AN ANALYSIS OF CO_2 EMISSIONS OF TURKISH INDUSTRIES AND ENERGY SECTOR

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Abstract

One of the prominent environmental problems arising within the past two decades is global warming, and hence the closely associated phenomenon of climate changes. In this context, the long run relationships and causalities among the industrial, cement and steel productions; power generation; oil consumption; and finally CO_2 emissions in Turkey were investigated in this study by using a vector autoregression (VAR) testing approach for the period of 1990-2010. According to the empirical results, bidirectional Granger causality was inferred between CO_2 emissions and the production of cement and electricity. In light of the results of the impulse-response analysis, the CO_2 emissions were mostly affected by a shock given to industrial production, followed by cement production, power generation, oil consumption and steel production, in decreasing order of impact.

Keywords: CO_2 Emission, Steel Production, Cement Production, Energy, VAR Analysis
JEL Codes: Q010, Q560, C320, C530.

1. Introduction

Among the numerous types of environmental problems that dominate the public discussion, “climate change” has been at the top of the agenda as a result of the substantial escalation in anthropogenic green house gases since 1980s. Carbon dioxide (CO_2) is by far the most important one among the greenhouse gases due to being associated with in excess of 60% of the total global warming effect (Kaygusuz, 2009; Bacon et al., 2007). Consequently, global warming is considered as one of the most crucial environmental problems of the current age. Furthermore, the ever increasing levels of carbon dioxide (CO_2), which is the primary factor underlying the greenhouse effect, only add to these concerns by aggravating this problem (Zhang and Cheng, 2009).

Reduction of CO_2 emissions occupies a fundamental spot in the discussions pertaining to the protection of environment and attaining sustainable development. As a result of the rise in CO_2 emissions being partially attributed to economic growth, it was suggested by some researchers that a reduction in CO_2 in expense of economic growth is most likely an undesirable outcome especially in developing countries. Furthermore, another obstacle to massively reducing CO_2 emissions is that they are directly caused by a majority of the energy consuming processes, which are among the essential components of the global economy regarding both production and consumption activities. Consequently, the relationship between economic growth and CO_2 emissions introduces some critical implications regarding economical and environmental policymaking (Lotfalipour et al., 2010; Díaz-Vázquez, 2009; Cancelo, 2010; Tiwari, 2011).

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The economy of Turkey is best characterized by its heavy dependence on industries with high carbon or CO_2 emissions. For this reason, the Turkish government put great emphasis towards the implementation of its energy and environmental policies towards achieving some effective reduction in the level of CO_2 emissions in parallel to championing the idea of green growth. Besides, the Turkish economy experienced a dramatic jump in energy consumption in combination with a high level of economic growth within the last decade. As a summary, these are the most common economic issues encountered by a majority of the developing countries during the course of their rapid industrialization process.

What is more important is that a more comprehensive understanding of the relationship between CO_2 emissions and economic growth yields some important information for implementing the appropriate energy and environmental policies. The implications for policy making arising from these different empirical findings are surely expected to exhibit different effects. For instance, one may suggest that the policies and measures are quite effective in terms of compensating for the economic losses attributed to the mitigation of CO_2 emissions. On the other hand, it can also be suggested that such measures are irrelevant due to the lack of credible evidence or even finding non-existent evidence displaying the relationship between CO_2 emissions and economic growth (Kim et al., 2010).

This paper is organized as follows: a literature review is presented in the next section;. Section 3 consists of the data description and the econometric methodology used in the study; the fourth section presents the VAR results; finally followed by the conclusion and policy analysis in Section 5.

2. Literature Review

The purpose of this study is to draw attention to the environmental damages inflicted during the course of production processes, in addition to emphasizing the importance of revising the current production technologies within the framework of the theory defined as “sustainable development” in the economics literature. On the other hand, economic growth is one of the principal goals for every country as well as being the primary engine of national development. However, it must be remembered that economic growth does not equate to excessive consumption of natural resources and generate more waste instead for the sake of achieving higher production. Accordingly, the contemporary environmental problems emerging in the aftermath of countries entering into a race of industrialization have necessitated the consideration of “environment” and “development” concepts as an inseparable whole.

In the literature, the studies conducted on the relationships between economic growth, energy consumption, and environmental pollutants are divided into three main sections (Zhang and Cheng, 2009). The first one centers upon the framework of environmental pollutants and economic growth, and is primarily concerned with performing a validity test of environmental Kuznets curve (EKC) hypothesis, which proposes that the level of environmental degradation and income growth are linked by an inverted U-shaped relationship (Bruyn and Opschoor (1997), Unruh and Moomaw (1998), Heil and Selden (1999), Taskin and Zaim (2000), Friedl and Getzner (2003), Coondoo and Dinda (2008), and Managi and Jena, 2008). The second section focuses on the relationship between economic output and energy consumption, as a virtue of the emissions being largely induced by combustion of fossil fuels (Stern, 1993; Huang et al., 2008). Many studies analyzed the empirical evidence by developing Granger causality and co-integration models (Mehrara, 2007; Narayan et al., 2008; Belloumi, 2009; Pao, 2009). Lastly, the third section combines these two approaches introduced by the recent literature, hence simplifying the investigation of dynamic relationships among economic growth, energy consumption and environmental pollutants as a whole (Pao and Tsai, 2010). This combined approach was investigated by many researchers in single or multi country settings (Ang, 2007; Soytas et al., 2007; Ang, 2008; Halicioglu, 2009; Zhang and Cheng, 2009; Halicioglu, 2009; Zhang and Cheng, 2009).

3. Data and Econometric Methodology

3.1. Data

In this study, the effects of industrial production activities on one of the key determinants of environmental pollution, namely CO_2 emissions, was investigated. The indicator variables for industrial production activities were taken as cement (CP), steel (SP) and electricity production (EP), in addition to the consumption of petroleum products (PPC), which are among the most conventional energy resources in industrial production, and finally the aggregate real industrial production index (IPI). For the analysis, annual data for the period of 1990-2010 were employed, which were obtained from the statistics databases of Turkish Statistical Institute (TSI). The relationships among the stated variables were revealed via VAR analysis.

3.2. Unit Root Test

The stationary structures of the series were analyzed using the Augmented Dickey Fuller (ADF), Phillips-Perron (PP), and finally Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests.

A suitable test for a unit root in a time series sample is the Augmented Dickey–Fuller (ADF) test in econometrics. The following formulation is used in this method to apply this unit root test in practice:

$$\Delta Y_t = a + \rho Y_{t-1} + \delta T + \sum_{i=1}^{n} b_{1i} \Delta Y_{t-i} + \varepsilon_t \quad i = 1,2,\ldots,n \qquad (1)$$

ADF statistics and McKinnon's critical values were derived using the fixed term regressions with trend. In the formulation above, $\Delta Y_t = Y_t - Y_{t-i}$, the drift term is denoted by α, T is the time trend with the null hypothesis being H_o: $\rho=0$ and its alternative hypothesis being H_1: $\rho \neq 0$, n is the number of lags necessary to obtain white noise and ε is the error term. If the time series is non-stationary, the result would be a failure in rejecting the null hypothesis H_o (Dickey and Fuller, 1979).

