Sectoral Energy Consumption by Source and Economic Growth: The case of Turkey*

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Abstract

This paper provides a brief summary of economic development while analyzing in detail energy consumption in Turkey during the last forty years. It investigates the causal relationship between income and energy consumption in two ways. First, it distinguishes between different categories of energy consumption: industrial, residential and total energy consumption. Second, the growth of different sources of energy consumption is analyzed in order to capture any difference in behavior of the long term linkage between income and energy consumption among various sources. Previous findings suggest that in Turkey, there is a unidirectional causality running from energy consumption to growth. In contrast, we find no evidence of long run relationship and energy and income appear to be neutral with respect to each other. The analysis shows also strong evidence of instantaneous causality between these variables. These results imply that energy conservation policies do not impede economic growth in the long term.

Keywords: Turkey; Disaggregate energy consumption; Economic growth; Granger temporal causality

JEL classification: C52; Q42; Q43

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1 Introduction

The process of economic development in the developing countries involved a strong growth of energy demand over the last 50 years. As in most of the industrial countries, they had to reduce energy requirements due to rising energy prices following the energy crises in the 1970s. As Stern and Cleveland (2003) pointed out; if the level of economic activity and the energy use are tightly coupled, the economy is called energy-dependent and all typical energy policies can affect economic growth.

Jones (2002) pointed out four stylized facts for the US economy for a 48-year period (1950-1998);

- 1.4 percent of increase *per annum* in energy efficiency (GDP per unit of energy used).
- 1 percent of increase in per capita energy use.
- About 1 percent of decrease in the share of energy cost in GDP.
- Decline in energy prices per unit of labor cost.

In a more theoretical study, Smulders and de Nooij (2003) build a growth model where the direction of technical change is endogenous, and they confirmed these stylized facts for Japan, West Germany, France and United Kingdom.

The causal relationship between economic growth and energy consumption has been studied in a large number of empirical studies which give conflicting results in this area. Using the energy consumption and gross national product (GNP) of United States over the period from 1947 to 1974, Kraft and Kraft (1978) argue that the direction of causality is from GNP to energy consumption. Their result indicates that the low level of energy dependence of US economy enable energy conservation policies which have no effect on income (Jumbe, 2004). This pioneer work in this area intensified the interest of researchers in the relationship between income and energy consumption. Akarca and Long (1980), just by changing the time period used in Kraft and Kraft (1978) found no statistically significant causal relationship. The neutrality hypothesis is also found by Yu and Hwang (1984), Yu and Choi (1985), Yu and Jin (1992) and Cheng (1995). However empirical studies focusing on some developing countries give disparate estimations of the causal relationship e.g. for different time periods, in Indonesia the direction of Granger causality (Granger, 1988) is from income to energy (Masih and Masih, 1996), but Fatai et al. (2004) found a unidirectional causality running from energy consumption to income. For the same country, energy and income were found to be neutral with respect to each other at least in the short run (Asafu-Adjaye, 2000). The empirical evidence is mixed also for industrialized countries e.g. Erol and Yu (1987) found a significant causal relationship between income and energy consumption in the case of Japan for the period 1950-1982, supporting the view that Granger causality runs from energy consumption to income. However, this result does not hold in a more restricted period 1950-1973. Recently, Lee (2006) pointed out that their results are spurious and the direction of causality is from income to energy consumption.

Inconsistent results concerning the direction of the relationship might be due first to methodological differences and second to the time period chosen. In recent studies the cointegration technique, used first by Engle and Granger (1987), is commonly utilized to test for long run equilibrium relationships. Johansen (1988) and Johansen and Juselius (1990) maximum likelihood procedure is used to detect the Granger causality; If two or more variables are cointegrated and have common trends, there is at least one long run relationship between this variables, hence, the direction of the Granger causality can be tested through the vector error correction model (VECM). Using this methodology, Soytas and Sari (2003) found, in the long run, a unidirectional causality running from energy consumption to GDP per capita and in the short run a bidirectional relationship in Turkey. In a very recent study Lise and Montfort (forthcoming), using annual data over the period 1970-2003, found that in Turkey, energy consumption and GDP are cointegrated and there is a unidirectional causality running from GDP to energy consumption. For the same country, Sari and Soytas (2004), utilizing a small sample of disaggregate energy consumption and GDP (31-year period from 1969 to 1999), pointed out that 21 percent of forecast error variance of GDP is explained by total energy consumption. This result is obtained through the generalized forecast error variance decomposition developed by Koop et al. (1996) and Pesaran and Shin (1998). An advantage of this method may be the instruction of dynamic properties of a VECM.

