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Is there causality from investment for real estate to carbon emission in China: a cointegration empirical study

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Abstract

This paper for the first time examines the EKC(environmental Kuznets curve) relationship for CO2 emission for China over the period of 1990-2009, employing of time series data and a multivariate model of carbon emission among GDP, investment for real estate, fixed capital, urban household and money (M1). The empirical result reveals that there is Granger causality running from investment for real estate, GDP and fixed capital to carbon emission in the long run. The result of this study also suggests that there is unidirectional Granger causality from M1 to real estate industry. Therefore, China's government should adapt economic development model to reduce carbon emission for example keeping the sustainable and rapid development of real estate.

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Keywords: carbon emission; EKC; investment for real estate;VAR model

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1. Introduction

This paper for the first time examines the EKC(environmental Kuznets curve) relationship for CO_2 emission for China over the period of 1990-2009, employing of time series data and a multivariate model of carbon emission among GDP, investment for real estate, fixed capital, urban household and money(M1). The empirical result reveals that there is Granger causality running from investment for real estate, GDP and fixed capital to carbon emission in the long run. The result of this study also suggests that there is unidirectional Granger causality from M1 to real estate industry. Therefore, China's government should adapt economic development model to reduce carbon emission for example keeping the sustainable and rapid development of real estate.

Finding the relationship between economic growth and environmental quality is the first step to achieve China's economic harmonious development. About this topic there is a famous environmental Kuznets curve (EKC) hypothesis developed by Grossman and Krueger [1]. This model proposes that there is an inverted U-shape relation between environmental degradation with income. But increasing empirical testing results appear to challenge it. So Stern [2] employed Granger causality and cointegration model with energy consumption, gross domestic, capital and labor force for the USA. So far, nearly all the research literatures in the world are according to it For example, Sytas and Sari [3] , Seldon and Song [4] applying the multivariate model to analyze China's problem found that there is no causality between income and energy use. In a similar kind of study, Suri [5],Wang[6],Yuan et al[7] revealed that there is a bilateral Granger causality between GDP and energy use in the long run. Jail and Mahmud [8] using the same data in China, founded unidirectional causality from economic growth to CO_2 emission. Employing nearly similar method and variables, Zhang and Cheng [9], Zhang [10] surveyed the energy consumption output and carbon emission nexus for China to find the same result.

In above existing literature nearly all have used pooled panel data to establish a link between them, though a time series may be a better to reveal the relationship. Moreover, the most important real what real estate industry is the central arch an active role in the development of economy in China isn't concerned and revealed. This paper for the first time, applying a multivariate model with real estate industry development (investment for real estate development by use), money supply (M1), urban household, GDP, energy consumption ,carbon emission and fixed capital ,employing of time series data over the period of 1990-2009 in China, EKC relationship for carbon emission has been deeply studied.

This paper proceeds as follows. Section 2 lays out the econometric methodology and data. Section 3 describes empirical analysis and presents the main results. Section 4 concludes .

2. Econometric Methodology

ARDL (autoregressive distributed lag model) based on the general -to-specific modeling technique has the two most important advantage including that be applied irrespective and can take sufficient number of lags to capture the data generating process ,the error model can be derived through a simple level of growth[11].This paper follows closely the methodology of the recent studies [12] that using a long linear quadratic equation to test a long-run EKC relationship among carbon emission, energy consumption, GDP, real estate industry development (IRE),money(M1),fixed capital(fc), urban household (up).The estimable econometric regression line is as follows:

$$C_t = \alpha + \beta_1 e_t + \beta_2 g_t + \beta_3 i_t + \beta_4 m_t + \beta_5 f_t + \beta_6 u_t + \varepsilon_t$$

Where C_t is carbon emission per capital, e_t is energy consumption per capital, g_t is GDP ,i_t is investment for real estate development by use, m_t is money (*M1*),u_t is urban household , f_t is fixed capital , α is a vector of constant, coefficient matrix, ε_t is noise residuals.

In this paper an annual data on carbon emission(CO_2)(kt),energy consumption(ec) (kt of standard coal equivalent) , GDP(100 million yuan), investment for real estate (100 million yuan),Money (100 million yuan),fixed capital (100 million yuan) and urban household (10 thousand), over the period of 1990-2009 when the rapid development of both China’s economy and real estate industry .All data are posted by the National Statistics Bureau in China.