A number of unit root tests, which became popular especially in the analysis of financial time series, were also developed by Phillips and Perron (1988). The approach followed by the PP unit root tests in dealing with serial correlation and heteroskedasticity in error terms is different from those of the ADF tests. Notably, while the latter tests use a parametric autoregression to approximate the ARMA structure of the error terms in the test regression, whereas the PP tests do not acknowledge any serial correlation in the same respect. Alternatively, the PP tests include a test regression term in the following formulation;

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \qquad (2)$$

where u_t is $I_{(0)}$ and the formulation might exhibit heteroskedasticity. Nevertheless, any serial correlation and heteroskedasticity in the error terms denoted by u_t in the test regression are corrected in the PP tests through direct modification of the test statistics $t_{\pi=0}$.

The ADF and PP unit root tests are conducted to check whether the null hypothesis that a time series y_t is *I(1)* holds. Stationarity tests, on the other hand, test the null suggesting that y_t is I(0). The most commonly used stationarity test, namely the KPSS test, derives its name from Kwiatkowski, Phillips, Schmidt and Shin (1992).

3.3. VAR Analysis

The vector autoregression (VAR) model is among most convenient and flexible models for the purpose of analyzing multivariate time series, in addition to exhibiting a great ease of use. VAR is a particular extended version of the classic univariate autoregressive model for the specific purpose of analyzing dynamic multivariate time series. Also, as a statistical model, it is regarded to be especially useful for constructing non-theoretical models for various economic and financial time series, as well as being utilized for forecasting purposes. Superior forecasts can often be achieved with VAR compared to the elaborate theory-based simultaneous equations models as well as the univariate time series models. Lastly, VAR models demonstrate significant flexibility in terms of forecasting thanks to their ability to become conditional on the potential future paths of specified variables in the model (Zivot and Wang, 2005).

The effects of industrial production activities on one the primary indicators of air pollution, namely CO_2 emissions, was examined by means of VAR analysis within the scope of this study. VAR models are especially utilized for the purpose of revealing the relationships between variables in non-theoretical models. Also, considering that the aim of this study is to determine the particular industrial activities that make the greatest contribution towards environmental pollution, the research methodology was explicitly chosen to be VAR analysis since the industrial production activities impacting environmental pollution are correlated with each other as well. Furthermore, it was envisioned that as a method in which all variables are regarded as endogenous, VAR analysis is a healthier method than the other prediction methodologies in which the endogenous variables often take place on both the right and left hand sides of the model equation.

The standard model depicting the mutual causality between two variables in a VAR system is as shown below:

$$y_t = a_1 + \sum_{i=1}^{P} b_{1i} y_{t-i} + \sum_{i=1}^{P} b_{2i} x_{t-i} + v_{1t} \quad (3)$$

$$x_t = c_1 + \sum_{i=1}^{P} d_{1i} y_{t-i} + \sum_{i=1}^{P} d_{2i} x_{t-i} + v_{2t} \quad (4)$$

The model is built on only the lagged values, and in case $b_{2i} = d_{1i} = 0$, then it is said that x_t does not Granger cause y_t (Maddala, 1989: 329-330). In the model, v indicates error terms with a random normal distribution, a mean of 0 and a constant variance, and P denotes the lag length.

4. Empirical Result and Discussion

4.1. Unit Test Result

In order to conduct a reliable VAR analysis, the series must firstly be stationary. Hence, the deterministic properties of the series were investigated by Holt-Winters test and as a result, it was observed that all series exhibit a trend. The trend effect in the series were eliminated by using the polynomial trend model, and the stationarity of the series was tested via ADF, PP and KPSS unit root tests, whose results are displayed in Table 1 below.

Table 1. Unit Root Test Result

	ADF			PP		
	fixed	fixed and	none	fixed term	fixed and	none
CP	-3.141^{**}	-3.051^{***}	-3.228^{*}	-3.133^{**}	-3.041	-3.220^{*}
SP	-4.117^{*}	-4.174^{**}	-4.288^{*}	-3.481^{**}	-3.375^{**}	-3.587^{*}
EP	-3.431^{**}	-3.431^{***}	-3.564^{*}	-2.057	-1.942	-1.74^{***}
PPC	-3.672^{**}	-3.566^{***}	-3.775^{*}	-3.636^{**}	-3.524^{***}	-3.744^{*}
IPI	-2.679^{***}	-2.199	-2.342^{**}	-2.356	-2.280	-2.416^{**}
CO_2	-2.588	-3.920^{**}	-2.663^{**}	-2.683^{***}	-2.580	-2.754^{*}

	KPSS	
	fixed	fixed and
CP	0.056	0.056
SP	0.059	0.059
EP	0.062	0.062
PPC	0.078	0.078
IPI	0.092	0.092
CO_2	0.061	0.061

Note: The critical values for the 'fixed term', 'fixed and trend term' and 'none' models for both ADF and PP tests at significance levels of 1%, 5% and 10% are as follows: "-3.80;- 3.02; -2.65" , "-4.49;- 3.65;- 3.26", and "-2,68; -1.95; -1.60", respectively. As for KPSS test, the corresponding critical values for the 'fixed term' and 'fixed and trend term' models at significance levels of 1%, 5% and 10% are "0.73; 0.46, 0.34" and "0.21; 0.14; 0.11", respectively.

Analyzing the unit root test results, it is seen that the series cleared from trend effect are all stationary. Prior to moving on with the VAR analysis, the lag length for the series must be determined. For this purpose, the optimal lag length of the model was determined with Akaike (AIC), Schwartz (SC), Final Prediction Error (FPE) and Hannan-Quinn (HQ) information criteria. Since all of these information criteria were at their minimum at a lag 2, the lag length of the model was taken to be 2.

4.2. Granger Causality

The order of variables entering the system equation in VAR analysis is critical; such that they must be introduced into the system beginning with the exogenous variables and then proceeding with the endogenous variables. Otherwise, a different set of results might be obtained. Consequently, Granger causality test was employed to determine the order of variables, the results of which are presented in Table 2 below.

