Final Report

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Economic Evaluation for Policy Making Under the UNDP-GEF Project:

"Enabling Activities For The Preparation Of Turkey's Initial National Communication To The UNFCCC"

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EXECUTIVE SUMMARY

- It is the purpose of this report to seek out viable options for the Turkish environmental policy and to provide an impact analysis of possible environmental policy instruments on long run growth, employment, investments, and consumer welfare.
- As part of its attempts towards full membership to the European Union, Turkey is under significant pressure to recognize the conditionalities of the *Kyoto Protocol* to reduce its CO2 emissions and other gaseous pollutants over the next six years. Yet, as a newly emerging —developing- market economy, Turkey has not yet achieved stability in its energy utilization and gaseous emissions either as a ratio to its GDP or at a per capita level, and it is cited among the 25 countries that display fastest rate of growth in industrial use of energy sources. TURKSTAT data indicate, for instance, that on a per capita basis, consumption of electricity power in Turkey has increased by six-folds from 1980 to 2005. Per capita consumption of electricity is expected to increase from its current level of 300Kwh per person to 400 KwH per person by 2010. Aggregate CO2 emissions from fossil burning stand at 223.4 Gg as of 2004. TURKSTAT estimates that CO2 emissions will reach to 343 Gg by 2010 and to 615 Gg by 2020.
- Mainly because of these instabilities, Turkey's global standing in terms of its international abatement requirements is not yet clearly defined, as it is the only country which appears in the so-called *Annex-I* list of the Rio Summit of the United Nations and yet an official target for CO2 emission reductions has still not been established. Thus, as part of its accession negotiations with the EU, Turkey will likely to face significant pressures to introduce its national plan on climate change along with specific emission targets and the associated abatement policies.
- The current arsenal of Turkish environmental policy instruments is mostly limited to energy taxes, environmental impact assessments, and pollution penalties. Yet, it is a clearly recognized fact that these instruments will not suffice under a more active environmental policy design and will need to be expanded to include other forms of policy measures such as additional pollution taxes, emission trading and permits, and abatement investments towards reduced energy intensities. However, given the current lack of an adequate quantitative modeling paradigm for environmental policy analysis in Turkey, the effectiveness of such policy interventions and their economic impacts are not well-known. Hence, there is a strong need for the construction and utilization of analytical models for environmental policy analysis.
- The report attempts to fill this gap and aims to guide policy makers to respond with additional measures that may include a broad, market-based incentives designed to accelerate technology development and deployment in Turkey as part of its possible national objective towards reductions in aggregate COP2

emissions . To this end, a dynamic, multi-sectoral macroeconomic model for Turkey is constructed to study issues of environmental and macroeconomic policy interactions over both the commodity and the factor markets; the impact of various policies on the environment and on abatement; and to investigate various alternatives on environmental policy design along with their likely consequences from the points of view of growth, income distribution, social welfare and economic efficiency.

- The model projections reveal that under the business-as-usual base run, Turkish GDP is expected to grow by 5.9 percent per annum over 2006-2020. CO2 emissions are projected to increase from a total of 230 million tones in 2003 to 656 million tones by the end of 2020.
- The results suggest that the burden of imposition of direct carbon emission quotas would be quite high. This burden will necessitate a significant tax imposition on the producers to enforce the CO2 quotas. Imposition of the CO2 quota at 60% level to the base run, calls for a carbon tax of 20% to 15% over 2006 to 2020. The 60% carbon quota brings the expected 2020 level of CO2 emissions to their respective projected 2012 level. Yet, the GDP loss incurred under this scenario is above 30% as of 2020. The *cumulative* loss in GDP amounts to 3,145 billions 2003 YTL over the whole analyzed period (2006-2020).
- Such a tax burden will likely lead to tax evasion practices, encourage the underground (informal) economy and will lead to increased informalization of the production activities. The already high levels of producer tax incidences reduce the effectiveness of additional carbon taxation opportunities significantly.
- In contrast to the direct "CO2 quota-*cum*-carbon tax" policy, taxation of energy use in sectoral production seems to produce viable results. In returns to 20% energy tax for producers, aggregate CO2 emissions are reduced by 25.8% with a loss of GDP of 8.8% by the end of 2020. The energy taxation policy suffers strongly, however, from its very adverse employment effects. Unemployment rates rise significantly as a result of the introduced energy taxes. With limited substitution possibilities in input mix among labor and energy inputs, producers are bound to cut back labor employment as they are faced with increased energy costs.
- The taxation policies suggest very clearly that possible interventions of new environmental taxes would have adverse outcomes either on employment or on sectoral output levels directly. A *first-best* policy would necessarily call for a simultaneous reduction on the existing tax burden on producers elsewhere together with introduction of environmental taxes. A reduction of employment taxes can be envisaged along with the imposition of energy tax use. Such a policy would be conducive in attaining CO2 abatement targets together with employment incentives. Various studies in the literature do in fact show that using such tax revenues to finance reductions in the already existing (and mostly distortionary) taxes on employment, production, or sales can achieve superior outcomes with attaining environmental targets at lower cost –perhaps even at a positive net gain.
- Overall, however, a first best environmental policy has to call for further incentives towards reducing energy intensities in production through more efficient production methods. By itself this is no easy task and certainly comes at significant investment cost. CGE modeling results suggest that leaving the

burden of the abatement investments to production sectors alone creates significantly adverse results in terms of overall economic performance. According to our results, abatement investments that amount to 1.5% of GDP annually call for 23% tax rate on energy (primary and secondary) input usage.

- Further indirect taxes on the production sectors would likely trigger unfavorable dynamics in production and employment. Parallel to the reduction in output, one observes adverse outcomes on already high unemployment rates of the economy.
- The advantageous environment likely to be produced by foreign aid on abatement investments displays high economic growth attained together with reductions in CO2 emissions. An annual flow of foreign aid/credit of 1.5% as a ratio to the GDP designed to cover the costs of abatement investments for adoption of the "best available technologies" help reduce Turkish CO_2 emissions by 4.9% in 2020 and by a cumulative of 199.1 million tones over the whole analyzed period.

CONTENTS

INTRODUCTION

In this report our objective is to provide a general overview of the recent macroeconomic developments in Turkey with implications to environmental policy. Currently the Turkish economy can be said to be operating under conditions of a truly “open economy” –a macroeconomic environment where its commodity trade and capital accounts are completely liberalized, and the process of financial de-regulation is completed. In this setting, many of the instruments of macro and fiscal control have been transformed, and the constraints of macro equilibrium had undergone major structural change.[1] A characteristic shift of the macroeconomic balances was that the domestic economy has been trapped into mini-cycles of “growth-crisis-adjustment-growth” during the post-reform era. Furthermore the public sector has experienced increased deterioration of its fiscal balances with consequent rise of indebtedness. The economy also witnessed growing trade deficits despite falling investment ratios. As the rate of investment demand fell and public expenditures cut, unemployment levels rose. Finally the key macro economic prices have undergone through a structural shift with real rates of interest rising sharply and foreign exchange getting cheaper. All these meant a generally deflationary macroeconomic environment and deepening social problems.