This is a piece of pioneering work of employing with investment for real estate and money to reveal the truth in this paper [13].The reasons as follows:

(i)Investment for real estate industry by use is a more correlative index than other economic factors in VAR model because real estate industry is the important pillar of the national economy in China and have greater jia contribution than other factors in GDP. As we all know, since 1990 China’s real estate industry has been established as one of the mainstay industries in national economy because it’s driving and pulling to others sectors ,on it nearly covering with all excellent resource and good policies. This industry has achieved incredible progress in the world. In the past year a block sum of investment on real estate by the government and enterprise has forceful help China to moderate economic crisis and promote GDP to great increase .

(ii) Real estate industry is more sensitive than other sectors in national economy to carbon emission because its industry chain is very long. According to recent research results, there is at least 100 industries by direct or indirect relevant to real estate in China including steel and metallurgical industry, building material, architecture and decorative industry, household electric appliance, and so on. In fact above industries nearly are more higher level carbon emission industries.

(iii) Money can accurately indicate the impact of macroeconomic especially for asset price, inflation and so on the relationship between income and output in open and flexible economic environmental .And help us to achieve real EKC relationship for CO_2 in China.

In a word, the innovative choice of investment for real estate industry by use and money are according to economic operating principles and key mechanisms and China's actual conditions.

3. Empirical Analysis

3.1. unit root test

As the first step in VAR proceeding ,unit root test by Augmented Dickey-Fuller （ADF） in this paper is summarized in table 1. And all unit root tests have a null hypothesis that the series has a unit against the alternative of stationary.

Table 1 Unit root test (ADF)

		ADF		level
levels interce	ec	-3.725614	2	5%
	co2	-3.6968	2	5%
	fc	-3.8246	2	5%
	ire	-5.3149	2	1%
	m1	-4.64749	2	1%
	up	-3.9769	2	1%
	gdp	-3.1405	1	5%

From the above table, we know that horizontal-series of seven variables are non-stationary series, So all these variables are the first fractional integration serial. And we may employ a VAR model to analyze the relations.