Although all of these studies contribute to investigating the relationship between energy consumption and economic growth, they have not sufficiently shed light onto the dynamics of this relationship. We feel that the evolution of energy consumption and economic growth are more efficiently analyzed if different sectors and different energy sources are taken into consideration together with economic indicators such as population growth, capital intensity and sectoral production. The complexity of relationships among these variables requires a reexamination of the long term linkage between energy consumption and income in Turkey.

The paper has two important findings. First, it supports the neutrality of energy in Turkey. Hence, energy conservation policies may not be stimulus to economic growth. Secondly, as in Greece (Hodroyiannis et al., 2002), energy use in industrial production in Turkey increased considerably, despite the 1970s oil price shocks. This is a result of increasing capital intensity at the same time in Turkish Industry. Hence, this pattern of economic development does not seem to be supported by energy saving technical progress, and this is true for any kind of energy resource.

The paper is organized as follows. In the second section we describe economic developments and the pattern of development of total energy consumption in Turkey since 1960s. We find no evidence of long run relationship and energy and income appear to be neutral with respect to each other and we analyze trends in consumption in a sectoral level by energy type. In Section 3, we examine the links between production and energy consumption in industry sector and we give possible explanations for the econometric results that this research provides. We present the conclusions of our study and discuss policy implications in Section 4.

2 Economic Developments and Energy Consumption in Turkey

2.1 Macroeconomic Background

During the last 40 years a fragile economic system is created by boom-bust cycles produced by multiple growth and recession periods in the Turkish economy. For a better explanation of these cycles, the period (from 1960 to 2006) should be analyzed in three sub periods. In the first twenty years (1960-1980) a closed and planed economy, in the following twenty years (1980-2000) an open economy with an export-led growth strategy and finally (2000 to present) the acceleration of structural reforms to obtain a sustainable growth.

Table 1: Average Annual Growth Rate of Economic Indicators and Energy Use in Turkey (%)

	1960-1979	1980-1999	2000-2003
GNP at Fixed (1987) Prices	5.12	3.98	2.65
GNP per capita	2.66	1.85	0.79
Energy Consumption	5.27	3.76	3.71
Energy use per capita	2.8	1.64	1.83
Energy intensity (Energy use/GNP)	0.14	-0.14	0.96

Data sources: Energy Balances of OECD countries and Central Bank of the Republic of Turkey

According the estimations of The State Institute of Statistics (SIS), between 1960-1980 the country's population has been growing at an average annual rate of 2.5 percent. The annual growth rate of population decreased to 2.2 percent in the next twenty years period. Since 2000 excessive growth of population has been relatively slowed down to about 1.6 percent annual rate. Turkey's population at the end of 2003 exceeded 70 million. This number represents a 155 percent increase over the 27.7 million enumerated in 1960. In spite of this high population growth rate, GNP per capita is more than doubled in this period.[1]

The main economic indicators and energy use summarized in Table 1 show that one of the most important characteristic of the Turkish economy is, given that Turkey's population has growed quickly, GNP per capita and energy use per capita increased both about 2 percent annual rate. In 1960 Turkey's real (at fixed 1987 prices) per capita income was 7.3 thousand YTL and in 2003 it was more than 17.7. The real per capita income in 2003 was 2.5 times that of 1960. The Turkish economy has experienced a *planed economy* during the 1960-1980 period. The main objective of this planning is, on the one hand, increasing the capital stock. High level of subsidies, and increasing real wages in the industry sector created incentives for the substitution of capital to labor. In the next section we describe in detail the evolution of production and energy consumption in the industry sector. Hence, we just here point out that this period can be called as a capital accumulation period in the Turkish industry. On the other hand, supported by restrictions on importations, a monetary policy that aims at decreasing real interest rates and keeping the Turkish lira overvalued was the main tool of adopting a strategy of import substitution industrialization (ISI). As the economy expands, there was a very large growth in energy demand, especially that produced from fossil fuels. As in other developing countries, the ISI model of development in Turkey failed by successive energy crises in 1973 and 1979. The two oil price shocks had persistent effects on the Turkish economy: cumulated external dept and *via* well known pass through mechanism, about 100 percent annual inflation rate in the early 1980s.

