VAR(2) model using with L_C test of Hansen (1992). Additionally, we used Sup-LR, Exp-LR and Mean-LR tests of Andrews (1993) and Andrews and Ploberger (1994) to investigate the stability properties of estimated short-run parameters. As illustrated in Table 4, in case of GDP equation, the null of short-run parameter stability cannot be rejected for equations which TCO, COM, ELC, IND and TRA are used as explanatory variables while the long-run parameter instability is valid for TCO and RES equations. The models which environmental pollution indicators are used as dependent variable, the null hypothesis of parameter stability is rejected for both short and long-run. To sum up, the findings of previous studies which assume the long-run parameter stability may not be reliable because estimated parameters of cointegrated VAR model are not stable and obtained parameters do not reflect full sample.

[INSERT TABLE 3 HERE]

[INSERT TABLE 4 HERE]

Based on these reasons, the main aim of this study is to examine the causal relationship between economic growth and environmental pollution indicators in sub-sample periods and investigating the validity of Environmental Kuznets Curve hypothesis by rolling sample coefficients. The bootstrap *p*-values of observed LR statistics are computed rolling through all sample period from 1973 to 2015. Pesaran and Timmermann (2005) examined the optimal window size for rolling window estimation to minimize the bias in autoregressive parameters in case of frequent breaks. Based on the Monte Carlo simulation results of this study, we use a window size of 15 in order to reduce the risk of ignoring possible structural breaks in windowed sample.

[INSERT FIGURE 2 HERE]

The results of rolling window estimation are separated with six environmental pollution indicators. For all causality test results, the blue line indicates bootstrap *p*-values and red line implies 10% statistical significance level. The null hypothesis of there is no any causal relationship between variables can be rejected when the p-values (blue line) are below the 10% significance level (red line). In case of total CO_2 emissions, the findings are illustrated in Fig 2. The panel a of Fig 2 shows that economic growth causes total CO_2 emissions in 1994-1996, 1999-2000 and 2009 sub-sample period. In addition, total CO_2 emission causes economic growth in 1990-1996 sub-sample periods. In addition, as a shown in panel c of Fig 2, the coefficient of economic growth on total CO_2 emission is positive in 1988-2006 periods. However, it becomes negative in period of 2007-2015. When the coefficient of economic growth on total CO_2 emission is evaluated in terms of trend, it has increasing trend from 1988 to 2000 while it has decreasing trend from 2001 to 2015. Moreover, it can be seen that the effect of total CO_2 emission on economic growth is negative in most of the sub-sample periods. Overall, the inverted U-shaped EKC hypothesis is confirmed for total CO_2 emissions.

[INSERT FIGURE 3 HERE]

The rolling window estimation between economic growth and commercial CO_2 emission is shown in Fig 3. In panel a and b of Fig 3, it seems economic growth causes commercial CO2 emission in 1999-2005 sub-sample period and commercial CO_2 emission causes economic growth in 2010-2013 sub-sample period. Furthermore, in panel c of Fig 3, the coefficient of economic growth on commercial CO_2 emission is positive in the period from 1988 to 2008 except of 2006 and it is negative in the period of 2009-2015. As a shown in panel d of Fig 3, the effect of commercial CO_2 emission on economic growth is mostly negative in selected sample. When the results are evaluated in terms of trend, we concluded that the inverted U-shaped EKC hypothesis is not valid for commercial CO_2 emission.

In Fig 4, according to the findings of rolling window estimation for electrical CO_2 emission, economic growth causes electrical CO_2 emission in 1990-1996, 1999-2005, 2009 and 2011 sub-sample periods. CO_2 emission from electrical sector causes economic growth in 1995-1996 and 2000 sub-sample periods. The coefficient of economic growth on electrical CO_2 is shown in panel c of Fig 4. According to the results, the effect of economic growth on electrical CO_2

emission is positive in 1988-2007 periods while it becomes negative in 2008-2015 periods. When the results are interpreted with regard to trend, it seems the effect of real GDP has increasing trend for the period from 1988 to 2001, and it has decreasing trend between 2001 and 2015. Therefore, the inverted U-shaped relationship is supported in case of electrical CO_2 emission.

[INSERT FIGURE 4 HERE]

In case of industrial CO_2 emissions, the causal relationship between economic growth and environmental pollution from industrial sector can be shown in panel a and b of Fig 5. At a first glance, it seems economic growth causes industrial CO_2 emission in 1996-1997, 1999-2000, 2006, 2010-2015 sub-periods and industrial CO_2 emission causes economic growth in 1988-1996, 2010-2015 sub-periods. In addition, the coefficient of economic growth on industrial CO_2 emission is negative in 1988-1992 sub-periods, the coefficient of economic growth is positive in 1993-2000 sub-periods and it becomes negative in 2001-2015 sub-periods again. When the findings are commented with trend, it seems the coefficient of economic growth has increasing trend in 1988-1999 period and has decreasing trend in 1999-2015 period. Therefore, the validity of inverted U-shaped EKC hypothesis is confirmed for industrial sector of the United States. Moreover, in panel d of Fig 5, it can be seen that industrial CO_2 emission negatively affects economic growth for most of the periods.

[INSERT FIGURE 5 HERE]

The rolling window estimation of the economic growth-residential CO_2 emission nexus can be seen in Fig 6. In panel a and b of Fig 6, the results show that economic growth causes residential CO2 emission in 1999-2002 and 2004 sub-periods; residential CO_2 emission causes economic growth in 1988-1996 and 1999-2000 sub-periods. The coefficient of economic growth on residential CO_2 emission is positive in 1988-2010 sub-periods, and it becomes negative in 2011-2015 sub-periods. The increasing trend of the coefficient of economic growth is valid in the period from 1988 to 2002, and decreasing trend is valid in the period of 2003-2015. Therefore, the inverted U-shaped EKC hypothesis is found for residential sector too.