3.2. The Six Dimensional VAR Model

Table 2 The VAR model

	LGCO2	LGEC	LGFC	LGGDP	LGIRE	LGM1	LGUP

LGCO2(-1)	8.289433	7.168351	10.15281	0.492054	18.92444	-1.085001	-0.541085
	(3.28500)	(2.19955)	(10.9924)	(1.84450)	(38.8742)	(9.81016)	(0.45070)
	[2.52342]	[3.25901]	[0.92362]	[0.26677]	[0.48681]	[-0.11060]	[-1.20054]
LGCO2(-2)	-0.062795	0.115720	0.215182	0.520519	3.220532	0.528794	-0.005775
	(0.89080)	(0.59646)	(2.98083)	(0.50018)	(10.5416)	(2.66024)	(0.12222)
	[-0.07049]	[0.19401]	[0.07219]	[1.04067]	[0.30551]	[0.19878]	[-0.04725]
LGEC(-1)	-11.01082	-9.344786	-13.74776	-0.865175	-26.83265	1.188640	0.861108
	(4.65349)	(3.11586)	(15.5717)	(2.61289)	(55.0687)	(13.8970)	(0.63846)
	[-2.36614]	[-2.99911]	[-0.88287]	[-0.33112]	[-0.48726]	[0.08553]	[1.34873]
LGEC(-2)	0.009259	-0.003717	1.775518	-1.264311	-0.296732	-1.397499	-0.160278
	(1.01003)	(0.67629)	(3.37979)	(0.56712)	(11.9525)	(3.01629)	(0.13858)
	[0.00917]	[-0.00550]	[0.52533]	[-2.22935]	[-0.02483]	[-0.46332]	[-1.15662]
LGFC(-1)	3.956955	3.091031	3.238193	0.956502	5.789321	0.370670	-0.230078
	(1.06886)	(0.71568)	(3.57668)	(0.60016)	(12.6488)	(3.19200)	(0.14665)
	[3.70202]	[4.31899]	[0.90536]	[1.59375]	[0.45770]	[0.11612]	[-1.56891]
LGFC(-2)	-3.544093	-2.992735	-4.033064	-0.114878	-6.837990	0.202721	0.150697
	(1.09988)	(0.73645)	(3.68047)	(0.61757)	(13.0158)	(3.28463)	(0.15090)
	[-3.22225]	[-4.06372]	[-1.09580]	[-0.18602]	[-0.52536]	[0.06172]	[0.99863]
LGGDP(-1)	3.873642	3.274902	3.912562	1.642244	7.150965	0.050362	-0.230503
	(1.16511)	(0.78013)	(3.89874)	(0.65420)	(13.7877)	(3.47942)	(0.15985)
	[3.32470]	[4.19791]	[1.00355]	[2.51032]	[0.51865]	[0.01447]	[-1.44197]
LGGDP(-2)	0.596669	0.571101	0.673106	-0.068854	0.578674	0.874736	0.167534
	(0.31122)	(0.20838)	(1.04141)	(0.17475)	(3.68291)	(0.92941)	(0.04270)
	[1.91720]	[2.74062]	[0.64634]	[-0.39402]	[0.15712]	[0.94118]	[3.92359]
LGIRE(-1)	-1.021644	-0.785377	-0.678139	-0.143395	-1.133361	0.198798	0.068081
	(0.29963)	(0.20063)	(1.00264)	(0.16824)	(3.54578)	(0.89480)	(0.04111)
	[-3.40967]	[-3.91465]	[-0.67635]	[-0.85233]	[-0.31964]	[0.22217]	[1.65611]
LGIRE(-2)	0.815411	0.694356	0.778063	0.009344	1.253136	-0.045728	-0.049238
	(0.25087)	(0.16798)	(0.83947)	(0.14086)	(2.96875)	(0.74918)	(0.03442)
	[3.25034]	[4.13367]	[0.92685]	[0.06634]	[0.42211]	[-0.06104]	[-1.43053]
LGM1(-1)	-1.615294	-1.243564	-0.163423	-0.085234	-0.034977	-0.111663	0.047370
	(0.43375)	(0.29043)	(1.45142)	(0.24354)	(5.13288)	(1.29532)	(0.05951)
	[-3.72405]	[-4.28187]	[-0.11260]	[-0.34997]	[-0.00681]	[-0.08620]	[0.79600]
LGM1(-2)	-2.533325	-2.210067	-2.524928	-1.212454	-4.563818	-1.122879	0.120194
	(0.72587)	(0.48602)	(2.42892)	(0.40757)	(8.58977)	(2.16769)	(0.09959)
	[-3.49008]	[-4.54727]	[-1.03953]	[-2.97487]	[-0.53131]	[-0.51801]	[1.20691]
LGUP(-1)	-3.575107	-3.246560	-4.760233	-0.911581	-9.365985	0.720150	0.379039
	(1.65692)	(1.10943)	(5.54447)	(0.93035)	(19.6077)	(4.94815)	(0.22733)
	[-2.15768]	[-2.92633]	[-0.85856]	[-0.97983]	[-0.47767]	[0.14554]	[1.66735]
LGUP(-2)	9.629372	8.353899	9.350865	2.797813	17.23769	2.654731	0.159462
	(2.22066)	(1.48690)	(7.43088)	(1.24688)	(26.2790)	(6.63168)	(0.30467)
	[4.33626]	[5.61834]	[1.25838]	[2.24385]	[0.65595]	[0.40031]	[0.52338]
C	-42.75211	-39.16826	-55.39917	-9.012411	-87.55127	-19.56728	3.814987
	(14.0274)	(9.39238)	(46.9391)	(7.87624)	(165.998)	(41.8907)	(1.92456)
	[-3.04776]	[-4.17022]	[-1.18024]	[-1.14425]	[-0.52742]	[-0.46710]	[1.98227]
R-squared	0.999700	0.999855	0.999540	0.999980	0.995898	0.999585	0.999988
Adj. R-squared	0.997599	0.998839	0.996320	0.999836	0.967187	0.996683	0.999905
Sum sq. resids	0.000473	0.000212	0.005301	0.000149	0.066293	0.004222	8.91E-06