As part of its attempts towards full membership to the European Union, Turkey is currently under significant pressure to recognize the conditionalities of the *Kyoto Protocol* to reduce its CO2 emissions and other gaseous pollutants over the next six years. Yet, as a newly emerging —developing- market economy, Turkey has not yet achieved stability in its energy utilization and gaseous emissions either as a ratio to its GDP or at a per capita level, and it is cited among the 25 countries that display fastest rate of growth in industrial use of energy sources. TURKSTAT data indicate, for instance, that on a per capita basis, consumption of electricity power in Turkey has increased by six-folds from 1980 to 2005. Per capita consumption of electricity is expected to increase from its current level of 300Kwh per person to 400 KwH per person by 2010. Aggregate CO2 emissions from fossil burning stand at 223.4 Gg as of 2004. TURKSTAT estimates that CO2 emissions will reach to 343 Gg by 2010 and to 615 Gg by 2020.

Mainly because of these instabilities, Turkey’s global standing in terms of its international abatement requirements is not yet clearly defined, as it is the only country which appears in the so-called *Annex-I* list of the Rio Summit of the United Nations and yet an official target for CO2 emission reductions has still not been established. Thus, as part of its accession negotiations with the EU, Turkey will likely to face significant pressures to introduce its national plan on climate change along with specific emission targets and the associated abatement policies.

The current arsenal of Turkish environmental policy instruments is mostly limited to energy taxes, environmental impact assessments, and pollution penalties. Yet, it is a clearly recognized fact that these instruments will not suffice under a more active environmental policy design and will need to be expanded to include other forms of policy measures such as additional pollution taxes, emission trading and permits, and abatement investments towards reduced energy intensities. However, given the current lack of an adequate quantitative modeling paradigm for environmental policy analysis in Turkey, the effectiveness of such policy interventions and their economic impacts are not well-known. Hence, there is a strong need for the construction and utilization of analytical models for environmental policy analysis.

This study attempts to fill this gap and aims to guide policy makers to respond with additional measures that may include a broad, market-based incentives designed to accelerate

[1] Boratav, Türel and Yeldan (1996) offer a thorough analysis of the adjustment patterns and shifts in the modes of economic stabilization under structural adjustment reforms of the 1980s.

technology development and deployment in Turkey as part of its possible national objective towards reductions in aggregate CO_2 emissions . Its main objective is a coherent attempt to enable Turkey to integrate sustainable development principles into national development planning and implementation of environmental policy objectives both at the macro economic and sectoral levels. To this end, we propose to utilize a dynamic, multi-sectoral macroeconomic model for Turkey and to study issues of environmental and macroeconomic policy interactions over both the commodity and the factor markets; the impact of various policies on the environment and on abatement; and to investigate various alternatives on environmental policy design along with their likely consequences from the points of view of growth, income distribution, social welfare and economic efficiency.

Our model is in the tradition of applied general equilibrium paradigm where the production - income generation – consumption – saving – and investment decisions of an economy are depicted within a market equilibrium setting. Optimizing economic agents are modeled as responding to various price signals as affected by the government's various tax/subsidy policies. The economy operates in an internationally open environment where the exchange rate and the foreign capital inflows interact with the exports and imports of the domestic sectors.

We organize the Report under seven sections. First, we provide a broad overview of the recent macroeconomic developments in Turkey. Here we study the evolution of the key macroeconomic prices such as the exchange rate, the interest rate and price inflation, and report on the post-1990 macroeconomic path of the Turkish economy. In section two we introduce and provide an analytical evaluation of the key environmental indicators and the energy intensity of the Turkish economy, in the medium/long run. Sections three and four report on the fiscal and the foreign balances of the Turkish economy, respectively. We report on the social indicators and anti-poverty measures in section five. We introduce our analytical model in section six and carry out our environmental policy analysis in section seven.

I: Turkish Economy 1990-present: Main Characteristics

I-1. Phases of Macroeconomic Adjustment: 1980-1998

The post-1980 Turkish adjustment path can be partitioned into two broad phases: "1981-1988" and "1989-1998". The main characteristic of the first phase is structural adjustment with export promotion, albeit under a regulated foreign exchange system and controls on capital inflows. Over this period, integration to the global markets was achieved mainly through commodity trade liberalization. More importantly, both the exchange rate and direct export subsidies acted as main instruments for the promotion of exports and pursuit of macroeconomic stability. The period was also characterized by suppression of wage costs. This policy, however, could not be sustainable and reached its economic and political limits by 1988. Coupled with a new wave of populist pressures under approaching elections, there had been significant increases in wages over 1989-92. Furthermore, beginning 1989, there had been a major shift in the public expenditure accounts towards more socially desirable ventures. An overall increase in both the share and level of public salaries, and investments on social infrastructure enabled the workers and middle classes to attain improved living standards. All these, however, came at a significant cost with consequent rise in public deficits and high rates of inflation.

In Table I-1 we depict the post-1980 developments of the Turkish economy in a nutshell. Here a series of sub-periods are identified, based on the growth performance and the overall macro balances of the Turkish economy.

