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The Relationship between Environmental Taxation, Environmental Performance and Economic Growth: Comparative Study of Sweden and China 1985-2016

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Abstract

This paper explores the relationship between environmental tax, environmental performance and economic development in China and Sweden using time series data over the period 1985–2016. The mainly research method is constructive study method and this study mainly aims at improving environmental tax system of China. We performed ARDL Bound test to see if there is evidence of a long run relationship. Based on the results, we found that both countries have cointegrating vectors. Moreover, by setting up ARDL-ECM model we find out the triadic relation and testify the EKC theory and Double Dividend theory existing or not in China and Sweden. The Granger causality tells us environmental tax in China does not play a role in reducing carbon dioxide, environmental tax benefits to economic growth and economic growth of China will weaken growth of carbon emission but the function is not significant. To ameliorate this condition, governments should accelerate public relative environmental tax policy especially carbon tax to decrease emission of carbon without restricting growth of economy.

Keywords: environmental performance, ARDL bound, EKC theory, double dividend theory, emission of carbon

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INTRODUCTION

With the rapid economic growth, the problem of haze pollution, dust storms, light pollution and noise pollution occurs much more frequently than before. As the ecological pollution seriously harms the public health, environmental protection raises more attention and becomes a widely-discussed issue.

Based on that the above fact, several countries gradually establish the environmental protection mechanism and adopted a series of measures to reduce environmental damage and beautify the ecological environment. Among that, the role of the environmental tax should not be underestimated. The first environmental protection tax law of China came into effect in January 1, 2018, indicating that China has started its establishment process of environment protect through levying environment-related tax to the firms. This tax makes the environmental protection a legally enforceable policy rather than a voluntary action. Although China has taken the first step out for the environment taxation, the taxation mechanism and system are still unmatured. However, the green tax system in Nordic countries, such as Sweden, has started up earlier, and this system is relative matured and well-established in these countries. We can see intuitively that various pollutants, especially carbon dioxide in Sweden has been visibly deteriorated since coming up environmental tax. Therefore, the experience of Sweden in terms of the green tax system is able to provide guidance for the development of green tax system in China.

This study based on two basic theory, one is Double Dividend of tax and the other is Environmental Kuznets Curve Theory. About Kuznets Curve Theory, large parts of the literatures concentrate on invert U-shape Environmental Kuznets Curve, but we focus on exploring N-shape curve of China and Sweden.

The constructive method is the core measure of study. Most of researchers concentrate on one certain country or some cities and find out whether the

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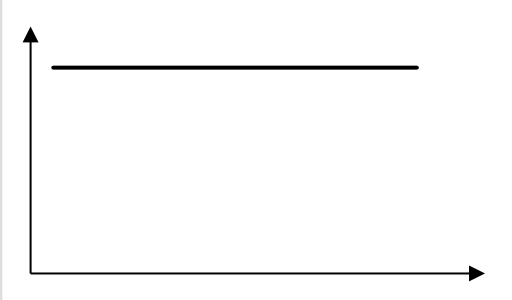
Table 1. Analysis of variable coefficient

Various form	Characteristic	graph
$\beta_2=\beta_3=\beta_4=0$	No relationship or a flat pattern	

environmental tax is valid in a certain region while we figure out the relationship of three objects by comparing China and Sweden. Concentrating on the existing literature we investigates the relationship between environmental taxation, emission of carbon dioxide and economy development using the time series data for the period of 1985-2016 of Sweden and China. The cointegration amid the variables is investigated by using the ARDL bounds testing. The direction of causal association among the variables is investigated by using the VECM Granger causality approach.

LITERATURE REVIEW

In recent years, the literature on the relationship of environmental tax, economic growth and environmental performance has gradually increased. Among these articles, there are two representative theories. One is Double Dividend Theory and the other is EKC (Environmental Kuznets Curve) theory.

Environmental taxation is regarded as producing a double effect where by the environment is improved and the economy is benefited through the reduction in these distortionary taxes at the same time (Bosquet 2000). Pearce (1991) defines the connotation of double dividend as "the reciprocal substitution of the environment tax and the distorting tax can get two dividends". In this double dividend theory, one element is to reduce the damage to the environment, which we call it "green dividend" and the other one is to reduce the distortion cost of the tax system, this is what we call "blue dividend".

The EKC (Environmental Kuznets Curve) theory is a theoretical tool widely performed in examining the relationship between environmental performance and economic growth. Grossman and Krueger (1991) further the study of EKC hypothesis, and claim that environmental quality deteriorates with economic development at low income levels and turns to improve at high levels (Grosman and Krueger 1994, Hettige and Wheeler 1992, Koop 1998, Panayotou 1993, 2000, Selden and Song 1994, Shafik and Bandyopadhyay 1992). With the rapid growth of economy, Kuznets approaches become of key policy interests in designing environmental management strategies in developing nations (Chowdhury and Moran 2012).

To sum up, lots of researches exploring the relationship between two variables, most of which is environmental taxation and carbon dioxide. Based on that, we explore the triadic relation that among environmental taxation, GDP and emission of carbon dioxide. In other words, this study contains not only Double Dividend Theory but also EKC (Environmental Kuznets Curve) theory.