Not only for reducing external dept and diminishing inflation but also in order to follow the new trend of liberalization in the world economy, many structural changes were necessary for the Turkish economy. Hence, with support from the International Monetary Fund (IMF), a new reform program was implemented by the Turkish government on February 14, 1980 with adoption of export-led growth strategy instead of ISI. Under this programme, that can be called as the neo-liberal experiment of Turkey, the government's role in the economy was changed. The main objective of the economic policy was to encourage exports and foreign direct investments with a new monetary policy that take aim at adapting exchange rates to match this strat-

[1] The results presented in this study do not change whether we use GNP or GDP (measured in 2000 constant US dollars using exchange rate or using PPP). A full set of results and graphiques is available upon request from the authors. For a further discussion on the use of GNP in an output-energy model, see Sun (2001).

egy of opening (IEA, 2001). On the other hand, subsidies and price controls were cut back, low productivity in SEEs require the government to launch a privatization programme in 1985 that followed by the full capital account convertibility, that lifted foreign exchange controls, and trade liberalization in 1989.

In the 20-year period of protectionism, from 1960 to 1980, production efficiency did not much increase and it was not evident that the national industry could face up to international competition in an open economy environment. However, as pointed out by Ertugrul and Selcuk (2001), the new strategy of stabilization and development, that take aim at opening the Turkish economy to international markets, was quite successful in restoring economic growth. The economy did not experience any recession between 1981-1988 and the average growth rate *per annum* of real gross domestic product (GDP) reached to 5.8 percent. We can explain the high performance of the Turkish economy in early 1980's in spite of the military *coup d'Etat* on September 12, 1980, by the receipt of structural adjustment Loans (SALs) from the World Bank.

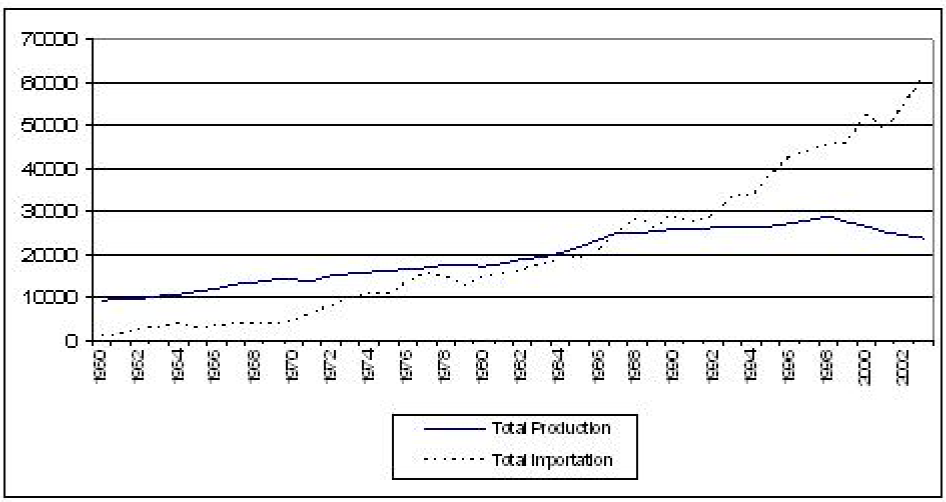

Figure 1: Energy Production and Importation (kilo tonnes of oil equivalent). Data sources: Energy Balances of OECD countries.

In this period, increasing energy requirements were satisfied *via* word energy markets. In 1984 the government implemented a law that liberalizes the energy market in order to open the market to the private sector. Investments in the energy sector decreased about 65.2 percent in an 8-year period following 1987. In 1973 the share of Turkey's energy production in total primary energy supply (TPES) was 64% (IEA, 2001). By 1987, total energy importation passed the national energy production (see Figure 1) and the ratio of national production to TPES diminished to 49% in 1990.

This makes Turkey an energy import-dependent country, that is, due to increasing energy prices, the main factor of the increase of the total import-GDP ratio.[2] An effective export-led growth policy impeded the possible deterioration of balance of trade. However, dependency of the economic growth to the short-term capital inflows created a fragile equilibrium that became evident with financial crisis in 1994 and Russian crises in 1998-1999.

The crisis of November 2000 and February 2001 were two of the biggest that Turkey has experienced in the history of the Republic. After two decades of neo-liberal reforms, it was evident that governments should take necessary measures to produce domestic macroeconomic stability that is no doubt the *conditio sine qua non* of financial globalization. Supported by IMF the government launched a new restructuring and reform program. The aim of the program was to establish the confidence, reduce inflation and increase economic efficiency.