Macroeconomic Phases of the Turkish Economy, 1980-2004

	Post-Crisis Adjustment	Export-Led Growth	Exhaustion	Unregulated Financial Liberalization					Financial Crisis	Reinvigoration to Short-Term Foreign Capital-Led Growth			Contagion of World Financial Crisis		Exchange Rate Based Disinflation and Financial Meltdown		IMF-led Post-Crisis Adjustment		
	1981-82	1983-87	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
I. Production and Accumulation (Real Rate of Growth, %)																			
GDP	4.2	6.5	2.1	1.2	7.9	1.1	5.9	8.0	-5.5	7.2	7.0	7.5	3.1	-5.0	7.4	-7.6	7.6	5.8	9.0
Fixed Investment																			
Private Sector	-1.0	14.1	29.2	-6.2	20.6	8.1	3.3	38.8	-9.6	16.9	12.5	10.1	-6.7	-18.8	14.1	-34.9	-7.2	20.3	41.5
Public Sector	4.8	12.0	-2.3	-8.2	6.7	12.7	2.2	14.1	-39.5	-18.7	24.4	30.1	8.0	1.0	20.8	-22.0	14.5	-6.6	3.1
As % of GDP:																			
Savings	17.7	19.5	27.2	22.1	22.0	21.4	21.6	22.7	23.1	22.1	19.8	21.3	22.7	21.2	18.2	17.4	19.0	19.3	22.1
Investments	18.3	20.9	26.1	22.5	22.6	23.7	23.4	26.3	24.5	24.0	25.0	26.3	24.3	22.1	22.8	19.0	17.4	17.6	19.2
Public Sector Borrowing	3.7	4.7	4.8	5.2	7.4	10.3	10.6	12.1	7.9	5.2	8.8	7.6	9.2	15.1	12.5	16.5	12.6	9.4	5.9
Stock of Domestic Debt		3.5	5.7	6.3	7.0	8.1	11.7	12.8	14.0	14.6	18.8	21.4	22.5	29.3	28.7	69.2	54.8	54.6	52.0
II. Distribution and Prices																			
Inflation Rate (CPI)	33.2	39.5	75.4	64.3	60.4	71.1	66.1	71.1	106.3	88.0	80.4	85.7	90.7	70.5	54.9	54.4	45.0	25.3	10.6
Annual Rate of Change in Exchange Rate (TL/$)	45.0	39.7	66.0	49.0	23.0	60.0	65.0	59.0	170.0	54.0	77.0	87.0	71.7	58.2	28.6	114.2	23.0	-0.6	-4.9
Real Interest Rate on GDIs [a]	..	..	-5.8	-2.7	-4.0	5.3	13.9	9.9	28.6	18.1	31.1	22.1	29.5	36.8	4.5	31.8	9.1	15.4	13.1
Real Wages Growth Rate:																			
Private Manufacturing [b]	0.4	-1.5	-5.7	16.1	22.2	20.2	-5.4	-0.1	-30.1	1.4	-1.4	2.1	0.8	4.9	2.1	-20.1	1.1	5.1	3.9
Public Manufacturing[b]	-0.4	-5.9	-7.8	47.5	18.8	37.1	5.8	-0.9	-18.1	-18.0	-3.2	12.5	4.6	22.5	17.2	-21.0	6.9	-1.1	2.9
III. Internationalization																			
As % Share of GNP:																			
Imports[c]	14.0	15.9	15.8	14.5	14.6	13.8	14.3	16.2	17.8	20.8	23.6	25.2	22.5	21.7	27.2	28.2	30.7	27.4	30.2
Exports [c]	8.5	10.8	12.8	10.7	8.5	8.9	9.2	8.4	13.8	12.6	17.8	17.1	13.2	14.2	13.7	21.7	19.2	21.5	22.2
Current Account [c]	-2.7	-1.9	1.8	0.9	-1.7	0.2	-0.6	-3.6	2.0	-1.4	-1.3	-1.4	1.0	-0.7	-4.8	2.4	-1.0	-3.4	-5.2
Foreign Debt[d]	27.1	37.8	44.8	38.8	32.5	33.6	35.2	37.7	63.2	53.1	55.5	57.3	55.4	69.5	64.4	93.9	76.2	58.5	53.7

Sources: SPO Main Economic Indicators; Undersecretariat of Foreign Trade and Treasury Main Economic Indicators;
SIS Manufacturing Industry Surveys.

a. Annual average of Compounded Interest Rate on Government Debt Instruments deflated by the WPI.
b. Real wages per hour, as reported by the TR Central Bank from the SIS sources.
c. Inclusive of Luggage Trade after 1996.
d. Debt stocks are denominated in TL by using the end-of-year CB sale prices of foreign exchange.

With the advent of elimination of controls on foreign capital transactions and the declaration of convertibility of the Turkish Lira in 1989, Turkey opened up its domestic asset markets to global financial competition. The immediate three year period after the 1989 reforms was marked with a virtual elimination of the "foreign exchange gap" which had crippled the Turkish macro balances for almost 4 decades. With the eruption of hot money inflows, Turkish commodity markets were all of a sudden flooded with cheap imports. Consequently the rise in the real wages was financed by such import flows.

Erratic movements in the current account, a rising trade deficit (from 3.5% of GNP in 1985-88 to 6% in 1990-93) and a drastic deterioration of fiscal balances showed the unsustainability of the post-1989 model. The prolonged instability reached its climax during the fourth quarter of 1993, when the currency appreciation and the consequent current account deficits rose to unprecedented levels. With the sudden drainage of short-term funds in the beginning of January 1994, production capacity contracted, followed by continued fall in industrial output throughout that year. Together with this contraction, the post-1994 crisis management gave rise to significant shifts in income distribution, and to an intensification of the ongoing processes of transfer of economic and political power to the newly expanding financial sectors.

As can be followed from Table I-1, growth was reinvigorated after 1995. Growth of real GDP averaged above 7% between 1995-1997. Yet, the contagion effects of the 1997 Asian crises as well as the 1998 Russian moratorium on its public debt reached the Turkish shore by 1998, and Turkey once again shifted to a crisis. A devastating earthquake in 1999 had also led to the postponement of stabilization efforts. Yet, in August 1998, conditions for macroeconomic adjustments were already laid out by a new round of *Staff Monitoring Program* signed with the IMF.

Turkey entered the millennium under a new austerity programme which was put into effect in December 1999. The International Monetary Fund (IMF) was involved with both the design and supervision of the programme, and has provided financial assistance totaling $20.6 billion *net*, between 1999 and 2002.

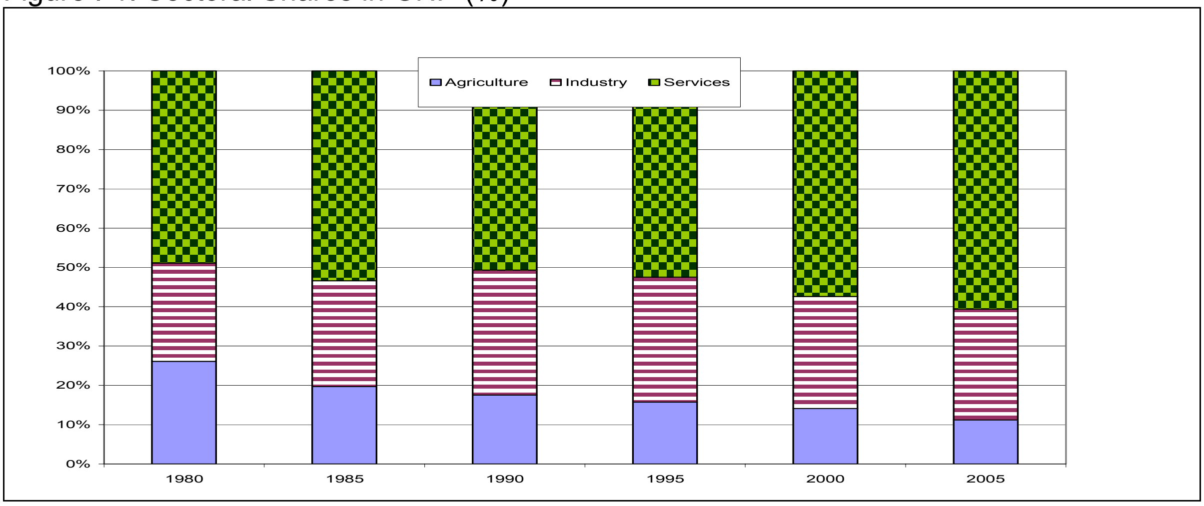
The aim of the Staff Monitoring Programme of 1998 and the consequent December 1999 stand-by was to decrease the inflation rate to a single digit by the end of 2002. The December 1999 Stand-by relied exclusively on a nominally pegged (anchored) exchange rate system for disinflation, which has been a major concern for Turkish policy makers for over three decades. However, on February 19, 2001, shortly after this arrangement with the IMF, Turkey suffered from a full-fledged financial crisis and the Central Bank declared the surrender of the pegged exchange rate system on February 22, 2001, thereby letting the exchange rates to free float.