MODEL CONSTRUCTION AND METHODOLOGICAL FRAMEWORK

The data used in the study are annual observations during 1985 to 2016, which were searched from several resources. The data of carbon dioxide emissions, GDP, GDP^2 and GDP^3 are extracted from World Bank. Meanwhile, environment tax (tax) data of Sweden were collected from OECD statistics. Cong et al. and Cong and Shen supported the use of log-linear specification for empirical analysis and formations as shown in Eq. (1):

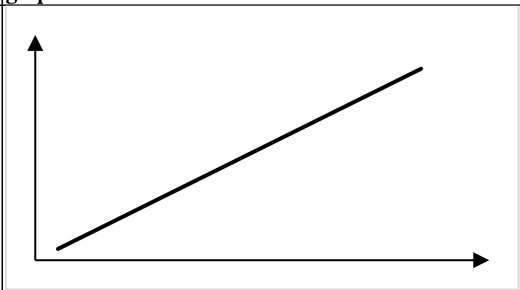
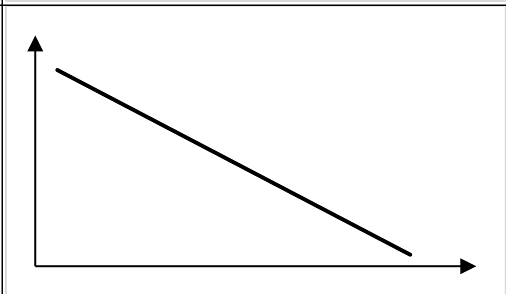
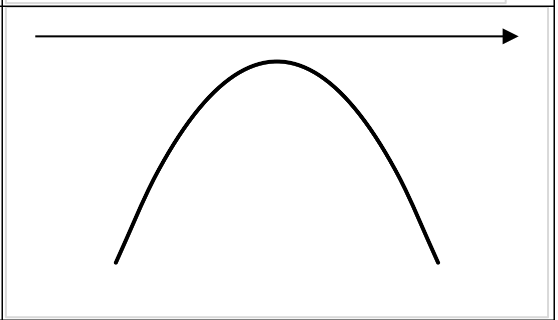
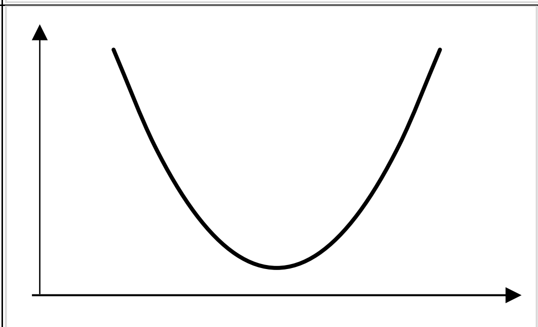
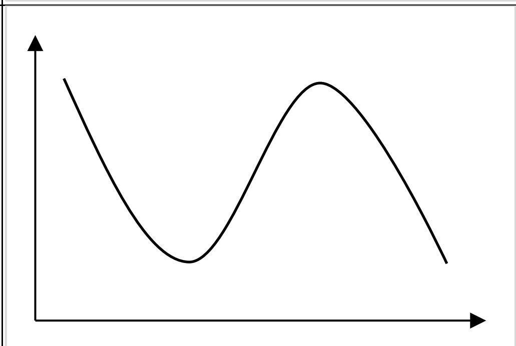
$$lnco_{2t} = \beta_1 + \beta_2 lnctax_t + \beta_3 lngdp_t + \beta_4 lngdp^2{}_t + \beta_5 gdp^3{}_t + \mu_t \quad (1)$$

According to Eq. (1), we can test the various forms of relationship between environmental performance and economic development as **Table 1**.

Unit Root Tests

In this study, we use the Augmented Dickey–Fuller and Phillips–Perron unit root tests.

Table 1 (continued). Analysis of variable coefficient

Various form	Characteristic	graph
$\beta_2>0$, $\beta_3=\beta_4=0$	Increasing linear relationship	
$\beta_2<0$, $\beta_3=\beta_4=0$	Decreasing linear relationship	
$\beta_2\geq 0$, $\beta_3<0$ and $\beta_4=0$	Invert-U shape curve (conventional EKC)	
$\beta_2\leq 0$, $\beta_3>0$ and $\beta_4=0$	U shape curve	
$\beta_2\leq 0$, $\beta_3\geq 0$ and $\beta_4<0$	Invert N-shape (notice: β_2 and β_3 cannot be 0 at the same time)	

As is shown in Eq. (2), David Dickey and Wayne Fuller unit root test— Fuller Dickey test is a method of comparison in the data stationarity test. μ_t means the random error term of white noise—zero mean, constant variance and non—autocorrelation.

$$Y_t = \rho^T Y_{t-T} + \rho\mu_{t-1} + \rho^2\mu_{t-2} + \cdots + \rho^T\mu_{t-T} + \mu_t \tag{2}$$

The Eq. (3) increase in the lag of Δy_t and Eq. (3) is also known as the Augmented Dickey-Fuller test, which has the same asymptotic distribution with DF and uses the same critical value.

$$\triangle Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \triangle Y_{t-i} + \varepsilon_t \tag{3}$$

Phillips and Perron proposed a PP test statistic in 1988. The PP test statistic is applicable for the stationary test of the heteroscedasticity and it obeys the corresponding limit distribution of the ADF test statistics. The PP test is shown as Eq. (4).

$$Z(\tau) = \tau(\hat{\sigma}^2/\hat{\sigma}_{sl}^2) - (1/2)(\hat{\sigma}_{sl}^2 - \hat{\sigma}^2)T\sqrt{\hat{\sigma}_{sl}^2 \sum_{t=2}^{T}(x_{t-1} - \bar{x}_{T-1})^2} \tag{4}$$