Just as the government tried to increase the productivity of other production factors, it has also made considerable efforts to address the "3 Es", namely energy security, energy efficiency and environmental protection, in a sustainable manner (IEA, 2005). Intensifying R&D on energy technologies, in order to satisfy increasing energy demand with the economic growth, maintaining security of energy supply (exploration activities, particularly in the south-eastern part of the country, and reduction of import dependence) constitute the main objectives of the energy policy objectives of the Eighth Five-Year Development Plan for the period 2001-2005. Today three main boards are responsible for the implementation of energy policies and regulation of energy market: The Ministry of Energy and Natural Resources (MENR), The General Directorate of Energy Affairs (EIGM) and The Energy Market Regulatory Authority (EMRA).

2.2 Methodology, Data and Empirical Study

To measure the causal relationship between energy consumption and income, we use the notion of Granger causality and the notion of instantaneous causality. These notions can be used when we are dealing with stationary series. The first notion can be defined as follows: the process X_2 does not Granger cause the process X_1 if

$$E(X_{1t}/I_{t-1}(X_1), I_{t-1}(X_2)) = E(X_{1t}/I_{t-1}(X_1))$$

where $I_{t-1}(X_i)$ is the space generated by the linear combinations of the past values of X_i. The concept of Granger causality can be interpreted in terms of predictability. If the process X_2 Granger causes the process X_1, then it is possible to use the past values

[2] Decreasing trend of energy prices stopped by the 1991 Gulf War, and price of barrel of crude oil rose above 27 dollar and average oil prices have gained more than 72 percent in two years. See Fig. 5 in Appendix.

of X_2 to forecast X_1. The second notion, instantaneous causality, investigates if there is a linkage between two variables without giving the direction of the causality. The process X_2 does not cause instantaneous the process X_1 if

$$E(X_{1t}/I_{t-1}(X_1), I_t(X_2)) = E(X_{1t}/I_{t-1}(X_1))$$

where $I_t(X_i)$ is the space generated by the linear combinations of the present and past values of X_i.

Our empirical study has been carried out using annual time series for the period 1960-2003. The data for real GNP, and industrial value added are obtained from the Central Bank of Turkish Republic. Other variables, total, residential and industrial energy consumption are considered in different categories that consist of petroleum products, electricity, natural gas and coal consumption. The energy consumption variables are measured in kilo tons of oil equivalents and are taken from the *Energy Balances of OECD Countries* published by International Energy Agency. All variables are in logarithms.

First, we test the stationary of different series: energy consumption, energy consumption per capita, income and income per capita. Unit root tests of Dickey-Fuller and Phillips-Perron, show that the logarithm of the series are not stationary but the series taken in first difference (growth rate) are stationary[3].

Since the series are integrated of order one, we have searched for a cointegrating relation between one the hand the logarithm of the GNP, and the logarithm of energy consumption. To analyze the multivariate process generated by GNP and energy consumption, we have chosen to use the method proposed by Johansen (1991). [4]
According to Table 2, the trace test demonstrates, as well as the lambda max test, the absence of cointegration between energy consumption and GNP which means that these two variables do not have any long run equilibrium. This is a sufficient condition to have an unsteady production function. These two series admit thus a VAR[5] representation with two non-stationary and un-cointegrated variables.[6]
Table 3 gives the P.values for the tests of non-causality as well as the signs of the estimated coefficients.

The results reveal that there is no causal relationship between total energy consumption and GNP in Turkey. In other words, not only the past values of energy

[3]Results are available on request.

[4]The advantages of this method compared to Engle and Granger's (1987) is that it allows us to test for the number of cointegrating relations, it does not impose an arbitrary normalization on cointegrating vector, and it permits us to test for constraints on the coefficients of the cointegrating relation.

[5]Akaike's information criterion (AIC) and Schwatz Bayesian criterion determine a VAR model of order 1.

[6]We do not discuss the methodology here to conserve space. Detailed explanations can be found in Hamilton (1994).

Table 2: Johansen Test for the number of cointegrating relationships

	Eigenvalue	$H_0 : r =$	Trace	L Max	Critical values at 95%	
					Trace	L Max
Model with GNP and Energy	0,1076	0	8,75	4,67	15.41	14.07
	0,0947	1	3,56	3,56	3.76	3.76
Model with GNP and Energy per capita	0,1078	0	4,79	8,26	15.41	14.07
	0,0791	1	3,46	3,46	3.76	3.76

r indicates the number of cointegrating relationships. The critical values for Maximum eigenvalue and trace test statistics are given by Johansen and Juselius (1990).

