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The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey

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ABSTRACT

The aim of this paper is to examine the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the 1960–2007 period. The bounds *F*-test for cointegration test yields evidence of a long-run relationship between per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development. The results show that an increase in foreign trade to GDP ratio results an increase in per capita carbon emissions and financial development variable has no significant effect on per capita carbon emissions in the long- run. These results also support the validity of EKC hypothesis in the Turkish economy. It means that the level of CO_2 emissions initially increases with income, until it reaches its stabilization point, then it declines in Turkey. In addition, the paper explores causal relationship between the variables by using error-correction based Granger causality models.

1. Introduction

The carbon emissions in a country do not necessarily depend on its income level alone; energy consumption, foreign trade (or trade openness) and financial development may be another sources. Thus, researchers have attempted to incorporate not only output/income or economic development *per se* but also extended their analysis for financial development or for variables capturing openness or trade intensity of a country (Zhang, 2011).

The branch of literature which emphasizes the relationship between carbon emission and foreign trade considers the fact that pollution is generated in the production of goods and is related to consumption in another country and therefore the intensity of foreign trade of an economy might have important implication to the level of pollution of that country.

On the other hand, the effects of financial development on the carbon emissions have been investigated by many authors, such as Frankel and Romer (1999), Dasgupta et al. (2001), Sadorsky (2010) and Zhang (2011), who argue that financial development increases carbon emissions. According to these studies, financial development leads to increase in carbon emissions for the following reasons: First, stock market development helps listed enterprises to lower financing costs, increase financing channels, disperse operating risk and optimize asset/liability structure, so as to buy new installations and invest in new projects and then increase energy consumption and carbon emissions. Second, financial development may attract foreign direct investment so as to boost economic growth and increase carbon emissions. Third, prosperous and efficient financial intermediation seems conducive to consumers' loan activities, which makes it easier for consumers to buy big ticket items like automobiles, houses, refrigerators, air conditioners, washing machines, etc. and then emit more carbon dioxide (Zhang, 2011:2197). However, Tamazian et al. (2009) and Claessens and Feijen (2007) argue that financial development may increase energy efficiency and enterprises' performance and then reduce energy consumption and carbon emissions.

Recent studies which examine the effects of financial development on carbon emissions are as follows: Tamazian et al. (2009) investigate the relationship among economic growth, financial development and environmental quality in the BRIC countries, and find that financial development proves a key factor to cut carbon emissions. Sadorsky (2010) explores the influence of financial development in 22 emerging countries on energy consumption using a panel data model, and argues that, as a whole, financial development in these countries significantly

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promote the increase of energy consumption. Tamazian and Bhaskara Rao (2010) point out that financial development in transition countries may exert evident influence on carbon emissions. Zhang (2011) investigates the influence of financial development on carbon emissions in China. Following results obtained: China's financial development acts as an important driver for carbon emissions increase, the influence of financial intermediation scale on carbon emissions outweighs that of other financial development indicators but its efficiency's influence appears by far weaker although it may cause the change of carbon emissions statistically and finally China's stock market scale has relatively larger influence on carbon emissions but the influence of its efficiency is very limited. Jalil and Feridun (2011) investigate the impact of financial development, economic growth and energy consumption on environmental pollution in China. The results of the analysis reveal a negative sign for the coefficient of financial development, suggesting that financial development in China has not taken place at the expense of environmental pollution. On the contrary, it is found that financial development has led to a decrease in environmental pollution. In addition, the findings confirm the existence of an EKC in China. According to the mentioned studies, we can conclude that financial development and trade variables play an important role in the environmental issues.

Turkish economy had witnessed impressive growth rates and a high level of financial development between 2002–2010. Also the annual growth rate of CO_2 emissions in Turkey was 4% between 2000–2008. CO_2 emissions increased from 0.5 in 1960 to 4 in 2008. In fact, this kind of work is of great importance for Turkey to design the path for carbon emissions intensity reduction. During 1960–2010 period, the electricity use per capita rose from 379.6 to 1,440.6. Since there are only a limited number of empirical evidences on the linkages between financial sector development and environmental performance, this paper proposes to make a contribution to the existing literature through examining the relationship between financial development and carbon emissions in Turkey.