ARDL Model

According to Pesaran (1999), the ARDL method has additional advantage of yielding consistent estimates of the long—run parameters that are asymptotically normal irrespective of whether the variables are I(0), I(1) or mutually integrated. The null hypothesis is H_0:$\pi_1=\pi_2=\pi_3=\pi_4=\pi_5=0$; alternative hypotheses H_1:$\pi_1\neq\pi_2\neq\pi_3\neq\pi_4\neq\pi_5\neq0$. The ARDL model used in this study is as follows:

$$dlnco_{2t} = \beta_1 + \sum_{i=1}^{n}\alpha_1 dlnco_{2t-i} + \sum_{i=1}^{n}\alpha_2 dlntax_{t-i} + \sum_{i=1}^{n}\alpha_3 dlngdp_{t-i} + \sum_{i=1}^{n}\alpha_4 dlngdp^2{}_{t-i} + \sum_{i=1}^{n}\alpha_5 dlngdp^3{}_{t-i} + \pi_1 lnco_{2t-i} + \pi_2 lntax_{t-i} + \pi_3 lngdp_{t-i} + \pi_4 lngdp^2{}_{t-i} + \pi_5 lngdp^3{}_{t-i} + \varepsilon_{1t} \tag{5}$$

$$dlntax_t = \beta_2 + \sum_{i=1}^{n}\alpha_1 dlnco_{2t-i} + \sum_{i=1}^{n}\alpha_2 dlntax_{t-i} + \sum_{i=1}^{n}\alpha_3 dlngdp_{t-i} + \sum_{i=1}^{n}\alpha_4 dlngdp^2{}_{t-i} + \sum_{i=1}^{n}\alpha_5 dlngdp^3{}_{t-i} + \pi_1 lnco_{2t-i} + \pi_2 lntax_{t-i} + \pi_3 lngdp_{t-i} + \pi_4 lngdp^2{}_{t-i} + \pi_5 lngdp^3{}_{t-i} + \varepsilon_{2t} \tag{6}$$

$$dlngdp_t = \beta_3 + \sum_{i=1}^{n}\alpha_1 dlnco_{2t-i} + \sum_{i=1}^{n}\alpha_2 dlntax_{t-i} + \sum_{i=1}^{n}\alpha_3 dlngdp_{t-i} + \sum_{i=1}^{n}\alpha_4 dlngdp^2{}_{t-i} + \sum_{i=1}^{n}\alpha_5 dlngdp^3{}_{t-i} + \pi_1 lnco_{2t-i} + \pi_2 lntax_{t-i} + \pi_3 lngdp_{t-i} + \pi_4 lngdp^2{}_{t-i} + \pi_5 lngdp^3{}_{t-i} + \varepsilon_{3t} \tag{7}$$

$$dlngdp^2{}_t = \beta_4 + \sum_{i=1}^{n}\alpha_1 dlnco_{2t-i} + \sum_{i=1}^{n}\alpha_2 dlntax_{t-i} + \sum_{i=1}^{n}\alpha_3 dlngdp_{t-i} + \sum_{i=1}^{n}\alpha_4 dlngdp^2{}_{t-i} + \sum_{i=1}^{n}\alpha_5 dlngdp^3{}_{t-i} + \pi_1 lnco_{2t-i} + \pi_2 lntax_{t-i} + \pi_3 lngdp_{t-i} + \pi_4 lngdp^2{}_{t-i} + \pi_5 lngdp^3{}_{t-i} + \varepsilon_{4t} \tag{8}$$

$$dlngdp^3{}_t = \beta_5 + \sum_{i=1}^{n}\alpha_1 dlnco_{2t-i} + \sum_{i=1}^{n}\alpha_2 dlntax_{t-i} + \sum_{i=1}^{n}\alpha_3 dlngdp_{t-i} + \sum_{i=1}^{n}\alpha_4 dlngdp^2{}_{t-i} + \sum_{i=1}^{n}\alpha_5 dlngdp^3{}_{t-i} + \pi_1 lnco_{2t-i} + \pi_2 lntax_{t-i} + \pi_3 lngdp_{t-i} + \pi_4 lngdp^2{}_{t-i} + \pi_5 lngdp^3{}_{t-i} + \varepsilon_{5t} \tag{9}$$

The VECM Granger Causality Test

In this study, we use Granger (1969) causality estimation based on the ARDL framework by carrying out the ARDL-ECM and the lagged conditions. The ARDL-ECM models for the Granger causality test in this study can be expressed as follows:

$$\begin{bmatrix} dlnco_{2t} \\ dlntax_t \\ dlngdp_t \\ dlngdp^2{}_t \\ dlngdp^3{}_t \end{bmatrix} = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \end{bmatrix} + \begin{bmatrix} \delta_{11,1}\delta_{12,1}\delta_{13,1}\delta_{14,1}\delta_{15,1} \\ \delta_{21,1}\delta_{22,1}\delta_{23,1}\delta_{24,1}\delta_{25,1} \\ \delta_{31,1}\delta_{32,1}\delta_{33,1}\delta_{34,1}\delta_{35,1} \\ \delta_{41,1}\delta_{42,1}\delta_{43,1}\delta_{44,1}\delta_{45,1} \\ \delta_{51,1}\delta_{52,1}\delta_{53,1}\delta_{54,1}\delta_{55,1} \end{bmatrix} \begin{bmatrix} dlnco_{2t-1} \\ dlntax_{t-1} \\ dlngdp_{t-1} \\ dlngdp^2{}_{t-1} \\ dlngdp^3{}_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} \delta_{11,i}\delta_{12,i}\delta_{13,i}\delta_{14,i}\delta_{15,i} \\ \delta_{21,i}\delta_{22,i}\delta_{23,i}\delta_{24,i}\delta_{25,i} \\ \delta_{31,i}\delta_{32,i}\delta_{33,i}\delta_{34,i}\delta_{35,i} \\ \delta_{41,i}\delta_{42,i}\delta_{43,i}\delta_{44,i}\delta_{45,i} \\ \delta_{51,i}\delta_{52,i}\delta_{53,i}\delta_{54,i}\delta_{55,i} \end{bmatrix} \begin{bmatrix} dlnco_{2t-i} \\ dlntax_{t-i} \\ dlngdp_{t-i} \\ dlngdp^2{}_{t-i} \\ dlngdp^3{}_{t-i} \end{bmatrix} + \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \\ \varphi_5 \end{bmatrix} \times ECT_{t-1} + \begin{bmatrix} \mu_{1,t} \\ \mu_{2,t} \\ \mu_{3,t} \\ \mu_{4,t} \\ \mu_{5,t} \end{bmatrix} \tag{10}$$