Table 2: Results of the Granger Causality Test

Variables	p-Value
Cement Production → Steel Production	0.001
Cement Production → CO_2	0.010
CO_2 → Cement Production	0.040
Electricity Production → Cement Production	0.020
Cement Production → Electricity Production	0.020
Industrial Production → Steel Production	0.050
Electricity Production → Steel Production	0.030
Petroleum Consumption → Industrial Production	0.050
Petroleum Consumption → Electricity Production	0.060

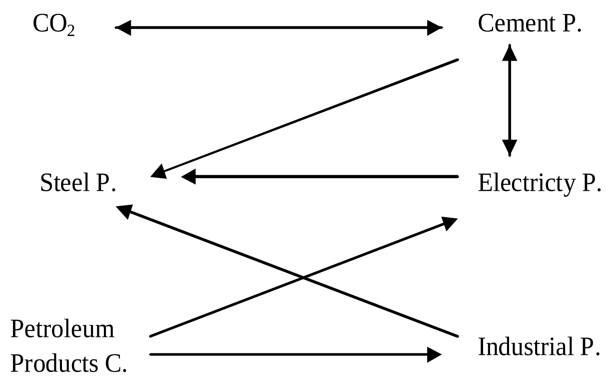

Figure 1: Graph of Causality

According to the results of the Granger causality test, the order of variables to be included into the VAR system are determined as IP, PPC, CP, EP, SP, and finally CO_2 emissions. Although steel production is indeed the most endogenous variable, the variable of CO_2 emissions was taken as the last input variable in line with the objective of this study.

From the results of causality analysis, it was inferred that increases in cement production and CO_2 emissions mutually cause one another. Cement production is also the cause of electricity and steel production. Thereby, rising levels of SP and EP will culminate in a higher level of CO_2 emissions even though they do not directly impact CO_2 emissions; since the production of steel and electricity leads to increasing cement production, which in turn translated into greater emission levels.

The cement subsector accounts for approximately 12–15% of the total industrial energy consumption, consequently releasing immense amounts of. CO_2 emissions into the atmosphere due to burning fossil fuels for producing the energy required for running cement manufacturing processes. Overall, the cement industry contributes to about 5% of the total worldwide CO_2 emissions (IPPC, 2005). The third most significant source of global carbon dioxide emissions into the atmosphere is the cement industry, which is thereby one of the primary sources of the greenhouse gases. On average, 8% of the total greenhouse gas emissions in Turkey are estimated to arise from the domestic clinker production industry (TSI, 2009).

It can be suggested that the consumption of petroleum products has an indirect effect on CO_2 emissions since a rise in petroleum consumption firstly induces a jump in electricity production, which in turn triggers cement production, and thereby boosts the overall CO_2 emissions. As for industrial production growth, since it is one of the causes for steel production alongside of cement production, it can also indirectly culminate in increasing CO_2 emissions. As a result, with cement production being in the first place, intensifying industrial production activities lead to higher CO_2 emissions due to interacting with each other.

4.3. VAR Estimation Results

Results of the VAR analysis is provided in Apx-1, from which it can be observed that lag 2 values of both cement and electricity production positively impact CO_2 emissions. For instance, a unit change in lag 1 and lag 2 values of cement production induces a positive impact of 3.97 and 2.76 units in CO_2 emissions, respectively. Similarly, a unit change in lag 1 and lag 2 values of electricity production positively influence CO_2 emissions by 1.43 and 1.08 units, respectively. On the other hand, the impact of industrial production and petroleum consumption variables on CO_2 emissions for lag 2 values were found to be positive and negative, respectively. Although these results are contradictory with each other, the fact that the coefficient of lag 1 value of industrial production in the regression model CO_2 emissions turned out to be 314.19 can be regarded as an evidence of its positive impact on CO_2 emissions. Moreover, it is quite worthy of attention that the most significant determinant of steel production is cement production. This result implies that increases in steel and cement production take place jointly, and a hike in cement production leads to higher CO_2 emissions. The same logic also prevails for electricity production. The lag 1 and lag 2 values of cement production both positively influence electricity production at a higher extent compared to the other variables.

4.4. Impulse Response Analysis

After performing the causality and VAR model analyses, the correlations among the investigated variables were examined by the assistance of impulse-response functions. These impulse-response functions illustrate the impact of a one-standard deviation shock applied to one of the random error terms on the current and future values of endogenous variables.The impulse-response functions pertaining to the variables of greenhouse gas emissions and industrial production activities are given in Figures 2, 3, 4, 5, 6 and 7. The impulse response analysis tables are provided in Apx-2.