The growth path of the Turkish economy over the post-2001 period had been erratic and volatile, mostly subject to the flows of hot money. In 2003 the economy has grown by 5.8% in real terms. Price movements were also brought under control through the year and the 12-month average inflation rate in consumer prices has receded from 29.7% in 2002 to 9.3% in 2004, and from 50.1% to 11.1% in wholesale prices. 2003-2005 has also meant a period of acceleration of exports, and export revenues have reached $62 billions over 2004. Nevertheless, with the rapid rise of the import bill over the same period, the deficit in the current account reached $25.8 billion (or about 6.4% of GDP in 2005).

I-2. Transformation of the Economy from Rural to Urban/Services

Turkish economy was mostly an agrarian economy by mid-1970s. The 1980 transformation led the country to reduce the share of agricultural activities. As portrayed in Figure I-1, the share of the agricultural economy declined from 26% of the GNP in 1980, to less than 12% by 2005. The share of industry (including construction and mining activities) rose during the mid-1990s. However, “financial liberalization” of the 1990s led to a more rapid increase of the services sectors (trade, commerce and banking). As of 2005, the relevant share of the services reached to about 60% of the gross national product, while industry maintains a share of around 28%.

Figure I-1. Sectoral Shares in GNP (%)



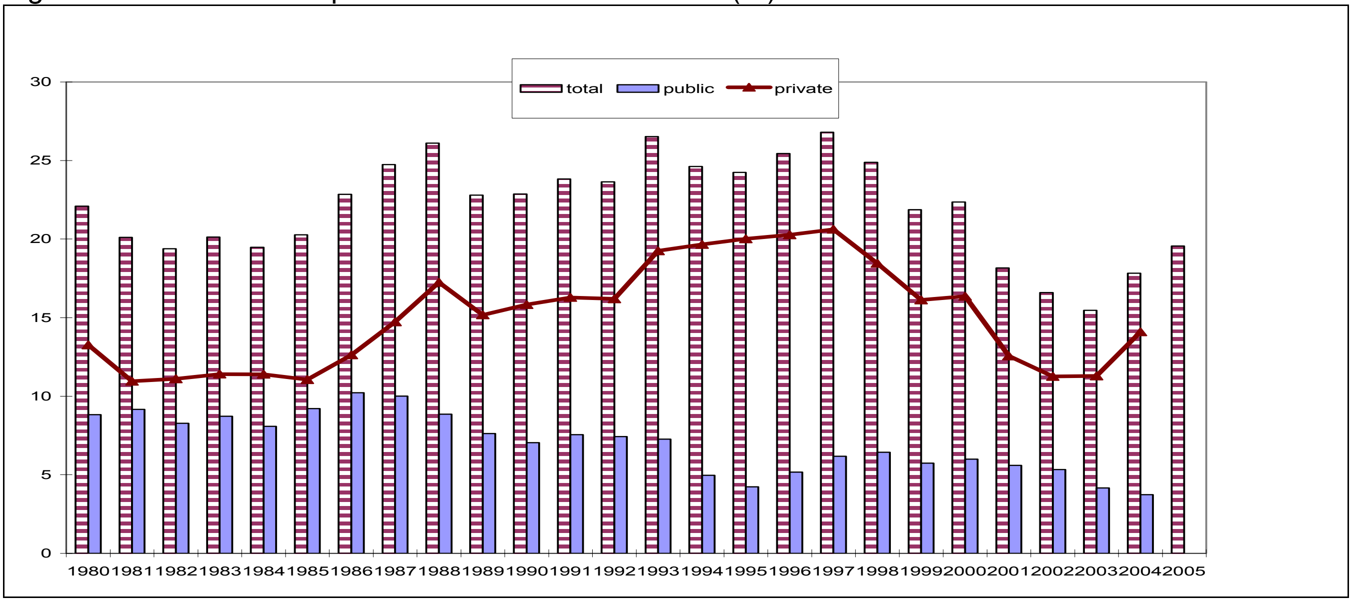
The rapid fall of the rural economy, and the relatively laggard expansion of the industrial sectors, no doubt, put significant strains on the overall production and consumption patterns.

Turkey is caught in the middle of a significant transition from traditional agriculture towards modern industry and services, with industry failing to provide sufficient impetus to the rest of the economy to absorb the rural labor surplus.

I-3. Patterns of Fixed Investments

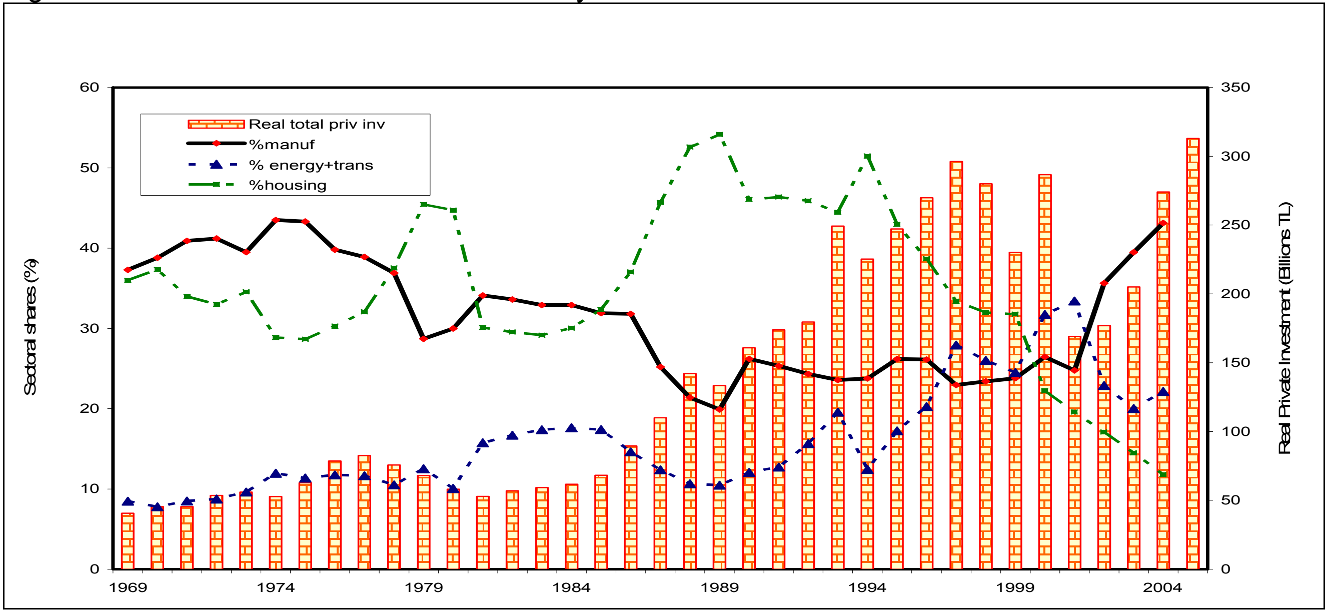
The patterns of investments of the post-1980 liberalization era also display significant shifts. Total investment expenditures as a share of GNP used to be on the order of 25% in the first half of the 1980's. The public sectors share was about half of the total. (see Figure I-2 below). With the advent of financial liberalization, there had been a significant rise of the total investment expenditures. Share of total investments, led by private sector, has increased its share in the GDP to above 25%. The 1998 contraction and the 2001 crisis led to a significant downfall, however, of the private investment demand.