ECT_{t-1} is the lagged error correction term,

$\mu_{1,t}, \mu_{2,t}, \mu_{3,t}, \mu_{4,t}$ and $\mu_{5,t}$ are serially independent random errors.

The CUSUM and CUSUM$_{sq}$

Test a structural stability of the model there are different tests based on recursive residuals. The two most important are the CUSUM and the CUSUM OF SQUARES, with the data ordered chronologically, rather than according to the value of an explanatory variable.

The CUSUM test is based on the cumulated sum of the residuals:

$$w_t = \sum_{J=K+1}^{T} \frac{w_t}{\hat{\sigma}} \tag{11}$$

$$\hat{\sigma}^2 = \frac{\sum_{j=k+1}^{T}(w_t - \overline{w})^2}{T-K-1} \tag{12}$$

$$\overline{w} = \frac{\sum_{j=k+1}^{T} w_t}{T-K} \tag{13}$$

k is the minimum sample size for which we can fit the model.

The second test statistic, the CUSUMSQ, is based on cumulative sums of squared residuals:

$$S_t = \frac{\sum_{k+1}^{t} {w_j}^2}{\sum_{k+1}^{T} {w_j}^2}, t = k+1, \ldots, T \tag{14}$$

The expected value of S_t is $\mathrm{E}(S_t) = \frac{t-k}{T-k}$, which goes to zero at t = k. The significance of departures from the expected value line is assessed by reference to a pair of lines drown parallel to the $\mathrm{E}(S_t)$ line at a distance Cs above and below. This value depends on both the sample size T-k and the significance level α.

EMPIRICAL FINDINGS AND DISCUSSION

Before going to the time series econometric analysis, a detailed statistical analysis is carried out. The descriptive statistics of two countries are shown in **Table 2** and **Fig. 1**, which exhibit that average of environmental performance ($lnco_2$), environmental taxation ($lntax$) in Sweden is less than China. However, the average of economic development

Table 2. Descriptive statistics

Descriptive items	China					Sweden				
	LNCO2	LNTAX	LNGDP	LNGDP2	LNGDP3	LNCO2	LNTAX	LNGDP	LNGDP2	LNGDP3
Mean	1.14	6.700	8.877	80.263	738.22	0.026	3.888	12.421	154.421	1921.4
Median	1.146	7.252	8.933	79.799	712.87	0.038	3.879	12.470	155.496	1939.03
Maximum	1.244	9.821	10.762	115.825	1246.53	0.298	4.136	12.914	166.776	2153.768
Minimum	1.031	2.219	6.764	45.746	309.40	-0.103	3.576	11.661	135.973	1585.546
Std. Dev.	0.060	2.376	1.231	21.679	290.76	0.091	0.180	0.372	9.178	170.139
Skewness	-0.042	-0.569	-0.152	0.026	0.199	0.451	-0.144	-0.404	-0.365	-0.327
Kurtosis	1.981	2.052	1.882	1.865	1.899	3.090	1.743	2.047	1.998	1.954