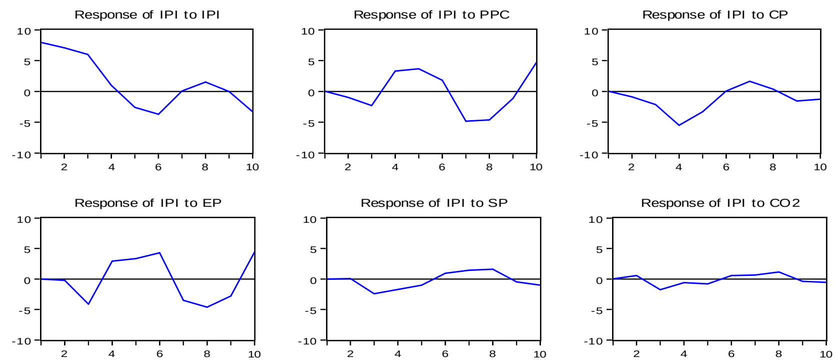

Figure 2: Impulse Response Analysis of IPI

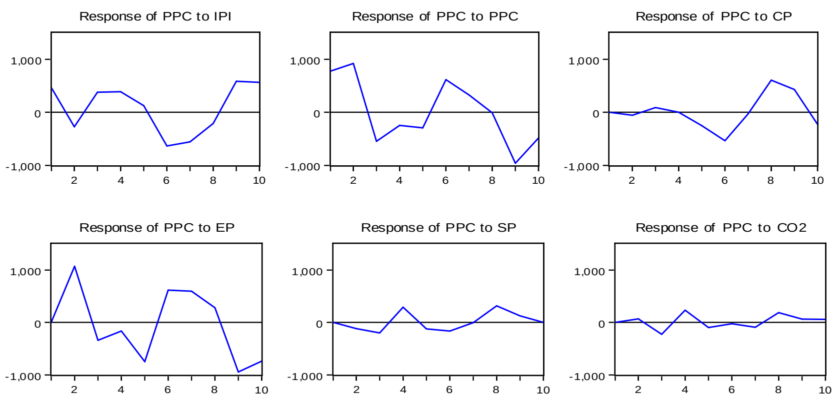

Figure 3: Impulse Response Analysis of PPC

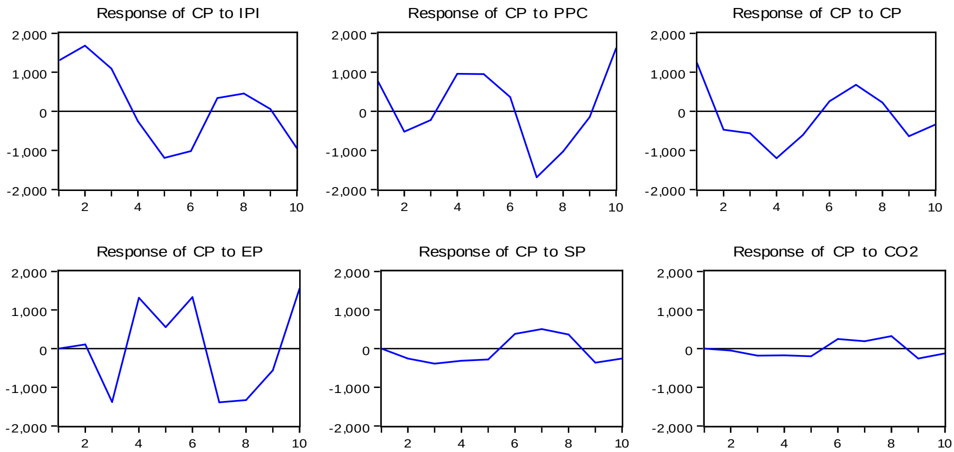

Figure 4: Impulse Response Analysis of CP

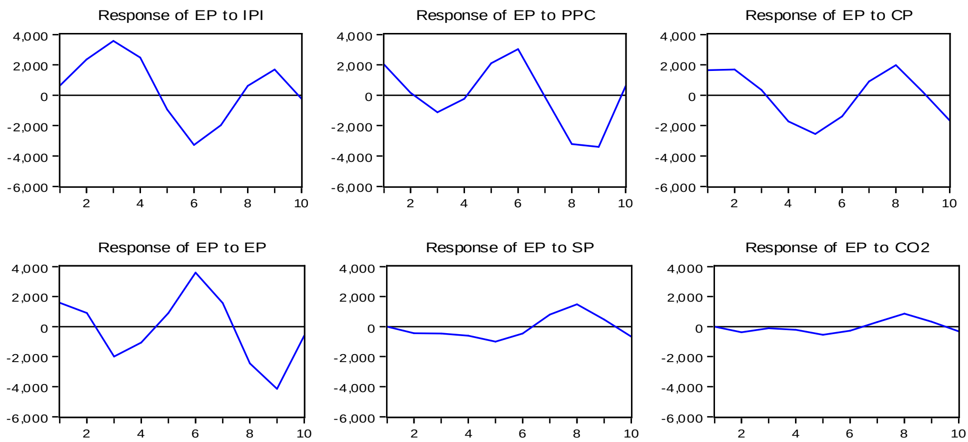

Figure 5: Impulse Response Analysis of EP

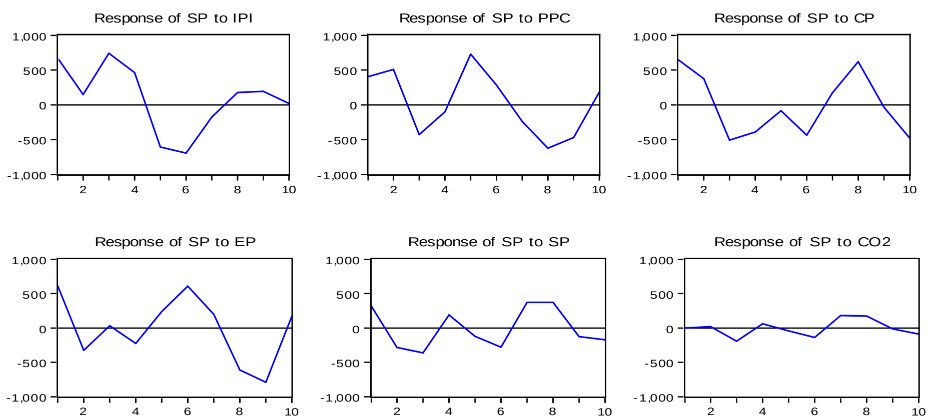

Figure 6: Impulse Response Analysis of SP

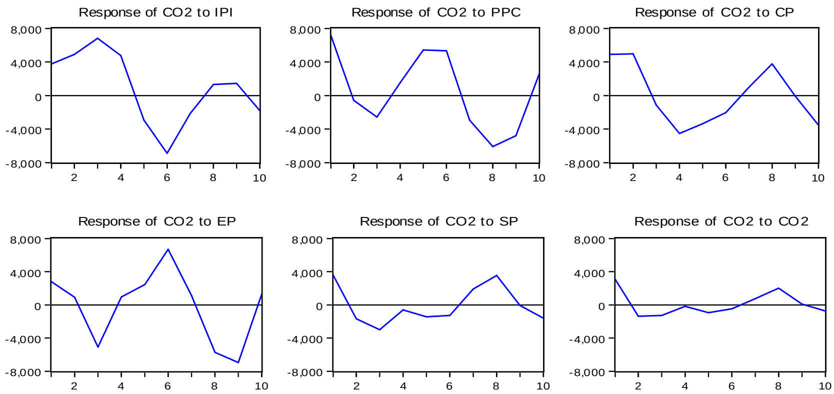

Figure 7: Impulse Response Analysis of CO_2

In light of the results of impulse-response analysis, it can be inferred that when a one-standard-deviation shock is given to the other variables in the model that impact CO_2 emissions, the strongest influence belonged to the industrial production shock. It is observed that a shock in this variable positively influence CO_2 emissions in the initial 4 periods. The next strongest influence was determined for cement production, since a shock given to this variable caused a positive response in CO_2 emissions variable in the first two periods. Then, the next influential variable is electricity production, as a shock in this variable also induced a positive response in CO_2 emissions variable in the first two periods. Finally, the shock analyses demonstrated that the other variables affecting CO_2 emissions were petroleum production consumption and steel production, in order of decreasing strength. These results are in agreement with those of the causality and VAR model analyses.

4.5. Variance Decomposition

Variance Decomposition, which is determined from the estimation of VAR model and measures the variance of prediction errors, is another technique used in the analysis of residuals. In this methodology, where the ratio of variance explained for a variable shock by the other variables is calculated, the influence of random shocks on the variables are observed in a different way. The results of variance decomposition analysis are presented in Apx-3. Analyzing the results of variance decomposition, it is seen that the variance of CO_2 emissions is least explained by the variable itself, thus demonstrating that it is the most endogenous variable due to being affected mostly by the other variables. In contrast, the variance of industrial production variable in the first period is fully explained by the variable itself. These results are in conformity with the findings of causality analysis which also suggested that industrial production was the most exogenous variable and CO_2 emissions is the most endogenous variable. According to the variance decomposition analysis which determined the contribution of other variables in percent change of the variance of CO_2 emissions variable, the shares of variables in decreasing order of variance explained were as follows; petroleum consumption by 42.97%, cement production by 19.95%, industrial production by 11.87%, steel production by 10.74%, and finally electricity production by 6.62%.