Figure I-2. Investment Expenditures as a Share of GNP (%)



Also critically important is the rise of the housing investments during the 1990s. As displayed in Figure I-3 below, the early 1990s had witnessed a period of increased investments on housing and construction. The real private investments contracted significantly after 1997. This contraction is just about to be reversed as of 2005.

Figure I-3. Real Private Fixed Investments by Sectors



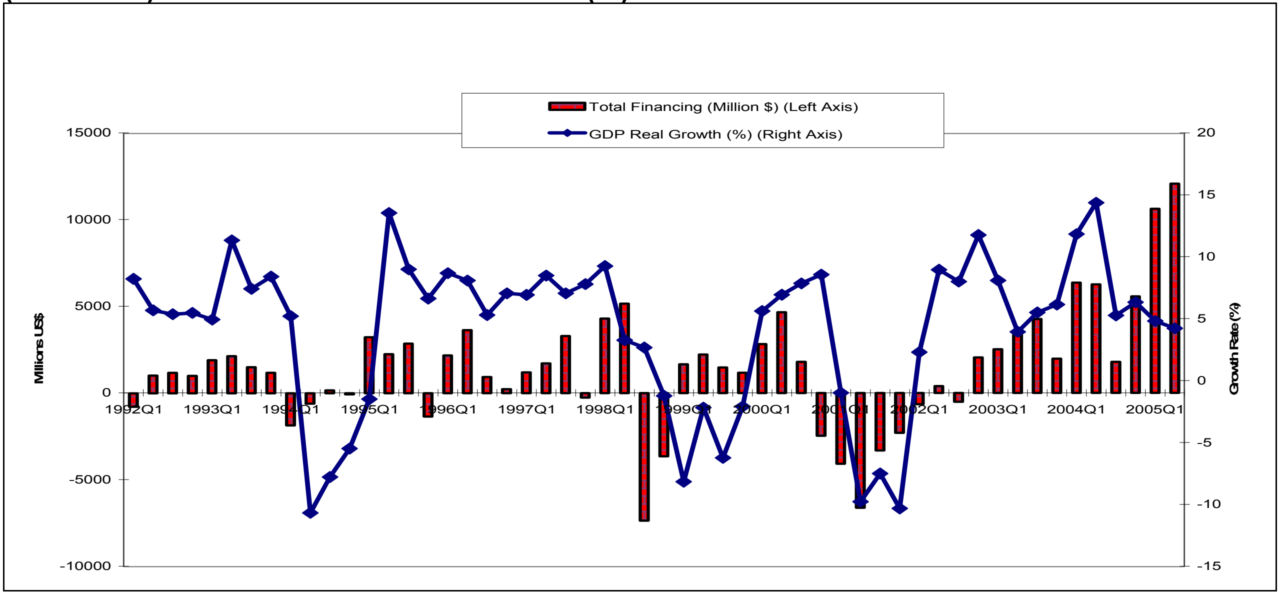
The share of manufacturing investments started to increase especially after 2002 and reached its highest magnitude by 2005. So it seems that the heavy pace of foreign capital inflows (see discussion below) generated strong incentives for increased manufacturing investments by the private sector. Likewise the real level aggregate private investments reached its highest magnitude in real prices.

I-4. Volatility of Economic Performance and Dependence on Foreign Capital Flows

Turkish gross domestic product has reached to $340 billion by the end of 2005. Growth, while rapid, was not free from problems. In fact, the two key characteristics of the recent upswing in economic activity were that (i) it was mostly fueled by inflows of hot money, hence was *speculative-led*; (ii) it was accompanied by high rates of unemployment; hence was of the *jobless-growth* type.

In Figure I-4 we depict the dependence of growth on the financial capital flows. On the left-hand side of Figure I-4, we numerate the financial capital inflows in quarterly periods. The financial capital flows are expressed as the sum of the finance account and the net errors and omissions terms of the balance of payments statistics. On the right-hand side we have the growth rate of the GDP. The Figure discloses the dependence of the growth rate cycles to the in- and out-flows of financial capital very clearly. At times of heavy inflows of foreign finance capital, as in third quarter of 2000 and second and third quarters of 2004, GDP growth was rapid. Declines in the growth rate are directly related to the outflows of foreign finance capital as in 2001.

Figure I-4. Balance of Payments Finance Account + Net Errors and Omissions (Millions $) and Real Growth Rate of GDP (%)



Source: TR Central Bank, www.tcmb.gov.tr

I-5. Persistent Unemployment

A second key characteristic of the post-2001 Turkish growth is its jobless nature. *Open* unemployment rate was 5.6% in 2000. In 2001, the official rate of open unemployment rose to 8%, and accelerated to reach 10.3% in 2003, and finally to 11.2% by the end of 2005. (See Table I-2). More alarmingly, the rate of unemployment among the educated urban young labor force is reported to reach to 31.1% by the end of 2005. This ratio was 28.7% in 2001.

Table I-2. Developments in Turkish Labor Market (1,000 persons)

	2002	2003	2004	2005
15+ Age Population	48,041	48,912	50,189	51,202
Labor force participation rate (%)	49.6	48.3	48.4	47
Civilian Labor Force	23,818	23,640	24,297	24,034
Civilian Employment	21,354	21,147	21,870	21,332
Unemployed	2,464	2,493	2,428	2,702
Unemployment Ratio (%)	10.3	10.5	10.0	11.2
Underemployed	1,297	1,143	764	841
Underemployment Ratio (%)	5.4	4.8	3.1	3.5

Source: TURKSTAT, Household Labor Force Surveys

The civilian labor force (ages 15+) is observed to reach 51.2 millions people as of 2005. On the other hand, the participation rate fluctuates around 46% to 50%, due mostly to the seasonal effects. It is known, in general that, the participation rate is less than the EU averages. This low rate is principally due to the size of the discouraged workers who had lost their hopes for finding jobs. If we add the TURKSTAT data on the *underemployed* people, the excess labor supply (unemployed + underemployed) is observed to reach 14.7% of the labor force.

Thus, despite the very rapid growth performance across industry and services, employment growth has been minimal so far. This observation, which actually is attributed to many developing economies as well,[2] is characterized by the phrase *jobless-growth* in the economics literature. In Turkey this problem manifests itself in meager employment generation despite the very rapid growth conjuncture especially after 2002.