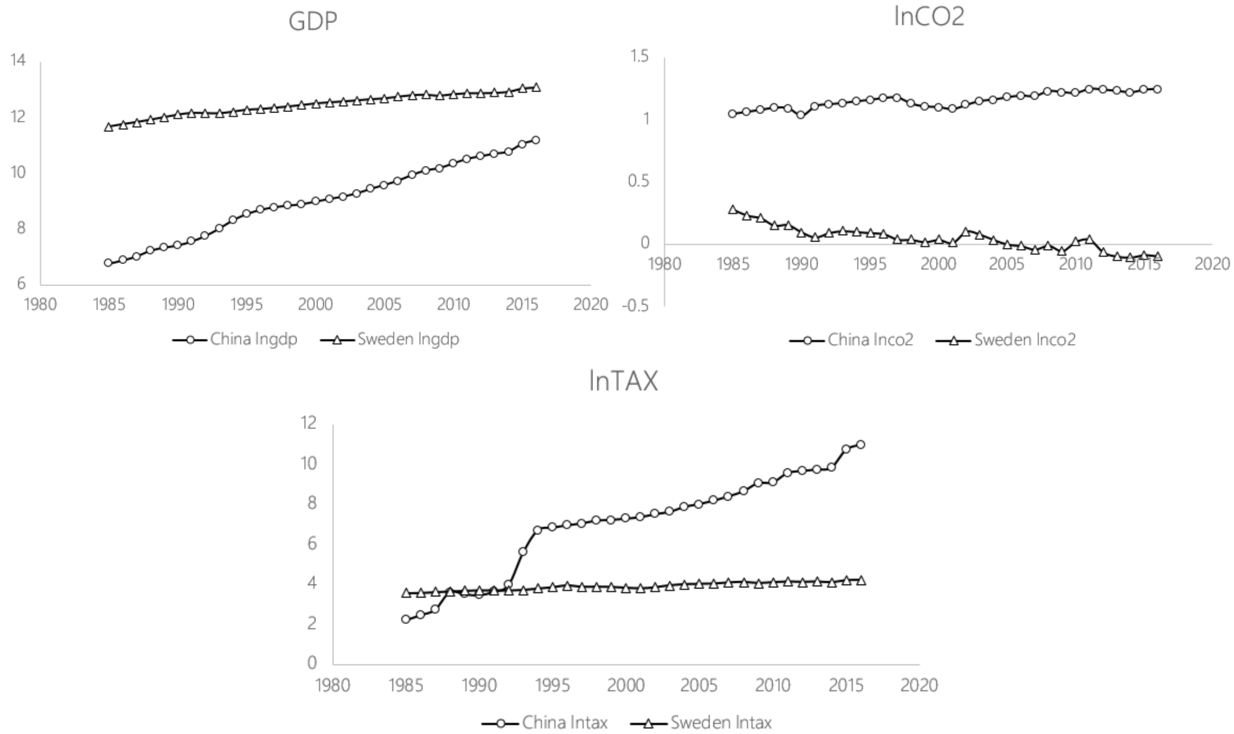


Fig. 1. The constructive picture of descriptive statistics

($lngdp$, $lngdp^2$ and $lngdp^3$) in Sweden is greater than China.

We note that there presents different stationary condition in two countries. The variables of both countries should be stationary at I(1) or I(0) or the variables are integrated mixed at I(1) and I(0), which we apply ADF and PP unit root tests to certify. The results of ADF and PP unit root test are reported in **Table 3**.

Based on unit root test, can we establish ARDL models to explore the relationship of environmental performance, economic growth and environment taxation between the variables over the period from 1985 to 2016 in the case of China and Sweden.

Next, we established five ARDL models using different variable as dependent variable. In addition, we perform a Bound test to see if there is evidence of a long run relationship. The details is shown in **Table 4**. If F<bound values, we can conclude that there is no cointegration among variables. We can see that all the value of F-statistic is above from upper and lower bound test, so there exists four cointegrating vectors in China and Sweden. Therefore, we can confirm the existence of the long-run relationship between the variables.

After discussing the existence of the long-run relationship among emission of carbon dioxide and environmental taxation and economic growth, we turn to investigate the marginal impact of environment taxation and economic growth in emission of carbon dioxide. The results are reported in **Table 5**.

According to ECM-ARDL of two countries, we can get two results of our research. First, environmental tax promotes improvement of carbon dioxide in China, which is significant. In contrast, environmental taxation in Sweden has done well. Carbon tax in Sweden has reduce emission of carbon dioxide.1% improvement in environmental tax have result in 18.8% descending of emission of carbon dioxide although it's not significant. The current environmental tax system in Sweden includes energy tax (about 75%), traffic tax (about 20%), pollution tax and resource tax (the total amount of about

Table 3. ADF and PP Unit root test

China						
Variables	**intercept**		**trend and intercept**		**none**	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**
lnco2	-1.514	-1.498	-2.406	-2.493	1.136	1.138
dlnco2	-5.481***	-5.481***	-5.38***	-5.389***	-5.32***	-5.33***
lntax	-1.647	-1.643	-3.393*	-1.649	1.309	2.375
dlntax	-3.420**	-3.356**	-3.69**	-3.456*	-2.756***	-2.76***
lngdp	-1.709	-1.094	-2.243	-1.643	0.925	6.952
dlngdp	-3.158**	-2.452	-2.991	-2.594	-0.622	-0.989
lngdp2	-0.633	0.067	-4.865***	-2.047	0.897	7.067
dlngdp2	-3.77***	-2.657*	-3.54*	-2.579	-0.864	-0.923
lngdp3	0.561	1.212	-2.604	-1.795	1.382	7.358
dlngdp3	-3.472**	-2.511	-3.323*	-2.349	-0.789	-0.780
Sweden						
Variables	**intercept**		**trend and intercept**		**none**	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**
lnco2	-1.977	-1.961	-3.456*	-3.570**	-2.735***	-2.922***
dlnco2	-5.786***	-6.337***	-5.684***	-6.571***	-5.362***	-5.346***
lntax	-1.328	-1.328	-2.866	-2.361	2.373	2.311
dlntax	-4.198***	-4.062***	-4.252**	-4.171**	-3.687***	-3.688***
lngdp	-3.722***	-4.733***	-2.112	-2.119	7.157	5.645
dlngdp	-3.413**	-3.269**	-4.512***	-4.795***	-1.885*	-2.042**
lngdp2	-3.404**	-4.631***	-2.012	-1.974	7.033	5.63
dlngdp2	-3.529**	-3.37**	-4.595***	-5.461***	-1.886*	-2.148**
lngdp3	-3.10**	-4.273***	-1.940	-1.885	6.927	5.596
dlngdp3	-3.624**	-3.518**	-4.62***	-5.347***	-1.697*	-1.979**

Table 4. The ARDL cointegration estimation results

	China				
Variables	LNCO2	LNTAX	LNGDP	LNGDP2	LNGDP3
F	8.994***	9.432***	7.121***	5.878***	5.223***
Critical values	1%	5%	10%		
Lower bounds	3.71	2.86	2.45		
Upper	5.11	4.01	3.52		
R2	0.902	0.979	0.999	0.999	0.999
Adj-r	0.745	0.94	0.999	0.999	0.999
F	5.743***	25.139***	50503.07***	164849.2***	40636.83***
	Sweden				
Variables	LNCO2	LNTAX	LNGDP	LNGDP2	LNGDP3
F	6.826***	4.549**	53.223***	54.583***	55.745***
Critical values	1%	5%	10%		
Lower bounds	3.71	2.86	2.45		
Upper	5.11	4.01	3.52		
R2	0.586	0.421	1	1	1
Adj-r	0.467	0.256	1	1	1
F	4.950***	2.549*	2887500***	1.15E+08***	2853890***