4.6. Discussion

According to the IPCC Fourth Assessment Report (IPPC, 2007), CO_2 emissions from power generation activities represented over 27% of the total CO_2 emissions worldwide, making the power generation industry by far the most important source of emissions. Furthermore, according to 2004 data, about 26% of CO_2 emissions were originating from energy production (electricity and heat generation), followed by 19% from industrial production, 14% from agriculture, 17% from land use and land transformation, 13% from transportation, 8% from the residential, commercial and service sectors, and finally 3% from wastes. Industrial sector makes up for about 70% of the total global energy consumption (Madloola et al. 2011). In this total, the cement subsector constitutes for approximately 15–19% of the total industrial energy use.

In this study conducted on Turkey, conformity with the report published by The Intergovernmental Panel on Climate Change (IPCC) is observed with respect to the empirical analysis results. Besides industrial production, the effects of cement and electricity production on CO_2 emissions are clearly observed from the entire set of analysis results. Diverging from the other studies in the literature, the impact of cement production is came to the forefront this study. An overview of the Granger causality results demonstrates that cement production exhibits a unidirectional relationship with CO_2 emissions and electricity production. Besides, cement production affects steel production as well. Turkey is among the top 10 cement producers worldwide with a cement output of 60 million tons, ranking second in Europe behind Spain only. Concordantly, cement production in Turkey is hugely influential on industrial production. For instance, the share of cement production in total CO_2 emissions, which is on the order of 5% globally, turns out to be much higher at 8% in case of Turkey.

The cement industry creates CO_2 emissions in two ways: Firstly, it releases CO_2 emissions to the atmosphere due to combustion of fossil fuels in order to produce the energy required for cement manufacturing processes, and the secondary source of emissions is the chemical reactions ongoing during the course of clinker production. However, in recent years the cement industry made great strides with respect to partially decoupling economic growth from absolute CO_2 emissions:; such that the global cement production increased by 100% from 2000 to 2010 (USGS 2010) in parallel to a slower rise in absolute CO_2 emissions. However, this trend cannot continue indefinitely –at the point where the growth of market demand for concrete and cement outpaces the technical potential to reduce CO_2 emissions per ton of product, the absolute CO_2 emissions must continue to increase.

Innovation efforts in cement production, which are highly effective on CO_2 emissions, promising significant improvement. The appropriate measures that need to be taken in this respect could be listed as follows: (a) the substitution of clinker by mineral admixtures like pozzolans and blast-furnace slag; (b) raising the energy efficiency of the production process; and finally (c) the use of alternative fuels such as bio-fuels and waste (Humphreys and Mahasenan, 2002). On the other hand, a wholly different strategy for reducing CO_2 emissions is to improve the efficiency of cement use (Damtoft, 2008).

5. Conclusion

The present study investigated the effect of industrial production activities in Turkey on CO_2 emissions, which are among the fundamental determinants of environmental pollution. The primary objective of this study was to point to the substantial damages inflicted on the environment by the industrial production activities, as well as emphasizing the exigency of making revisions on manufacturing technologies within the framework of “sustainable development” theory as defined in the economics literature.

Achieving economic growth is one of the major objectives for every country in addition being the primary engine of national development. However, it must not be forgotten that economic growth does not equate to excessive consumption of natural resources and generate more waste instead for the sake of achieving higher production. Accordingly, the current level of environmental problems emerging in the aftermath of countries entering into a race of industrialization underscored the necessity of considering the concepts of "environment" and "development" in an inseparable unity.

In Turkey, a great burden falls onto the cement industry as it accounts for 8% of national CO_2 emissions. The sector must accelerate its innovation efforts and reduce its share in CO_2 emissions to a level below the global average. For this purpose, the main measures to be taken are employing alternative energy resources and the replacement of clinker by raw materials which consist of lower carbon content.

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Annex

	Cement Production	Steel Production	Electrcity Production	Industrial Production Index	Petroleum Products Consumption	CO_2 Emission
	x1000 ton	x1000 ton	Gwh		x1000 ton	x1000 ton
1990	24400.00	11053.00	57543.00	92.18	23901.00	187029.26
1991	26000.00	10996.00	60246.30	95.12	23315.00	199127.55
1992	28600.00	11658.00	67342.20	100.07	24865.00	210229.42
1993	31300.00	13860.00	73807.50	106.01	28412.00	221662.43
1994	29500.00	13815.00	78321.70	99.32	27142.00	217150.73
1995	33200.00	13783.00	86247.40	107.90	29324.00	237507.29
1996	35200.00	16350.00	94861.70	114.25	30939.00	258620.77
1997	36000.00	18320.00	103295.80	126.71	30515.00	271882.43
1998	37500.00	14148.00	111022.40	130.01	30349.00	274046.13
1999	34200.00	17240.00	116439.90	124.44	30138.00	274777.63
2000	36200.00	17706.00	124921.60	121.96	32297.00	297005.53
2001	30100.00	16103.00	122724.70	111.38	30936.00	278112.07
2002	36523.00	17210.00	129399.50	122.01	30932.00	286087.73
2003	37960.00	19605.00	140580.50	132.75	31806.00	302753.45
2004	40517.00	21124.00	150698.30	145.60	32922.00	312261.28
2005	44440.00	23704.00	161956.20	153.48	32192.00	329866.96
2006	49105.00	27376.00	176299.80	162.41	32551.00	349639.18
2007	50950.00	30827.00	191558.00	171.14	33527.53	379975.61
2008	52808.00	31633.00	198418.00	172.57	35237.43	366502.15
2009	53122.00	34345.00	199512.00	156.16	32947.00	362654.00
2010	60484.00	37890.00	201456.00	176.11	32345.89	367645.00