II. Key Environmental Indicators

In this report we will focus mostly on CO2 emissions as the key indicator of environmental pollution. Turkey displays a mid-score in its emission coefficients in comparison to the world and the OECD averages. By 2002, with a per capita CO2 emissions of 2.8 tons per person, Turkey lies significantly below the OECD average of 11.o tons per person and ranks below the world average of 3.9 tons per person. In 1990 these ratios were, 2.3 tons for Turkey, 10.6 tons for the OECD and 4.0 tons for the world, respectively (See Table II-1).

Table II-1. Main Indicators on CO2 Emissions

	1990			2002		
	World	OECD	Turkey	World	OECD	Turkey
CO2 (Million Tons)	20,662	11,012	129	24,102	12,554	193
CO2 Emissions from Energy Supply	2.37	2.44	2.43	2.32	2.35	2.60
CO2 per capita (tons)	4.0	10.6	2.3	3.9	11.0	2.8
CO2 / GDP (kg / $-1995)	0.78	0.51	0.89	0.68	0.44	0.94

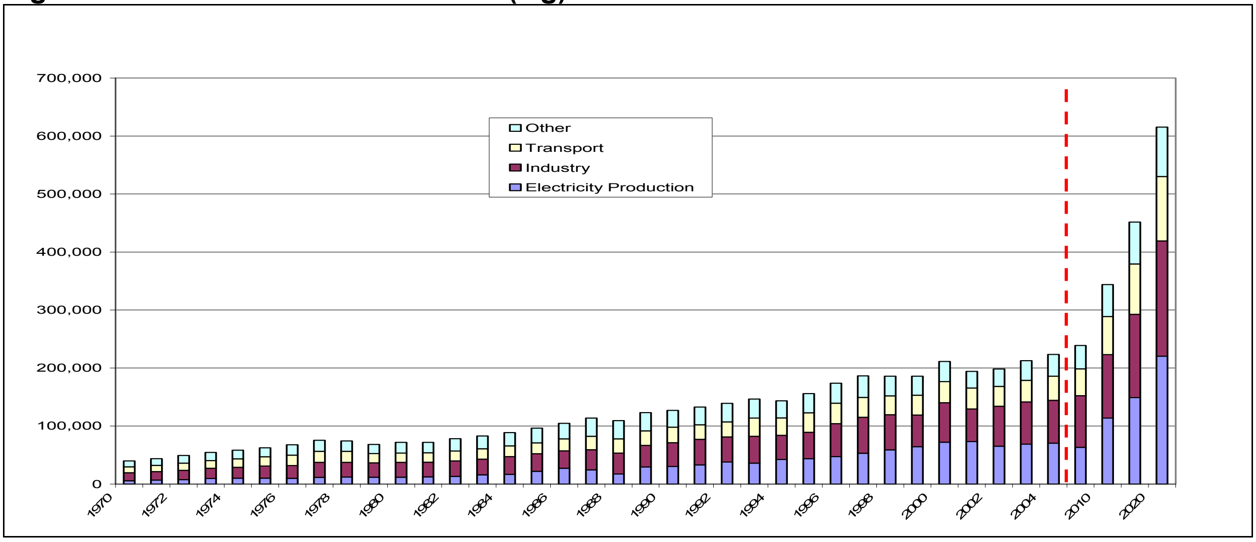
Source: TSA and Ministry of Environment and Forestry.

Turkish emissions are less robust when the comparison is done with respect to per $ GDP. In 2002 Turkish CO2 emissions per $ GDP (measured in fixed 1995 prices) was 0.94 kg. The same ratio was 0.44 for the OECD and the world average was 0.68. As compared to the 1990 values, both the world and the OECD averages on CO2 emissions per $ GDP were observed to fall, and for Turkey there had been a slight increase from 0.89 to 0.94.

In Figure II-1, we provide a sectoral breakdown of the aggregate CO2 emissions.

[2] See, e.g., UNCTAD, *Trade And Development Repor*t, 2002 and 2003).

Figure II-1. Sectoral CO2 Emissions (Gg)



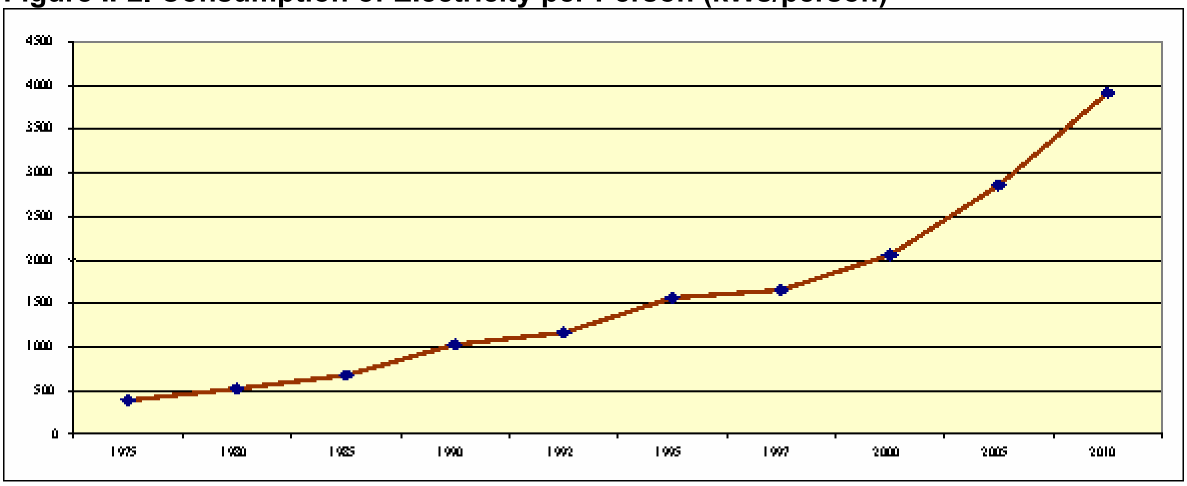
Source: TURKSTAT and MoEF.

The TURKSTAT data indicate that aggregate CO2 emissions from fossil burning stand at 223.4 Gg as of 2004. TURKSTAT estimates that aggregate CO2 emissions will reach to 343 Gg by 2010 and to 615 Gg by 2020.

According to the TURKSTAT data the significant share of CO2 emissions originate from electricity production. By 2020, the share of electricity production in CO2 emissions is expected to reach around a third of the total.

Turkey is clearly in a transition phase with respect to its increased demand to electricity and primary energy sources. On a per capita basis, consumption of electricity power is observed to increase by 6-folds from 1980 to 2005. Per capita consumption of electricity is estimated to be 300Kwh per person, and is expected to increase to 400 KwH per person by 2010. (See Figure II-2).