Table 3: P. values of the Granger non causality tests

		Causality	GNP	Energy
Model with GNP and Energy	GNP equation	Granger	0,3(+)	0,52 (+)
		Instantaneous	-	0,00 (+)
	Energy equation	Granger	0,71 (-)	0,84 (-)
		Instantanteous	0,00 (+)	-
Model with GNP and Energy per capita	GNP equation	Granger	0,27 (-)	0,53 (+)
		Instantaneous	-	0,00 (+)
	Energy equation	Granger	0,69 (-)	0,82 (-)
		Instantanteous	0,00 (+)	-

(-) Indicates that the sum of the coefficients is negative.
(+) Indicates that the sum of the coefficients is positive.

consumption do not impact the GNP, but also the past values of GNP do not influence the energy consumption in Turkey. On the other hand, the instantaneous causality test indicates that there is a very robust positive linkage between energy consumption and GNP.

2.3 Energy Consumption by Sector

In analyzing energy use in Turkey, it is important to appreciate sectoral differences. As can be seen in Figure 2, in 1960, the domestic sector contributed towards 72 percent of final energy consumption. The residential energy consumption increased annually by 2 percent between 1960 and 2003 while energy consumption in the industry and transport sectors increased by 7 percent and 5 percent respectively. Hence, in the total energy consumption in 2003 industry became the largest sector, followed by the residential sector. In this period, energy consumption in other sectors, service and agriculture has been increasing at an average annual rate of 14 percent and 8 percent respectively. However, as these sectors are not intensive in energy use, the share of these sectors in the total energy consumption remained stable. Before we analyze in detail the upward trend in energy use in the Turkish industry sector, a brief comparison of the pattern of energy consumption with two industrialized country, France and Germany, is certainly not useless.

After the second oil price shock in 1979, industrialized countries increased the incentives in order to improve energy efficiency in the industry sector. Energy saving technical progress induced by increasing R&D efforts reduced energy intensity in France and Germany. However, with the rise of wealth, residential energy consumption increased in both countries and exceeded industrial energy consumption in France. Then one can easily see that decreasing trend in industrial energy consumption and increasing trend in residential energy consumption in industrialized countries seem to be reversed in Turkey, as in most of developing countries. The following section expands the analysis on the industry sector so as to illustrate the linkage between energy consumption and industrial value added (IVA) and to explain why Turkish industry do not benefit from the energy saving technical progress.

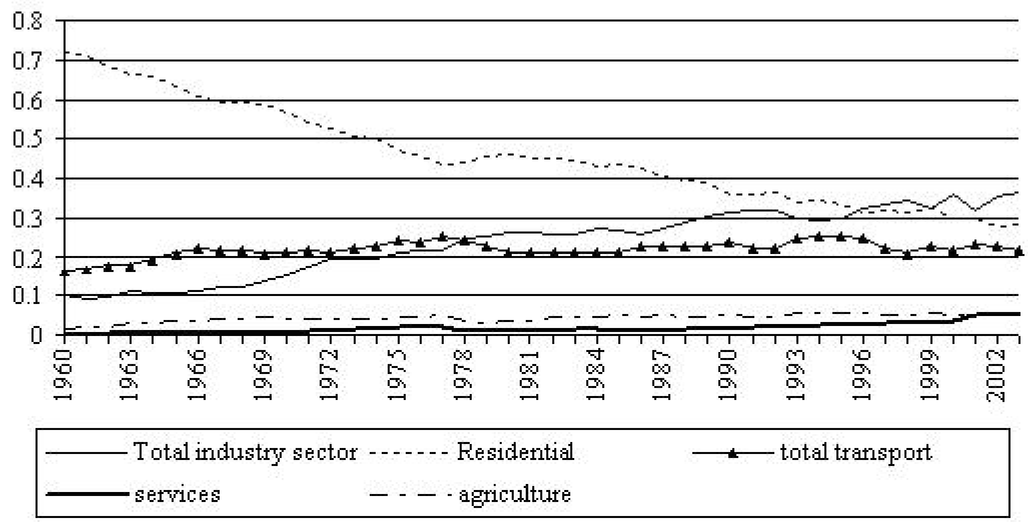

Figure 2: Energy Consumption by Sector. Data sources: see FIG. 1.