5%). The carbon tax is worth mentioning in the energy tax. In recognition of the impact of greenhouse gases on the destruction of the ecological environment and the impact of global climate change, in January 1991, Sweden began to levy a carbon tax to reduce carbon dioxide emissions throughout the country. In the 26 OECD countries, the carbon dioxide emissions of the unit GDP in Sweden dropped the fastest. However, there are still lack of certain law or regulation to reduce emission of carbon dioxide in China. The current tax relevant to environment contains resource tax, excise tax, urban maintenance and construction tax, vehicle and vessel tax, urban land use tax, tax on land occupation and charges for disposing pollutants. There are not any greenhouse gas has been included in the scope of taxation.

Besides, we established another ECM-ARDL model to study cointegration relationship between environmental tax and economic growth. The environmental tax is propitious to economic growth both in long run and short run in China while environmental tax have no impact on GDP in Sweden. Therefore, environmental tax is benefit to economy in China. There exists "blue dividend" of taxation in China. As for Sweden, the levy of environmental tax in Sweden is a good embodiment of the theory of tax shift by setting the environmental tax system and reducing

Table 5. ECM-ARDL cointegration analysis

Dependent variables	China			Sweden		
CO_2	coefficient	t-statistic	p-value	coefficient	t-statistic	p-value
long-run estimates						
LNTAX	0.361*	8.655	0.068	-0.188	-0.644	0.813
LNGDP	-13.69**	-10.97	0.043	-211.343**	-2.610	0.019
LNGDP2	1.964**	16.621	0.039	16.632**	2.562	0.019
LNGDP3	-0.069**	-17.098	0.057	-0.486**	-2.514	0.020
short-run estimates						
DLNTAX	-0.070	-3.587	0.284	0.453**	2.274	0.021
DLNGDP	80.086**	25.432	0.028	-224.939**	-2.345	0.035
DLNGDP2	-7.643**	-24.260	0.028	16.432**	2.130	0.046
DLNGDP3	0.226**	25.364	0.028	-0.492**	-2.156	0.046
ECTt-1	-1.036***	-3.587	0.002	-1.106***	-4.373	0.000

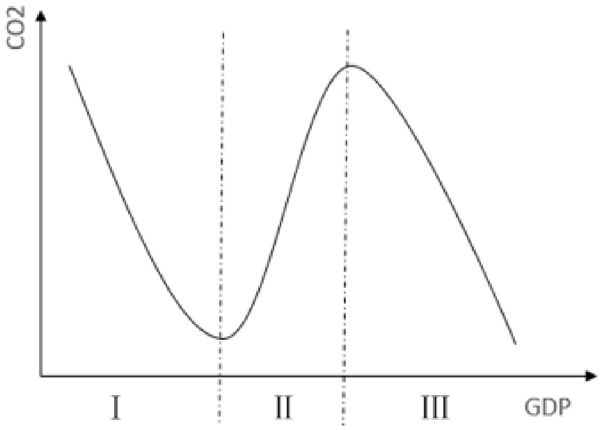


Fig. 2. Invert (reversed) N-shaped curve

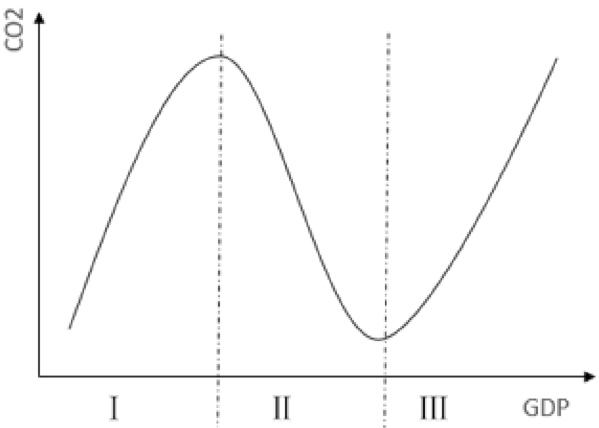


Fig. 3. N-shaped curve

the other types of tax, such as income tax, consumption tax and property tax, to keep the overall tax burden of the people not increasing.

Second, in the long run, China is in the first stage of invert (reversed) N-shaped trajectory (**Fig. 2**). 1% increase in economic growth is linked to a 13.69% decrease in emission of carbon dioxide. In the short run, coefficient shows N-shaped trajectory (**Fig. 3**). 1% improvement in GDP have result in 80.08% increase of emission of carbon dioxide and we can find in the short run China is in the first stage of N-shaped trajectory. All

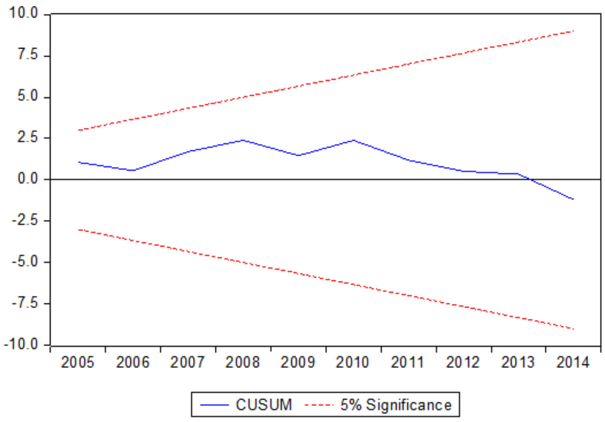


Fig. 4. Cusum of China

things considered, with economic development, emission of carbon would add in the short run and remove in the long run. No matter in long run or short run, Sweden is in the first stage of invert (reversed) N-shaped curve. In other words, emission will keep drop off with economic growth.