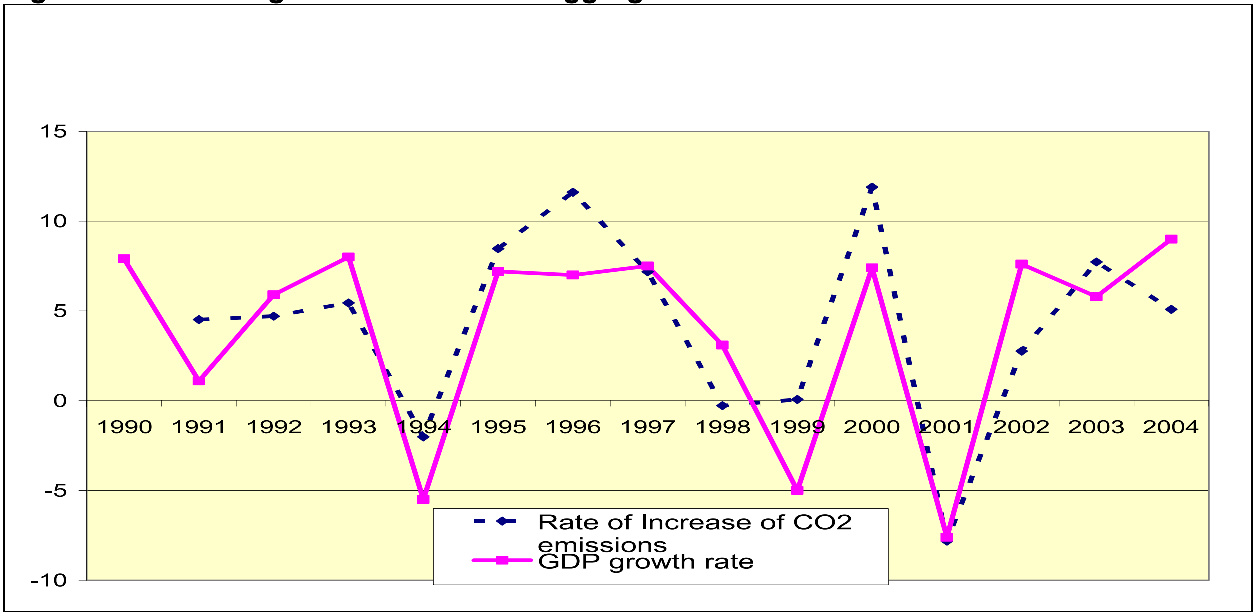
Figure II-2. Consumption of Electricity per Person (kWs/person)



Source: TURKSTAT and MoEF

The implication of this fact is that *Turkey has not reached to a stable level with respect to its energy demand per capita*. This observation maintains the main difficulty in making assessments about the future likely path of the CO2 emissions from industrial processes as well as from residential consumption, and makes it difficult to provide clear environmental policy measures. The observed volatility of the gross domestic product over the last two decades is also another witness to this fact. In Figure II-3 below we portray the path of the growth rates of GDP and contrast wit the rate of growth of CO2 emissions over 1990-2004.

Figure II-3. Rate of growth of GDP and Aggregate CO2 Emissions



Source: TURKSTAT

The volatility of both the growth rates is evident from the Figure. The high correlation between the rates of growth of GDP and aggregate CO2 emissions reveal that there is a strong *complementarity* between production activities and emissions. The limited substitution possibilities for energy use and the unstable character of the production activities make it quite hard to offer viable guidelines on the available menu of abatement policies.

II-1. Energy Intensities

With increased production capacity and increased consumption demand, Turkish energy intensities are projected to rise. Overall, the general equilibrium system of energy use and supply indicators shows that Turkey is dependent on import sources very heavily. The 2004 general energy equilibrium data reveal that total energy supply is 87.5 million tons of oil equivalent (mtons OE). Roughly 77% of this supply (67.5 mtons OE) is met by imports, and the rest (24.4 mtons OE) is domestically produced.

Crude oil imports cover32.9 mtons OE of the total supply, with natural gas imports reaching to 19.8 mtons OE. Domestic production of total coal supply is 16.1 mtons OE, and this is complemented with imports of coal of 12.2 mtons OE.

The 2004 energy general equilibrium balances also indicate that total final energy consumption was 67.8 mtons OE. About a third (27.8 mtons OE) of this magnitude is claimed by industrial consumption. Here the iron and steel (3.3 mtons OE) and cement (3.6 mtons OE) industries stand out in energy consumption.

Transportation sector claims13.8 mtons OE, and other sectors (mostly residential services and agriculture) takes up 24.0 mtons OE.

The rise in energy intensities is very clearly exposed in the country's rapid reliance on electricity generation. In Table II-2 below we document the gross generation and consumption levels of Turkish electricity sector balances. Gross electricity generation is observed to almost double from 86,247 GWh in 1995 to 149,982 GWh in 2004. This rapid expansion gives an annual average rate of growth of 7.2% over the mentioned period. Data suggest network losses of 17% on the average annually. This leaves the country with net consumption of 111,766 Gwh in 2003 and 118,050 GWh in 2004. The rate of growth of net consumption of electricity had been 6.8% annually between 1995 and 2004.

Imports and exports of electricity had been marginal given the domestic production and consumption magnitudes thus far. However, the rapid expansion in the demand for electricity in the coming years and the likely volatility associated with the production conditions make the country vulnerable to future demand and supply shocks.

Table II-2. 2004 General Energy Equilibrium (One Thousand Tones of Oil Equivalent)