3 Industry Sector

3.1 Developments in the Sector

As we mentioned above, the period from 1960 to 1980 can be called as a capital accumulation period with adoption of a closed model of planned economy by the State Planning Organisation. The industry sector was dominated by publicly owned State Economic Enterprises (SEEs), especially in some sub-sectors where capital requirements are too heavy that private investors hesitate to invest. During this period, the capital intensity of the production process increased sharply: growth rate of investments in fixed capital was 32 percent in the 1960s and 15.7 percent in the 1970s. Hence, annual average growth rate of real capital stock was 5,9 percent in 1960s and 8 percent in 1970s.[7]

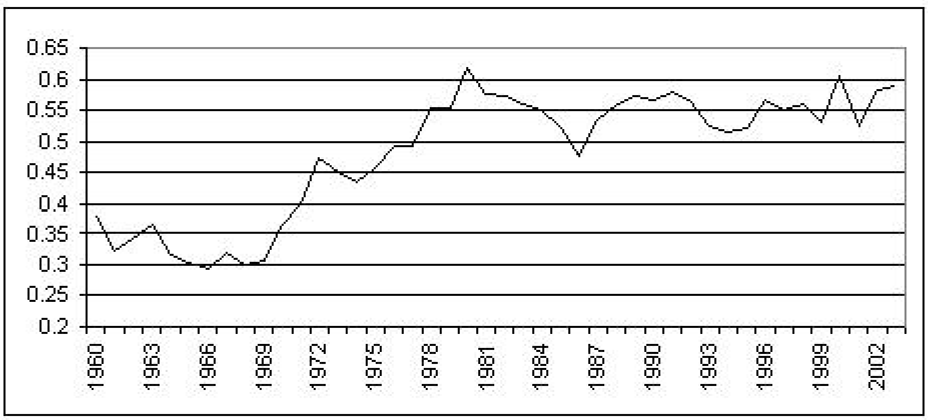

Figure 3: Energy Consumption/Industrial value added (IVA). Data sources: Energy Balances of OECD countries and Central Bank of the Republic of Turkey

However, without any serious regulation to reduce the energy consumption and any energy saving technical progress in the industry, this period of capital accumulation, that is dominated by a state-led inward-oriented growth strategy, raised the energy requirements of Turkish industry. As a result, during this period, the increase in industrial value added was above the growth of energy consumption (see Figure 3).[8] Though, after the first energy crisis in 1973, energy consumption did not slow down,

[7]This period can be analyzed better by considering two sub-periods; economic crisis period (1978-79) and pre-crisis period (1963-77). In the first period investment performance was better, real private investment grew, on average, by 9.3% per year and the annual growth rate of public investment was more impressive, 12.2% (Ismihan et al.(2005)).

[8]See also Figure 6 in Appendix for the evolution of capital stock and value added in the industry.

the second one in 1979 seems to stop the pace of increase of energy consumption in the industry.

During 1980s and 1990s the direction of the capital accumulation oriented towards other sectors, tourism, education and medical sector. Not only the energy price shocks but also the relative decrease of the capital stock in the industry and the adoption of an open economy strategy, that makes easier the substitution of the vintage capital by new information and communication technologies increasing energy efficiency, reduced the energy consummation of the sector.

On the other hand, as we will discuss in the next section, the ratio electricity consumption/IVA has an increasing trend and in a very recent research Soytas and Sari (Forthcoming) pointed out that there is a a unidirectional causality running from electricity consumption to IVA.

3.2 Empirical Study

We use the same methodology as in section 2.2. Time series used here are industrial value added and energy consumption in this sector. Unit root tests of Dickey-Fuller and Phillips-Perron, show that the logarithm of the series are not stationary but the series taken in first difference (growth rate) are stationary, thus they are integrated of order one.

Table 4 reports the results of the test for the existence of cointegrating vectors and we find, once again, no evidence of cointegrating vector between industrial value added and energy consumption in the industry, neither in the model *level* nor in the model *per capita*. This result is consistent with our previous remarks that the industrial energy consumption per unit of output in the sector is not stable during the 1960-2003 period.

As the series are non-stationary in levels and are not cointegrated in order to test for causality we use a VAR model where the series are first differenced. The estimated coefficients of Granger non causality test are presented in Table 5.

In spite of the strong evidence of instantaneous causality between energy consumption and industrial value added, the results obtained by using two VAR models (*level* and *per capita*) seem to support the neutrality hypothesis among these variables.