Appendix-1

Vector Autoregression Estimates

	IPI	PPC	CP	EP	SP	CO2
IPI(-1)	1.187181	97.32890	351.7677	247.5415	-1.841.504	314.1990
	(0.70305)	(79.8940)	(172.288)	(275.674)	(108.750)	(966.450)
	[1.68861]	[1.21823]	[2.04175]	[0.89795]	[-0.16933]	[0.32511]
IPI(-2)	-0.508079	4.583566	-2.354.089	-2.724.300	-5.179.457	-7.925.015
	(0.77333)	(87.8797)	(189.508)	(303.229)	(119.620)	(1063.05)
	[-0.65700]	[0.05216]	[-1.24221]	[-0.89843]	[-0.43299]	[-0.74550]
PPC(-1)	-0.001914	-0.032045	-0.636828	-1.529.477	0.132983	-4.133.316
	(0.00240)	(0.27322)	(0.58918)	(0.94274)	(0.37190)	(3.30503)
	[-0.79590]	[-0.11729]	[-1.08087]	[-1.62237]	[0.35758]	[-1.25061]
PPC(-2)	0.006382	0.905246	2.089766	1.163171	0.525423	4.085392
	(0.00405)	(0.45998)	(0.99194)	(1.58718)	(0.62612)	(5.56427)
	[1.57671]	[1.96799]	[2.10676]	[0.73286]	[0.83917]	[0.73422]
CP(-1)	-0.000793	-0.965790	-0.430432	0.810004	0.580955	3.979556
	(0.00334)	(0.38003)	(0.81952)	(1.31130)	(0.51729)	(4.59710)
	[-0.23709]	[-2.54134]	[-0.52522]	[0.61771]	[1.12308]	[0.86567]
CP(-2)	0.001580	-0.339162	0.437279	0.950065	0.444152	2.767661
	(0.00261)	(0.29710)	(0.64067)	(1.02513)	(0.40440)	(3.59386)
	[0.60440]	[-1.14159]	[0.68253]	[0.92678]	[1.09830]	[0.77011]
EP(-1)	0.000267	0.871849	0.329469	0.798395	0.156306	1.435057
	(0.00258)	(0.29372)	(0.63338)	(1.01347)	(0.39980)	(3.55298)
	[0.10336]	[2.96834]	[0.52017]	[0.78779]	[0.39096]	[0.40390]
EP(-2)	0.000332	-0.470499	-0.088758	-0.240968	0.015041	1.080207
	(0.00219)	(0.24927)	(0.53754)	(0.86011)	(0.33930)	(3.01535)
	[0.15149]	[-1.88750]	[-0.16512]	[-0.28016]	[0.04433]	[0.35824]
SP(-1)	-0.001963	-0.620371	-0.612786	-0.034268	-0.961980	-0.156014
	(0.00380)	(0.43171)	(0.93097)	(1.48962)	(0.58764)	(5.22227)
	[-0.51675]	[-1.43700]	[-0.65823]	[-0.02300]	[-1.63704]	[-0.02987]
SP(-2)	-0.002448	-0.786688	-1.118.325	-1.065.565	-0.955118	-4.386.468
	(0.00354)	(0.40234)	(0.86763)	(1.38828)	(0.54766)	(4.86698)
	[-0.69146]	[-1.95527]	[-1.28894]	[-0.76754]	[-1.74401]	[-0.90127]
CO2(-1)	0.000188	0.022988	-0.016180	-0.120728	0.005574	-0.450843
	(0.00056)	(0.06368)	(0.13733)	(0.21974)	(0.08669)	(0.77036)
	[0.33622]	[0.36098]	[-0.11782]	[-0.54941]	[0.06431]	[-0.58523]
CO2(-2)	-0.000634	0.012686	-0.081423	0.008249	-0.026403	-0.348554
	(0.00054)	(0.06128)	(0.13215)	(0.21145)	(0.08341)	(0.74130)
	[-1.17627]	[0.20700]	[-0.61614]	[0.03901]	[-0.31652]	[-0.47019]

C	0.381574	114.7207	256.4056	-6.535.542	-5.829.794	-1.338.727
	(1.93099)	(219.435)	(473.201)	(757.159)	(298.689)	(2654.43)
	[0.19761]	[0.52280]	[0.54185]	[-0.00863]	[-0.19518]	[-0.05043]
R-squared	0.764032	0.740083	0.783125	0.875633	0.728087	0.727149
Adj. R-squared	0.292095	0.220250	0.349376	0.626900	0.184260	0.181448
Sum sq. resids	379.7559	4904061.	22805291	58387392	9086214.	7.18E+08
S.E. equation	7.955668	904.0705	1949.585	3119.492	1230.597	10936.22
F-statistic	1.618928	1.423694	1.805480	3.520369	1.338822	1.332505
Log likelihood	-5.541.318	-1.453.406	-1.599.414	-1.688.725	-1.511.992	-1.927.063
Akaike AIC	7.201388	16.66743	18.20436	19.14447	17.28413	21.65329
Schwarz SC	7.847583	17.31363	18.85056	19.79066	17.93032	22.29948
Mean dependent	-0.300916	73.24256	45.44998	49.44547	8.032671	287.1523
S.D. dependent	9.455600	1023.822	2417.003	5107.063	1362.511	12087.72

Appendix-2
Impulse-Response Analysis

Response of IPI:

Period	IPI	PPC	CP	EP	SP	CO2
1	7.955668	0.000000	0.000000	0.000000	0.000000	0.000000
2	7.089976	-0.992360	-0.897619	-0.245645	0.050700	0.576518
3	6.005021	-2.305.686	-2.131.780	-4.128.778	-2.442.248	-1.743.884
4	0.967234	3.280857	-5.517.432	2.931269	-1.731.278	-0.603940
5	-2.606.006	3.671349	-3.285.410	3.333061	-1.016.509	-0.809025
6	-3.729.574	1.798248	0.065320	4.314387	0.918264	0.552362
7	0.060623	-4.848.251	1.622727	-3.494.969	1.444771	0.639387
8	1.497569	-4.631.857	0.368321	-4.639.394	1.595002	1.145693
9	-0.027160	-1.151.019	-1.558.852	-2.786.019	-0.486785	-0.402945
10	-3.288.682	4.707326	-1.247.176	4.438204	-1.036.004	-0.550895

Response of PPC:

Period	IPI	PPC	CP	EP	SP	CO2
1	461.5869	777.3551	0.000000	0.000000	0.000000	0.000000
2	-2.709.242	920.4486	-5.365.900	1072.596	-1.149.912	70.33936
3	376.9395	-5.476.921	88.57702	-3.375.632	-1.994.624	-2.238.687
4	391.0087	-2.472.219	-0.628388	-1.630.858	289.8707	232.1758

5	124.8305	-2.950.111	-2.506.690	-7.478.495	-1.228.022	-9.561.770
6	-6.349.902	616.3622	-5.386.105	615.1518	-1.640.326	-2.687.227
7	-5.554.093	328.0841	-2.795.420	599.1829	-4.138.953	-9.045.833
8	-2.088.193	-9.295.158	608.1279	279.8008	317.6778	188.3044
9	587.9141	-9.602.445	429.1957	-9.481.076	126.9750	63.43744
10	564.3294	-4.838.365	-2.273.709	-7.375.832	0.489449	59.11048

Response of CP:

Period	IPI	PPC	CP	EP	SP	CO2
1	1303.239	757.9932	1236.081	0.000000	0.000000	0.000000
2	1681.879	-5.189.434	-4.687.288	103.8088	-2.529.588	-4.950.651
3	1095.022	-2.223.919	-5.610.943	-1.385.419	-3.915.865	-1.796.600
4	-2.544.576	960.7314	-1.201.780	1313.710	-3.137.584	-1.748.716
5	-1.192.667	953.3547	-6.022.378	558.9368	-2.818.650	-1.977.426
6	-1.018.792	364.9854	260.5250	1332.408	379.9398	245.2824
7	343.0347	-1.685.869	678.5149	-1.388.262	503.5381	187.0826
8	456.2616	-1.026.749	226.3770	-1.329.914	364.6753	322.8705
9	56.14251	-1.528.783	-6.413.954	-5.608.438	-3.636.097	-2.581.682
10	-9.408.162	1615.866	-3.423.153	1559.590	-2.529.810	-1.240.679