[INSERT FIGURE 6 HERE]

[INSERT FIGURE 7 HERE]

The results of rolling window estimation for the relationship between economic growth and transportation CO_2 emission are illustrated in Fig 7. In panel a, there is causal relationship from economic growth to transportation CO_2 emission is found in 1988-1994, 1999-2000 and 2004-

2005 sub-periods. In panel b, it can be seen that transportation CO_2 emission causes economic growth in 2010-2015 sub-period. In addition, the coefficient of economic growth on transportation CO_2 is positive in 1988-2011 periods, and it becomes negative in 2011-2015 periods. On the other hand, the inverted U-shaped relationship between economic growth and transportation CO_2 emission is not confirmed. We found that the effect of economic growth on transportation CO_2 emission seems fluctuating trend in the period of 1988-2015.

Overall, inverted U-shaped relationship between real income and CO_2 emission is confirmed for industrial sector, electrical sector and residential sector. These findings are consistent with the studies of Hamit-Haggar (2012) for industrial sector; Congregado et al. (2016) and Wang et al. (2017) for electrical sector and Pablo-Romero and Sanchez-Braza (2017) for residential sector. However, the inverted U-shaped EKC hypothesis does not hold for commercial and transport sector. The rejection of the validity of EKC hypothesis is also found by Alper and Onur (2016) for commercial sector and Chandran and Tang (2013) for transport sector. Based on the findings, the United States seems to have been successful in using environmentally friendly technologies except in commercial and transport sector. In case of transport sector, it may be sourced from that the energy consumption of the transportation sector is still largely composed of motor gasoline and distillate fuel oil. However, in case of industrial sector, it is seen that coal consumption has decreased by 56% from 1990 to 2016 and that the energy demand is met by increasing natural gas and renewable energy consumption in the US. The findings from commercial sector also show that inverted U-shaped EKC hypothesis is not supported. Although there are many environmental regulations, a large proportion of energy consumption of the commercial sector has still met by fossil fuels during this period in the US. Fossil fuel energy consumption of the commercial sector was 28% in 1990 and it could be reduced to 22% in 2016 (EIA, 2017). These results indicate that the environmental regulation in the commercial sector has failed to achieve its goal and new regulations are needed to achieve environmental optimization in the commercial sector.

5. Conclusions and policy implications

The previous studies examining the validity of the EKC hypothesis generally focus on total CO_2 emissions, neglecting the sectoral decompositions of emissions, and use empirical models based on the assumptions of quadratic or cubic functions. However, it is a crucial issue to elaborate the policy proposals by observing the effect of economic output on sectoral emission. Unlike previous studies, this study aims to examine the validity of Environmental Kuznets Curve hypothesis for the period from 1973 to 2015 in different sectors of the United States. For this aim, the relationship between economic growth and environmental pollution indicators (i.e. total CO_2 emission, commercial CO_2 emission, electrical CO_2 emission, industrial CO_2 emission, residential CO_2 emission and transportation CO_2 emission) using with the rolling window estimation method.

In study, first, the findings show that there is parameter instability in empirical models which environmental pollution indicators are used as dependent variable. Therefore, it is concluded that previous studies based on cointegrated VAR models may not be reliable for policy implications and using rolling window estimation methodology gives more robust results on the nexus of economic growth and environmental pollution. According to the results of rolling window causality method, it seems there is causality from economic growth to total CO_2 emission in 1994-1996, 1999-2000 and 2009 sub-sample periods; to commercial CO_2 emission in 1999-2005 sub-sample period; to industrial CO_2 emission in 1996-1997, 1999-2000, 2006, 2010-2015 sub-sample periods; to electrical CO_2 emission in 1990-1996, 1999-2005, 2009 and 2011 sub-sample periods; residential CO_2 emission in 1999-2002 and 2004 sub-periods and to transportation CO_2 emission in 1988-1994, 1999-2000 and 2004-2005 sub-periods. Moreover, it is obtained from rolling window coefficients, inverted U-shaped EKC hypothesis is valid for total CO_2 emission, industrial CO_2 emission, electrical CO_2 emission and residential CO_2 emission. However, the inverted U-shaped relationship between economic growth and environmental pollution is not supported for commercial and transport sector of the US. Additionally, we also analyzed the effect of sectoral CO_2 emission on real GDP and found that increased sectoral CO_2 emissions negatively affect the real GDP for most of the sub-sample periods.

Our empirical results implied that the US government seems to have succeeded in reducing environmental pollution through economic growth. However, the government should increase its environmental regulatory policies, especially in the commercial and transportation sectors. In case of transportation sector, the technological researches on the development of hybrid engine and electric vehicle should be supported by the government to reduce CO_2 emission of this sector. In case of commercial sector, when measured in terms of energy intensity, hotel and catering industry and real estate industry consume more energy than other commercial industries (Wang and Lin, 2017). Based on this reason, the government should redirect the hotels and catering industry to the use of energy-saving appliances and should redirect the real estate industry to energy-saving building materials.

There are some strengths and limitations in this paper that will form the basis for future studies. Analyzing the validity of the EKC hypothesis through the method used in the study rather than modelling it based on assumptions in quadratic or cubic form may be pioneer for future studies. However, our study has periodic and geographical data set limitations. First, since the method used in the study creates a trim in the sample, the model can be examined in a longer period for future studies. Second, the geographical limitation is that the appropriate sample period to use this methodology for indicators that represent sectoral emissions exists only for the US. The development of data sets containing sectoral emission indicators for other countries or country groups will allow the study to be carried out in a wider perspective.

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