4 Conclusions and Policy Implications

In this paper cointegration test and Granger causality test were applied in order to reexamine the long run and causal relationship between real GNP and energy consumption in Turkey for the period 1960-2003. Our results show that there is no stationary linear cointegrating relationship between these two variables. In spite of the fact that

Table 4: Johansen Test for the number of cointegrating relationships

	Eigenvalue	$H_0 : r =$	Trace	L Max	Critical values at 95%	
					Trace	L Max
Model with IVA and Energy	0,2237	0	13,66	10,64	15.41	14.07
	0,095	1	3,03	3,03	3.76	3.76
Model with IVA and Energy per capita	0,2084	0	13,61	9,82	15.41	14.07
	0,0863	1	3,49	3,49	3.76	3.76

r indicates the number of cointegrating relationships. The critical values for Maximum eigenvalue and trace test statistics are given by Johansen and Juselius (1990).

Table 5: P. values of the Granger non causality tests

		Causality	IVA	Energy
Model with IVA and Energy	IVA equation	Granger	0,42(+)	0,62 (-)
		Instantaneous	-	0,00 (+)
	Energy equation	Granger	0,72 (+)	0,31 (-)
		Instantanteous	0,00 (+)	-
Model with IVA and Energy per capita	IVA equation	Granger	0,48 (+)	0,59 (-)
		Instantaneous	-	0,00 (+)
	Energy equation	Granger	0,76 (+)	0,29 (-)
		Instantanteous	0,00 (+)	-

(-) Indicates that the sum of the coefficients is negative.
(+) Indicates that the sum of the coefficients is positive.

GNP per capita has grown considerabily and that we have stability in energy intensity, the neutrality hypothesis among real GNP and energy use in Turkey seems to hold.

A sectoral analysis was conducted by using cointegration and causality tests for Turkish industry sector. We have chosen the industry sector for at least two reasons: First, we mentioned that the share of industry in the total energy consumption increased at an average annual rate of 7 percent, and today the industry is the biggest energy consummer sector in Turkey. The second reason which is environmental rather than economic is that the fossil resources as petroleum products and low-calorie domestic lignit, are extensively used in industry. Therefore, the industrial sector has the highest CO2 emission in Turkey. Our concluding remarks will thus be focused on this sector.

We pointed out that in the industry sector, increasing trend of energy consumption of 1970s slowed down by the mid-1980s. One can also show that the pattern of development of energy consumption in comparison with industrial value added given in Figure 3 is not specific to only one typical energy source.

Petroleum products consumed in the industry increased relatively to electricity consumption. Coal is also used extensively in the production and by 1980, at fixed 1987 prices, to create 1000 YTL of industrial value added, primary energy requirements of the sector reached to, approximately, 0.33 ktoe of oil, 0.19 ktoe of coal and 0.9 ktoe of natural gas. The evolution of primary energy consumption in relation to the industrial value added is given in Figure 4.

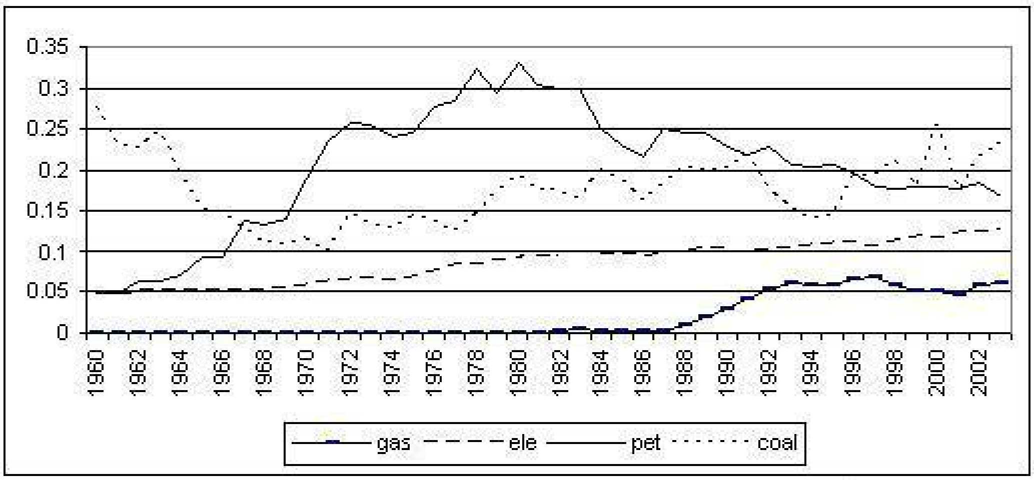

Figure 4: Energy Consumption by Source/Industrial value added. Data sources: see FIG. 1.