Response of EP:

Period	IPI	PPC	CP	EP	SP	CO2
1	640.6332	2023.161	1641.641	1591.432	0.000000	0.000000
2	2352.506	160.8950	1699.807	909.7391	-4.435.978	-3.694.001
3	3582.409	-1.127.409	350.4201	-2.003.041	-4.692.278	-1.087.011
4	2478.594	-2.263.438	-1.714.816	-1.065.317	-6.063.257	-2.228.022
5	-9.318.843	2096.712	-2.549.893	903.7436	-1.003.263	-5.390.336
6	-3.273.300	3032.164	-1.388.670	3604.855	-4.636.747	-2.709.618
7	-1.966.171	-1.108.556	909.1362	1560.238	805.6569	311.7314
8	618.7276	-3.207.391	1985.635	-2.459.310	1489.820	862.4867
9	1695.758	-3.409.338	227.2352	-4.151.134	459.8013	333.2853
10	-2.318.132	594.7773	-1.657.245	-6.168.102	-6.742.393	-3.125.221

Response of SP:

Period	IPI	PPC	CP	EP	SP	CO2
1	672.1089	405.0502	650.3157	611.9077	318.1689	0.000000
2	146.5881	510.2810	376.3482	-3.241.998	-2.860.934	17.05623
3	741.9832	-4.304.431	-5.079.763	31.82473	-3.651.056	-1.926.469
4	463.4248	-1.009.891	-3.929.166	-2.244.046	187.2622	58.82746
5	-6.065.719	730.2814	-8.344.570	237.5451	-1.215.360	-4.287.156
6	-6.956.277	282.3201	-4.392.275	609.2969	-2.782.881	-1.400.545
7	-1.748.631	-2.379.907	173.9700	196.1079	371.8764	180.1150
8	177.4525	-6.232.794	622.2807	-6.133.851	371.8447	173.0289
9	194.1532	-4.704.197	-3.719.695	-7.903.991	-1.271.832	-1.349.574
10	18.30535	184.8927	-4.789.706	168.6494	-1.713.136	-9.117.348

Response of CO2:

Period	IPI	PPC	CP	EP	SP	CO2
1	3768.318	7169.320	4885.500	2815.279	3584.052	3059.775
2	4893.660	-5.886.559	4970.850	919.0804	-1.665.483	-1.379.477
3	6805.629	-2.581.325	-1.147.126	-5.102.016	-3.001.394	-1.283.947
4	4765.104	1518.579	-4.521.969	953.8161	-6.182.986	-1.842.199
5	-2.934.038	5426.510	-3.369.409	2432.912	-1.433.651	-9.458.356
6	-6.890.596	5333.378	-2.028.769	6673.388	-1.280.898	-4.776.758
7	-2.132.723	-2.933.492	972.7674	1121.296	1906.879	747.7946
8	1306.180	-6.106.680	3767.131	-5.719.560	3533.334	2020.880
9	1439.535	-4.791.946	-8.538.606	-6.951.840	-6.755.000	93.68592
10	-1.803.399	2529.112	-3.524.550	1278.618	-1.624.876	-7.548.325

Appendix-3
Variance Decomposition

Variance Decomposition of IPI:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	7.955668	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	10.75854	98.11157	0.850809	0.696109	0.052132	0.002221	0.287157
3	13.70108	79.70433	3.356584	2.850104	9.113135	3.178755	1.797097
4	15.55042	62.26074	7.057024	14.80146	10.62771	3.707151	1.545908
5	16.90198	55.07885	10.69173	16.30730	12.88476	3.499676	1.537672
6	17.96070	53.08874	10.47082	14.44277	17.18072	3.360638	1.456314
7	19.06411	47.12217	15.76134	13.54382	18.61036	3.557211	1.405098
8	20.31387	42.04586	19.08070	11.96146	21.60688	3.749484	1.555616
9	20.60510	40.86589	18.85719	12.19807	22.82860	3.700055	1.550196
10	21.91288	38.38601	21.28829	11.10947	24.28723	3.495112	1.433886

Variance Decomposition of PPC:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	904.0705	26.06768	73.93232	0.000000	0.000000	0.000000	0.000000
2	1705.720	9.845821	49.88883	0.098962	39.54186	0.454479	0.170052
3	1887.652	12.02689	49.15410	0.300996	35.48500	1.487646	1.545362
4	1985.388	14.75059	45.98429	0.272101	32.75207	3.476445	2.764508
5	2165.806	12.72762	40.49753	1.568216	39.44575	3.242866	2.518020
6	2483.943	16.21124	36.94548	5.894059	36.12172	2.901477	1.926026
7	2637.061	18.81925	34.32749	5.240702	37.21147	2.574563	1.826521
8	2753.592	17.83521	31.48466	9.683944	35.16109	3.692253	2.142848
9	3154.877	17.05933	33.24866	9.227861	35.81662	2.974700	1.672829
10	3332.421	18.15775	31.90823	8.736302	37.00075	2.666174	1.530791

Variance Decomposition of CP:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	1949.585	44.68522	15.11632	40.19845	0.000000	0.000000	0.000000
2	2682.503	62.91358	11.72702	24.28634	0.149757	0.889240	0.034060
3	3296.087	52.70734	8.222558	18.98374	17.76629	2.000409	0.319661
4	3892.438	38.22153	11.98805	23.14492	24.13029	2.084159	0.431050
5	4275.051	39.46926	14.91133	21.17192	21.71369	2.162503	0.571298
6	4636.261	38.38751	13.29811	18.31720	26.72129	2.510243	0.765643
7	5208.738	30.84683	21.01133	16.20898	28.27395	2.923323	0.735596
8	5518.196	28.16773	22.18285	14.61026	31.00004	3.041375	0.997749
9	5603.731	27.32442	21.58524	15.47772	31.06257	3.370269	1.179774
10	6125.917	25.22326	25.01989	13.26374	32.47415	2.990724	1.028232

Variance Decomposition of EP:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	3119.492	4.217461	42.06232	27.69417	26.02604	0.000000	0.000000
2	4397.909	30.73527	21.29642	28.87209	17.37332	1.017387	0.705507
3	6149.249	49.66074	14.25457	15.09291	19.49700	1.102665	0.392117
4	6964.244	51.38437	11.21912	17.83009	17.54068	1.617677	0.408062
5	7898.171	41.34295	15.77009	24.28567	14.94700	2.871256	0.783042
6	9874.280	37.44015	19.51928	17.51572	22.89104	2.057524	0.576290
7	10265.80	38.30704	18.07047	16.98944	23.48820	2.519482	0.625380
8	11358.31	31.58898	22.73540	16.93445	23.87516	3.778556	1.087464
9	12693.17	27.07912	25.41938	13.59202	29.81293	3.156834	0.939711
10	12853.14	26.44179	25.00471	14.91826	29.30574	3.353918	0.975587