Third, the estimate of the lagged error term (ECTt-1) of China is negative (-1.036) and Sweden is -1.106, which are very significant. We may conclude that the adjustment from the short-run to the long-run equilibrium path is 104%, and that it may take approximately one year to reach the equilibrium path in Sweden. China is 111%, and that it may take approximately ten months to reach the equilibrium path.

To ensure the reliability of the ARDL estimation model, we applied the goodness of fit and diagnostic tests as well as the CUSUM and CUSUMsq diagrams. For the CUSUM test and the CUSUM of squares test in **Figs. 4-7**, we can see that the test statistic is not outside the corridor. Therefore, we can draw a conclusion that both model is structurally stable.

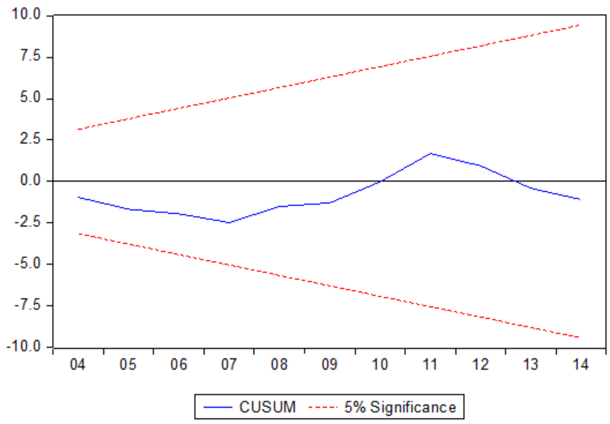


Fig. 5. Cusum of Sweden

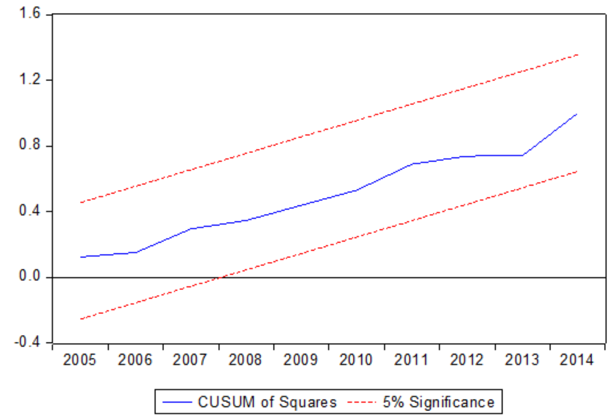


Fig. 6. $Cusum_{sq}$ of China

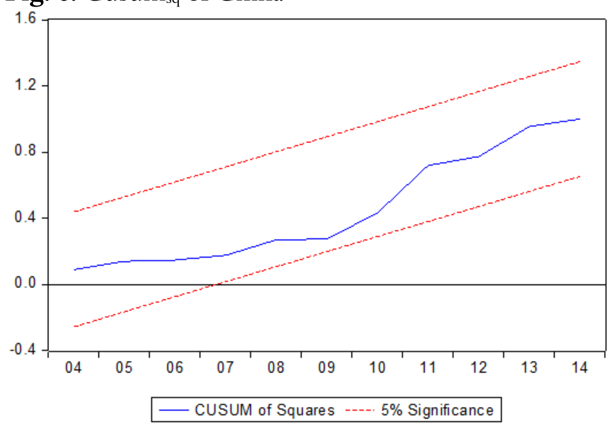


Fig. 7. $Cusum_{sq}$ of Sweden

Finally, we apply the ARDL-ECM Granger causality to examine the direction of causal relationships between environment taxation, economic growth and emission of carbon dioxide. It is recommended by Granger to apply the ECM Granger causality framework if the variables are integrated at I(1) (Dickey and Fuller 1981). There must be causality at least from one direction if the variables are cointegrated. The results are reported in **Table 6**.

In the short run, current environmental tax in China does not play a role in reducing carbon dioxide. Therefore, we may suggest China speeding up pursing conservative carbon emissions reduction policy in the long run without impeding economic growth (Zhang and Cheng 2009). Moreover, we notice that environmental tax does not granger cause economic growth. Lu et al. (2010) also put forward such idea by creating a dynamic recursive general equilibrium model to evaluate the effects of carbon taxes in China. Economic growth of China Granger causes emission of carbon dioxide and coefficients are significant. It confirms result of ECM-ARDL. It also indicates that economic development will exacerbate emission of carbon dioxide. Besides, In the long run, environmental tax and economic growth Granger cause environmental performance, which are significant. Economic development and environmental performance also granger causes environmental tax.

We notice that in the short run tax does not granger causes emission of carbon dioxide. The tax has a low effect in reducing the emission level but it can play a role in holding back increases in emissions (Grafström 2016). But in the strong causality, environmental tax will work well in reducing emission of carbon dioxide. In the short run of Joint Grainger causality, economic growth of Sweden Granger causes emission of carbon dioxide and coefficients are significant. Consequently, emission of carbon dioxide in Sweden is well suppressed by economic growth at present. Besides, we also find that environmental tax of Sweden has little effect on GDP but in the strong causality the improvement of economy will granger causes environmental tax. In the long run, environmental tax and economic growth Granger cause environmental performance, which are significant.