S.E. equation	0.015385	0.010301	0.051481	0.008638	0.182062	0.045944	0.002111
F-statistic	475.8957	983.9775	310.4314	6974.456	34.68635	344.3556	12086.25
Log likelihood	65.03295	71.85188	44.49970	74.84469	23.02658	46.43407	98.80035
Akaike AIC	-5.886230	-6.688457	-3.470553	-7.040552	-0.944304	-3.698126	-9.858864
Schwarz SC	-5.151041	-5.953268	-2.735365	-6.305363	-0.209116	-2.962937	-9.123676
Meandependen	13.87557	11.98579	10.55487	11.51623	8.687770	10.83810	10.71407
S.D.dependent	0.313991	0.302287	0.848666	0.674836	1.005065	0.797684	0.217069

3.3. Johansen Test

According to the Johansen test model, we may establish the test relations as follow:

Table 3 The cointegration test (Johansen test)

	Coefficient	Std. Error	t-Statistic	Prob.
DLGEC	1.251884	0.095677	13.08451	0.0000
DLGFC	-0.263096	0.086743	-3.033064	0.0104
DLGFC(-1)	0.219291	0.081680	2.684768	0.0199
DLGIRE	0.081404	0.031965	2.546639	0.0256
DLGIRE(-1)	-0.050949	0.031750	-1.604692	0.1345
R-squared	0.943823	Mean dependent var		0.002399
Adjusted R-squared	0.925098	S.D. dependent var		0.046978
S.E. of regression	0.012857	Akaike info criterion		-5.629902
Sum squared resid	0.001984	Schwarz criterion		-5.384839
Log likelihood	52.85417	Hannan-Quinn criter.		-5.605542
Durbin-Watson stat	1.982408			

Obviously, there are three co-integrations among seven variables, in other words, there are Long-term stable relationship among the three variables .By the normalization and application of the co-integrations, we may derive the co-integration equation based on carbon emission as dependent variable as table 3.

As the above equation shown, the relationship between GDP, M1, HP with CO_2 is not significant, and it indicates the long-term effect is not significant.EC factor is significant at 1% significance level, viewing from the coefficient of elasticity, when EC increase or decline 1%,CO_2 would decline or increase 2.59%;At the same time there is lagged effect of IRE and FC' force on CO_2, whenever FC or IRE increase or decline 1%, CO_2 would increase or decline 3.45% or 2.18% behind one period ;

3.4. Granger Causality Test

As table 3, all series are not integrated of the same order, we employ Granger causality to further study the relationships between them.

Table 1. Granger causality test

Null Hypothesis:	Obs	F-Statistic	Probability
LGEC does not Granger Cause LGCO2	18	2.77478	0.09919
LGCO2 does not Granger Cause LGEC		1.99375	0.17571

LGFC does not Granger Cause LGCO2	18	2.45806	0.12432
LGCO2 does not Granger Cause LGFC		3.15784	0.07625
LGGDP does not Granger Cause LGCO2	18	0.41957	0.66592
LGCO2 does not Granger Cause LGGDP		2.99669	0.08506
LGIRE does not Granger Cause LGCO2	18	1.28060	0.31071
LGCO2 does not Granger Cause LGIRE		3.84468	0.04878
LGM1 does not Granger Cause LGCO2	18	1.01266	0.39019
LGCO2 does not Granger Cause LGM1		2.71372	0.10354
LGUP does not Granger Cause LGCO2	17	6.95236	0.00988
LGCO2 does not Granger Cause LGUP		0.01979	0.98044
LGFC does not Granger Cause LGEC	18	1.63840	0.23197
LGEC does not Granger Cause LGFC		3.09799	0.07939
LGGDP does not Granger Cause LGEC	18	0.50181	0.61669
LGEC does not Granger Cause LGGDP		3.06467	0.08121
LGIRE does not Granger Cause LGEC	18	1.14809	0.34741
LGEC does not Granger Cause LGIRE		3.87528	0.04786
LGM1 does not Granger Cause LGEC	18	1.23077	0.32396
LGEC does not Granger Cause LGM1		2.74696	0.10115
LGUP does not Granger Cause LGEC	17	11.9220	0.00141
LGEC does not Granger Cause LGUP		0.00726	0.99277
LGGDP does not Granger Cause LGFC	18	0.50120	0.61705
LGFC does not Granger Cause LGGDP		9.89846	0.00244
LGIRE does not Granger Cause LGFC	18	5.43967	0.01921
LGFC does not Granger Cause LGIRE		8.13904	0.00511
LGM1 does not Granger Cause LGFC	18	0.63636	0.54493
LGFC does not Granger Cause LGM1		2.75582	0.10052
LGUP does not Granger Cause LGFC	17	10.0021	0.00278
LGFC does not Granger Cause LGUP		4.24155	0.04043
LGIRE does not Granger Cause LGGDP	18	5.28734	0.02088
LGGDP does not Granger Cause LGIRE		8.14157	0.00510
LGM1 does not Granger Cause LGGDP	18	17.9925	0.00018
LGGDP does not Granger Cause LGM1		0.23677	0.79250
LGUP does not Granger Cause LGGDP	17	11.9757	0.00138
LGGDP does not Granger Cause LGUP		6.62683	0.01151
LGM1 does not Granger Cause LGIRE	18	9.96459	0.00238
LGIRE does not Granger Cause LGM1		2.53034	0.11799
LGUP does not Granger Cause LGIRE	17	20.7307	0.00013