During the last 40 years, the main character of the industrial energy consumption by source is that it becomes more balanced: In 1960, the energy consumption in the sector was *coal-biased*; the share of coal in the total industrial energy consumption was 73 percent. In 2003 it diminished to 39 percent but the coal is still most commonly used energy source in the industry. As coal is one of the most polluting resources, the *coal-biased* energy consumption has negative environmental externalities in the economy. On the other hand, the share of petroleum products and electricity are, in 2003, 28 and 21 percent respectively. The use of natural gas in the industry is still modest, about 10 percent of total energy consumed in the industry.

In the industrialized countries, however, the pattern of industrial energy consumption by source is mostly dissimilar. In France and in Germany, for giving the same country examples as above, in 2003, coal is the less used energy source in the industry, about 7 percent and 10 percent respectively. Electricity and natural gas have increasing trends in both countries and energy consumption by source converges to a balanced growth path where the share of natural gas, petroleum products and electricity are equal and stable, about 30 percent each one. Hence, *neutral* energy use, that is not biased on a polluting resource, can lessen environmental impacts of energy consumption in this kind of countries.

Appendix

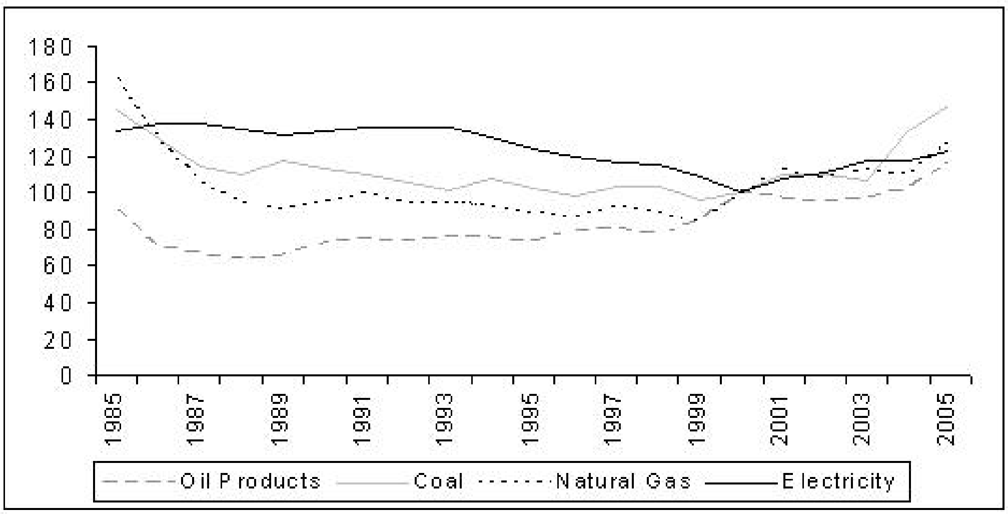

Figure 5: Indices of Real Energy Prices for End-Users in OECD Countries (2000=100). Data sources:International Energy Agency

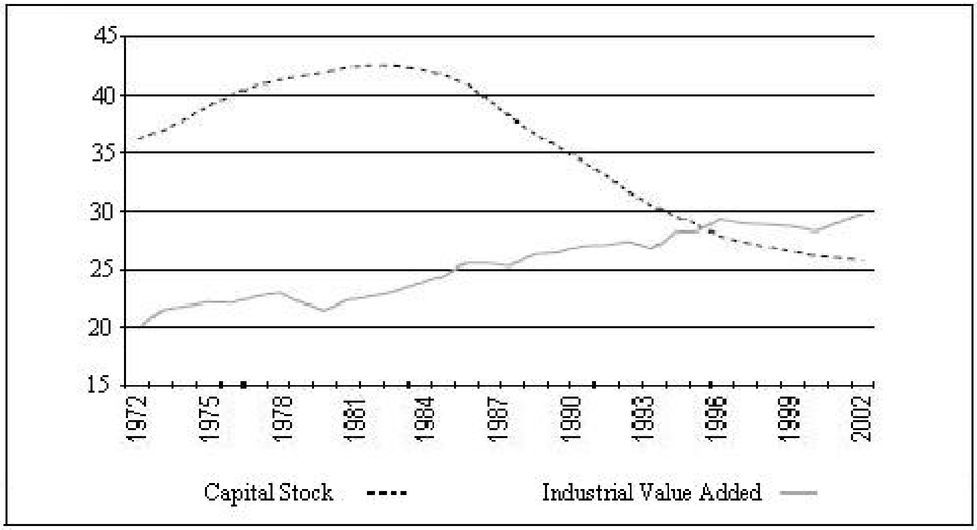

Figure 6: Share of Industrial sector in total capital stock and in GNP (%). Data sources: State Planning Organisation

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