CONCLUSION AND POLICY IMPLICATIONS

Based on study, current environmental tax in China does not play a role in reducing carbon dioxide, but environmental tax in Sweden will work well in reducing emission of carbon dioxide, which testifies environmental taxation especially carbon dioxide could curtail emission of carbon dioxide. Therefore, the improvement of environmental tax, especially carbon dioxide is imminent. At the same time, environmental tax facilitates economic growth in China but economic development not had contact with environmental tax in Sweden. The levying of environmental tax in Sweden has realized tax shifting, a change in taxation that eliminates or reduces one or several taxes and establishes or increases others while keeping the overall revenue the same. The shifting of tax makes the whole

Table 6. Granger causality estimations under the VECM approach

	China										
Dependent variable	**Weak causality**						**Strong causality**				
	Short run Granger causality					**Long run**	DLNCO2 and	DLNTAX and	DLNGDP and	DLNGDP2 and	DLNGDP3 and
	DLNCO2	DLNTAX	DLNGDP	DLNGDP2	DLNGDP3	ECTt-1	ECTt-1	ECTt-1	ECTt-1	ECTt-1	ECTt-1
DLNCO2	-	0.223	6.988**	6.941**	6.681**	**-1.036*****	-	3.563	2.867	2.862	2.718
		(0.901)	(0.022)	(0.030)	(0.029)	(-3.587)		(0.280)	(0.511)	(0.436)	(0.348)
DLNTAX	3.232	-	0.066	0.076	0.045	-0.679***	4.763	-	2.235	2.022	1.833
	(0.231)		(0.964)	(0.922)	(0.924)	(0.132)	(0.199)		(0.538)	(0.565)	(0.601)
DLNGDP	2.544	2.103	-	4.535	4.809*						
	(0.267)	(0.355)		(0.169)	(0.034)						
DLNGDP2	1.659	1.345	3.845	-	4.030						
	(0.469)	(0.469)	(0.119)		(0.183)						
DLNGDP3	1.537	1.284	3.024	3.752	-						
	(0.421)	(0.442)	(0.254)	(0.102)							
	Sweden										
Dependent variable	**Weak causality**						**Strong causality**				
	Short run Granger causality					**Long run**	DLNCO2 and	DLNTAX and	DLNGDP and	DLNGDP2 and	DLNGDP3 and
	DLNCO2	DLNTAX	DLNGDP	DLNGDP2	DLNGDP3	ECTt-1	ECTt-1	ECTt-1	ECTt-1	ECTt-1	ECTt-1
DLNCO2	-	0.067	19.923***	20.012***	20.110***	-1.106***	-	4.936**	1.468	1.934	1.949
		(0.897)	(0.001)	(0.0001	(0.001)	(-4.373)		(0.015)	(0.233)	(0.116)	(0.173)
DLNTAX	0.290	-	0.010	0.009	0.008	-0.198	0.733	-	4.123**	4.223**	4.332**
	(0.241)		(0.922)	(0.925)	(0.929)	(0.153)	(0.403)		(0.091)	(0.089)	(0.057)
DLNGDP	0.348	1.206	-	4.468**	4.240**						
	(0.461)	(0.272)		(0.029)	(0.097)						
DLNGDP2	0.487	1.192	4.569**	-	4.424**						
	(0.511)	(0.265)	(0.023)		(0.016)						
DLNGDP3	0.376	1.185	4.589**	4.590**	-						
	(0.528)	(0.281)	(0.002)	(0.021)							

tax system of Sweden become “dynamic”. By adjusting the tax amount of different tax items, the overall tax burden is stable. It has great significance for China to establish a perfect environmental tax system.

The empirical results suggest that economic growth in China affects carbon emissions. With economic development, emission of carbon would add in the short run and remove in the long run. This supports Kuznets’ theory in that with the development of economy and society, the awareness of people about environmental protection is stronger. As for Sweden, the empirical results also suggest that economic growth affects carbon emissions. The results are consistent in both the short run and long run, which indicates emission of carbon dioxide will keep drop off with economic growth. Plainly, the Kuznets’ theory in Sweden reaches a more mature level than China.

However, it should be noticed that on reaching the developed status less concern is given to environmental issues in China. China should make effective policies in reducing CO_2 emissions to alleviate global warming, although its per capita emissions are very low. The government should introduce corresponding tax policies to support the development of new energy in order to limit carbon emissions from the headstream. Deducting the carbon tax rate of new energy and raising the carbon tax rate of high pollution energy may be a good choice. Besides, considering different carbon emissions in different regions, government should formulating a graded or progressive environmental tax rate to balance the tax burden of all regions and achieve the goal of overall emission reduction. At the same time, we should reducing the environmental tax rate to encourage new environmental protection industries with low carbon content, high technology content and large added value. We hope that by this time environmental issues will change accordingly.

As a developing country, economic growth and CO_2 emissions is following the basic Kuznets theory. Basically, a carbon tax is one of the important policies choices to stimulate the realization of CO_2 in many developed and developing countries (Zhou et al., 2011). The top priority is to combat CO_2 emissions in China by encouraging the new energy and environmental protection industries. In the meantime, the government should considering the fairness of tax burden to weaken or eliminate great impact on the economy. When designing the scope and amount of environmental tax collection, government should also take full account of whether the tax burden is stable, so as to really achieve the purpose of setting up the environmental tax. Environmental tax can strengthen the awareness of environmental protection and reduce carbon emissions. Based on that, environmental protection will gradually become the spontaneous behavior of people and enterprises, rather than mandatory behavior.

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