Variance Decomposition of SP:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	1230.597	29.82961	10.83393	27.92652	24.72522	6.684727	0.000000
2	1457.782	22.26777	19.97303	26.56539	22.56507	8.615054	0.013689
3	1813.950	31.11332	18.53060	24.99953	14.60452	9.615289	1.136749
4	1938.723	32.95123	16.49350	25.99266	14.12495	9.350445	1.087211
5	2177.128	33.89216	24.33061	20.75862	12.39132	7.726370	0.900916
6	2442.276	35.04524	20.67071	19.73031	16.07081	7.438170	1.044773
7	2508.263	33.71157	20.49767	19.18689	15.84763	9.250068	1.506172
8	2764.604	28.16177	21.95548	20.86023	17.96769	9.423298	1.631526
9	2923.097	25.63181	22.22904	18.67563	23.38356	8.618430	1.461528
10	2979.015	24.68236	21.78757	20.56617	22.83444	8.628621	1.500843

Variance Decomposition of CO2:

Period	S.E.	IPI	PPC	CP	EP	SP	CO2
1	10936.22	11.87300	42.97554	19.95646	6.626867	10.74024	7.827885

2	13195.69	21.90832	29.71733	27.89785	5.036866	8.970081	6.469549
3	16282.18	31.86033	22.03200	18.81991	13.12706	9.289609	4.871084
4	17660.57	34.36113	19.46643	22.55290	11.44960	8.018676	4.151270
5	19239.89	31.27710	24.35669	22.06925	11.24605	7.311513	3.739394
6	22284.92	32.87436	23.88295	17.27897	17.35017	5.780298	2.833250
7	22719.38	32.51026	24.64541	16.80776	16.93652	6.265792	2.834261
8	24872.50	27.40110	26.59116	16.31769	19.41912	7.245981	3.024948
9	26306.36	24.79488	27.08958	14.58838	24.34346	6.478262	2.705445
10	26813.07	24.31896	26.96509	15.77010	23.65948	6.602964	2.683409

	Production x1000 ton	Consumption x1000 ton	Export (ton)	Import (ton)
2001-1	3391,00	2537,00	423004,00	1012432,00
2001-2	3156,00	1775,00	582967,00	902268,00
2001-3	3031,00	1950,00	536954,00	1077853,00
2001-4	3295,00	2445,00	485852,00	1234804,00
2002-1	2964,00	2098,00	473477,00	1003326,00
2002-2	3701,00	2937,00	506266,00	1349050,00
2002-3	3482,00	3293,00	603829,00	1666814,00
2002-4	3620,00	2958,00	635400,00	1474322,00
2003-1	3922,00	3377,00	723219,00	1524028,00
2003-2	3976,00	3162,00	694826,00	1711601,00
2003-3	3876,00	3605,00	725523,00	1843828,00
2003-4	3976,00	3511,00	755414,00	1740164,00
2004-1	3908,00	3764,00	898918,00	1689244,00
2004-2	4258,00	3361,00	1596324,00	1913350,00
2004-3	4544,00	4213,00	1220543,00	1874817,00
2004-4	4507,00	3948,00	1534799,00	2517027,00
2005-1	4542,00	4089,00	1271601,00	2154982,00
2005-2	4752,00	4286,00	1330939,00	2303330,00
2005-3	5132,00	5190,00	992141,00	2414937,00
2005-4	5175,00	4800,00	1274052,00	2720863,00
2006-1	5180,00	4338,00	1320530,00	2410224,00
2006-2	5874,00	5860,00	1364754,00	3187045,00
2006-3	5997,00	5255,00	1723877,00	2912547,00
2006-4	5993,00	5388,00	1660444,00	3209117,00
2007-1	6446,00	6108,00	1588855,00	3169580,00
2007-2	6668,00	5393,00	2408774,00	3013173,00
2007-3	6480,00	5993,00	2102948,00	3535113,00
2007-4	6501,00	6221,00	2007744,00	3491475,00
2008-1	6945,00	6449,00	2652639,00	3799601,00

2008-2	7020,00	5499,00	4415035,00	3560840,00
2008-3	7335,00	5314,00	5668212,00	3457623,00
2008-4	5400,00	4088,00	1965734,00	2007491,00
2009-1	5765,00	2962,00	2055394,00	2142741,00
2009-2	6728,00	4615,00	1737503,00	2566459,00
2009-3	6490,00	5266,00	1738240,00	2598629,00

	Export USD x1000	Import USD x1000	real-GDP	real-IPI
2001-1	2000039,00	318077,00	137677,84	238,06
2001-2	2750675,00	268554,00	132239,47	174,88
2001-3	2590773,00	306630,00	152347,04	158,24
2001-4	2334205,00	310118,00	128252,90	134,54
2002-1	2325420,00	279411,00	115295,55	130,46
2002-2	2501856,00	392525,00	125317,68	129,16
2002-3	2641448,00	512858,00	152390,27	121,01
2002-4	2635923,00	507735,00	138362,01	114,64
2003-1	2738576,00	571424,00	120201,95	104,79
2003-2	2487240,00	663939,00	129208,39	103,91
2003-3	2668588,00	715399,00	156759,42	109,13
2003-4	2555942,00	709093,00	145419,87	109,18
2004-1	2536999,00	807058,00	134865,77	106,78
2004-2	3597072,00	1071483,00	139283,59	104,34
2004-3	2800678,00	1112113,00	164134,58	101,73
2004-4	3260887,00	1587881,00	152553,65	96,82
2005-1	2771225,00	1439990,00	143408,06	96,75
2005-2	3001206,00	1537078,00	153348,43	96,57
2005-3	2361558,00	1378590,00	181166,19	100,10
2005-4	2940409,00	1479553,00	170590,85	106,25
2006-1	3173115,00	1316927,00	155389,56	99,99
2006-2	2947666,00	1797868,00	168999,72	99,13
2006-3	3353624,00	1881224,00	188989,11	95,87
2006-4	3191305,00	2110478,00	178762,86	99,40
2007-1	2968383,00	2133142,00	165642,30	100,64
2007-2	3982598,00	2283501,00	175651,74	98,43
2007-3	3476376,00	2568409,00	198635,89	98,22
2007-4	3364855,00	2630875,00	185153,47	99,38
2008-1	3858129,00	3015000,00	175333,62	99,98
2008-2	4995992,00	3503468,00	178242,03	88,23
2008-3	4934286,00	4184646,00	194845,06	84,05
2008-4	3000392,00	2034824,00	176711,81	77,93
2009-1	4347338,00	1410906,00	160158,82	74,14

2009-2	3871301,00	1470267,00	173486,05	75,57
2009-3	3730306,00	1634286,00	197788,91	78,38