LGIRE does not Granger Cause LGUP		2.77655	0.10209
LGUP does not Granger Cause LGM1	17	5.88553	0.01655
LGM1 does not Granger Cause LGUP		6.55581	0.01191

3.5. Results

From the above table, we may draw conclusions as follow:

Firstly, there is a stable cause-and-effect relationship between investment for real estate and GDP, fixed capital and urban household in the long run. Obviously, this result accurately reflects the truth in China. Since 1990S, real estate industry as Pillar industry in national economy has played an important role in promoting China's economic development and GDP'S growing. According to recent research results, investment for real estate by use is nearly 25% of fixed capital annual from 1990 to 2009, and revenue and contribution from it is more than 10% of GDP. Over three decade China's urbanizing movement has greatly promoted the sustained development of the real estate and growth of urban household. Meanwhile accelerating the progress of urbanization also improve the rapid development of real estate and increase the number of urban household. During the processing, total society fixed capital investment also experience the same circulation.

Secondly, there is a directional Granger causality running from GDP and energy consumption to carbon emission at the 5% significant level. And the same causality relationship is shared by urban household, fixed capital ,real estate . This result can be explained that an increase of GDP, urban household, real estate, fixed capital or energy consumption will bring about an increase in carbon emission. But the inverse is not true. In fact, the reason of this Granger causality is very logical and comprehensive in China. Just as above analysis, whenever an increase in investment for real estate and fixed capital as the most important driving and pulling force of China's national economy development ,It would bring about the boom of total industries and great progress in urbanization. As we all know, China's industries today are mainly typically small, inefficient and environmentally disastrous. Therefore, all this lead to an increase in carbon emission in the model and real lives Of course this result differs from that of Jail and Mahmud [2] and Chen and Zhang [3].

Thirdly, there is a significant relationship of mutual causal between investment for real estate with M1. That is, whenever or whatever M1 changes because of accommodative or tight monetary policy, real estate industry would fluctuate at once. Meanwhile, the change of real estate industry can lead M1 to change. The rule behind it is that real estate corporate capital fund is very small in contrast with project investment and greatly depend on money from the bank. The rise of M1 means rich money in circulation, so investment for real estate by use at once expand, real estate industry would increase at once .As every coin has two sides ,when investment for real estate growing or falling , M1 also would change.

Finally, the correlations between M1with carbon emission is not significant. This is the one and only among all causality tests. It may appear surprising. Yet this phenomenon accurately reflects China's basic sate conditions today.The Possible explanations about this is that money supply by the view of carbon emission may closely related to nearly all industries such as first industry, second industry and so on that there is a flexible relationship between them.

4. Conclusions

This paper is to test the EKC (environmental Kuznets curve) relationship for carbon emission in China over the period of 1990-2009. Employment of time series data ,using a multivariate model including GDP, fixed capital ,investment for real estate, money, urban household and energy consumption has shown that the interactive relationship between carbon emission with marc-economy in China can be dealt with a seven dimensional VAR model based on Granger causal test and Johansen test .The empirical result of a stable Granger causality relationship between investment for real estate and GDP, fixed capital and urban household in the long run implies that China's government through adapting develop model can promote and improve environmental quality. The result also indicates that real estate industry is another significant determinant of CO_2 emission. And negative and insignificant coefficient is also observed such as money.

The main contribution in this paper is to ,for the first time, employ the variables of investment for real estate and money in VAR model to empirically investigate EKC relationship for China and find a satisfied results. This finding may be surprising because of unique variables. And it is more important to extend the work to get further proof about this topic.

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