The rest of the paper is organized as follows. Section 2 presents the methodology and data. Empirical results are given in Section 3, and Section 4 concludes the paper.

2. Methodology and data

Following the empirical literature, the standard log-linear functional specification of long-run relationship between per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development in Turkey may be expressed as:

$$co_t = \beta_1 + \beta_2 ec_t + \beta_3 y_t + \beta_4 y^2{}_t + \beta_5 op + \beta_6 fd + \varepsilon_t \quad (1)$$

where, co is the carbon dioxide emissions (measured in metric kilograms per capita), ec is the energy use (measured in kg of oil equivalent per capita), y is per capita real GDP (constant 2000 US$), y^2 is the square of per capita real GDP, *op* is the openness indicator (foreign trade, % of GDP), fd is the financial development indicator (domestic credit to private sector, % of GDP) and ε_t is the error term. The annual time series data are taken from the World Development Indicators (WDI) online database for the 1960–2007 period. All variables are employed with their natural logarithms form to reduce heteroskedasticity and to obtain the growth rate of the relevant variables by their differenced logarithms. The parameters, β_i, i = 2, 3 …, 6, indicate the long-run elasticity estimates of per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development, respectively. The positive long-run elasticity estimates of per capita carbon emissions with respect to per capita energy consumption, $\beta_2 \rangle 0$, indicate that increase in per capita energy consumption results in an increase in per capita carbon emissions. Under the EKC hypothesis the long-run elasticity estimates of per capita carbon emissions with respect to per capita real income and the square of per capita real income expected to be $\beta_3 \rangle 0$ and $\beta_4 \langle 0$. This means there exists an inverted U-shape pattern that as per capita real income increases, per capita carbon emissions increase as well until some threshold level of per capita real income is reached after which per capita carbon emissions begin to decline. We also expect $\beta_5 \rangle 0$ and $\beta_6 \rangle 0$. Table 1 provides the descriptive statistics of these series for Turkish Economy.

The long-run and causal relationships between per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development in Turkey will be performed in two steps. Firstly, we will test the long run relationships among the variables by using the ARDL bounds testing approach of cointegration. Secondly, we will test the causal relationships by using the error-correction based causality models.

2.1. Autoregressive distributed lag (ARDL) cointegration analysis

The ARDL bounds testing approach of cointegration is developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The ARDL cointegration approach has numerous advantages in comparison with other cointegration methods such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) procedures: (i) no need for all the variables in the system be of equal order of integration, (ii) it is efficient estimator even if samples are small and some of the regressors are endogenous, (iii) it allows that the variables may have different optimal lags, and (iv) it employs a single reduced form equation.

Table 1
Descriptive statistics of variables.

	Mean	Max.	Min.	St. dev.
Log levels				
Carbon dioxide emissions (metric kg per capita)	7.52	8.28	6.39	0.51
Energy use (kg of oil equivalent per capita)	6.61	7.22	5.93	0.37
Real GDP (2000 US dollars per capita)	7.93	8.54	7.35	0.32
Square of real GDP (2000 US dollars per capita)	63.01	72.89	54.02	5.10
Foreign trade (% of GDP)	3.13	4.01	1.74	0.65
Domestic credit to private sector (% of GDP)	2.88	3.38	2.54	0.17
Growth rates (%)				
Carbon dioxide emissions (metric kg per capita)	4.03	19.45	−12.00	5.66
Energy use (kg of oil equivalent per capita)	2.74	9.53	−9.58	3.97
Real GDP (2000 US dollars per capita)	2.50	8.18	−7.34	3.71
Square of real GDP (2000 US dollars per capita)	39.71	127.36	−121.21	59.86
Foreign trade (% of GDP)	1.09	25.28	−42.54	13.37
Domestic credit to private sector (% of GDP)	4.60	73.45	−28.07	18.67