Date:21/09/2004																	
Source: ETKB/APKK/PFD																	
				Secondary				Total				Geotherm.			Geotherm.		
	Hard Coal	Lignite	Asfaltit	Coal	P.Coke	Wood	Biomass	Coal	Oil	Natural Gas	Hydraulic	Electiricty	Wind	Electiricity	Heat	Solar	Total
Domestic Production(+)	1040	9276	310			4318	1214	16158	2389	644	3963	80	5		811	375	24425
Import(+)	10506	0		273	1474			12253	35334	19835				40			67463
Export (-)		0						0	3923					97			4020
Bunker Sales (-)									631								631
Change in Stocks (+/-)	343	315	0	-33	-37			588	-391	-54							142
Statistical Discrepancy (+/-)									143								143
Primary Energy Supply	11889	9591	310	240	1437	4318	1214	28998	32922	20426	3963	80	5	-57	811	375	87523
Non-refined Production (+)									0								0
Total Energy Supply	11889	9591	310	240	1437	4318	1214	28998	32922	20426	3963	80	5	-57	811	375	87523
Generation and Energy Sector	-5367	-6149	0	2172			0	-9344	-5034	-11533	-3963	-80	-5	10274	0	0	-19685
Power Plants	-2135	-6078					0	-8213	-1822	-11526	-3963	-80	-5	12960			-12649
Coking Coal Firms	-3203			2093				-1110									-1110
Briquette		-42		80				38	-43								-6
Oil Refinery									-1870					-93			-1963
Domestic Consumption and Loss	-29	-29	0	0				-58	-1298	-7				-2593			-3957
Total Final Energy Consumption	6522	3441	310	2412	1437	4318	1214	19655	27888	8893	0	0	0	10217	811	375	67839
Sector Aggregates	6522	3441	310	2412	1437	4318	1214	19655	27888	8893				10217	811	375	67839
Industrial Consumption	5903	1822	310	2280	1437			11753	6149	4900				4904		121	27828
Iron and Steel				2181				2181	344	5				756			3285
Chemical- Petrochemical	61	10		0				71	758	326				183			1338
Petrochemical Feedstock									1446								1446
Fertilizer		3						3	835	472				44			1355
Cement	1216	542		0	1395			3154	50	65				334			3602
Sugar	38	227		30				294	229	115				0			638
Non-farreous metal	63	18		11	0			92	265	462				219			1039
Other Industry	4524	1022	310	60	42			5958	2222	3456				3369		121	15126
Transportation	0	0						0	13708	4				83		0	13795
Railway transportation	0	0						0	183	0				83			266
Sea transportation									389								389
Air transportation									1626								1626
Land Transportation									11510	4							11514
Other Sectors	619	1619	0	132	0	4318	1214	7902	5856	3988				5230	811	254	24041
Residence and Services	619	1619	0	132	0	4318	1214	7902	2878	3988				4889	811	254	20722
Agriculture									2979					341			3320
Non-energy									2174								2174
Electrical Energy Production(GWh)	11998	22450	0				104	34552	7670	62242	46084	93	58	150698			
Installed Capacity (MW)	1845	6451	0				28	8323	3215	12606	12645	15	19	36824			
		Population			Per capita energy			Per capita electirict		Net:	1681			GNP Growth Rate			9.9
		(Million people)		71.332	Consumption kep/k.		1227	Consumption kwh/		Gross:	2103			GDP Growth Rate			9.0

Table II-3. Turkish Electrical Energy Generation - Consumption and Losses

Years	Gross Generation	Increase %	Domestic Demand	Share %	Net Generation	Import	Supplied to Network (1)	Network Loss	Export (2)	Net Consumption	ncrease %
1995	86247.4	10.1	4388.8	5.1	81858.6	0.0	81858.6	13768.8	695.9	67393.9	9.8
1996	94861.7	10.0	4777.3	5.0	90084.4	270.1	90354.5	15854.8	343.1	74156.6	10.0
1997	103295.8	8.9	5050.2	4.9	98245.6	2492.3	100737.9	18581.9	271.0	81885.0	10.4
1998	111022.4	7.5	5523.2	5.0	105499.2	3298.0	5108797.7	20794.9	298.2	87704.6	7.1
1999	116439.9	4.9	5738.0	4.9	110701.9	2330.0	113032.2	21545.0	285.3	91201.9	4.0
2000	124921.6	7.3	6224.0	5.0	118697.6	3791.3	122488.9	23755.9	437.3	98295.7	7.8
2001	122724.7	-1.8	6472.6	5.3	116252.1	4579.0	120831.5	23328.7	432.8	97070.0	-1.2
2002	129399.5	5.4	5672.7	4.4	123726.8	3588.0	127315.0	23931.9	435.1	102948.0	6.1
2003	140580.5	8.6	5332.2	3.8	135248.3	1158.0	136406.3	24052.7	587.6	111766.0	8.6
2004	149982.1	6.7	5750.0	3.8	144232.1	462.0	144694.9	25540.1	1104.8	118050.0	5.6

(1) Supplied to Network = Net Generation + Import
(2) Network loss related with importing is also included
Source: TSA, Turkish Electricity Distribution and Consumption Statistics 1994-200

In Table II-3 we further document the electricity supply and demand forecasts by the Ministry of Energy and Natural Resources (MENR). The forecasts reveal that Turkish electricity demand will reach to 260,400 GWh by 2013. A total supply capacity of 295,722 GWh is forecasted until that date. Estimates show that of this total, 77% is to be supplied from *thermal* sources, with the rest to be supplied from hydraulic sources.

Also documented in Table II-3 is the dramatic fall in the back-up rates from 33.6% in 2007 to 13.6% in 2013. This fall may indicate increased pressures towards importation and/or increased need for upscaling generation possibilities.

Table II-4. Average Electricity Supply and Demand Table (GWh)

Generation Capacity/Years	2005	2007	2010	2013
Thermal	118931	183356	191387	228086
Hydraulic	42043	57420	59882	67636
Total	160974	240776	251269	295722
Imports	518			
Exports	1950			
Supply Capacity	159542	240776	251296	295722
Generation /Demand	159542	180250	216750	260400
Backup		60526	34519	345322
Backup%		33.6	15.9	13.6

Source: MENR, www.enerji.gov.tr

In Table II-5 we further our documentation with a direct focus on primary energy resources. In Table II-5 we give data on production of primary energy resources, while Table II-6 lays out the breakdown of final energy consumption. The balances on import and export on energy use is supplied in Table II-7.

Table II-5. Primary Energy Resources Production

		1990	1995	2000	2001	2002	2003	2004
Hard Coal	Thousand Ton	2745	2248	2259	2357	2245	2059	1946
Lignite	Thousand Ton	44407	52758	60854	59572	51660	46168	43709
Asphaltit	Thousand Ton	276	67	22	31	5	336	722
Oil	Thousand Ton	3717	3516	2749	2551	2420	2375	2276
Natural Gas	(Million m3)	212	182	639	312	378	561	708
Hydraulic	GWh	23148	35541	30879	24010	33684	35330	46084
Geotherm. Elect.	GWh	80	86	76	90	105	89	93
Geotherm. Heat	Thousand Toe	364	437	648	687	730	784	811
Wind	GWh			33	62	48	61	58
Solar	Thousand Toe	28	143	262	287	318	350	375
Wood	Thousand Ton	17870	18374	16938	16263	15614	14991	14393
Biomass	Thousand Ton	8030	6765	5981	5790	5609	5439	5278
TOTAL	Thousand Toe	**25478**	**26719**	**26855**	**25173**	**24727**	**23978**	**24397**
Rise	%		1.0	0.1	-6.3	-1.8	-3.0	1.7

Source: MENR, www.enerji.gov.tr

Table II-6. Breakdown of Final Energy Consumption

		1990	1995	2000	2001	2002	2003	2004
Hard Coal	Thousand Ton	2747	3040	9165	5267	8193	9747	9965
Lignite	Thousand Ton	15739	12420	11904	8104	9980	10461	10808
Asphaltit	Thousand Ton	285	66	18	30	5	336	722
Oil	Thousand Ton	19380	24193	25544	24341	24391	24632	26098
Natural Gas	(Milllion m3)	862	3335	5592	5807	6876	8345	9112
Electricity	GWh	45670	65724	96140	95445	101298	110748	120305
Geotherm. Heat	Thousand Toe	364	437	648	687	730	784	7962
Solar	Thousand Toe	28	143	262	287	318	350	375
Wood	Thousand Ton	17870	18374	16938	16263	15614	14991	14393
Biomass	Thousand Ton	8030	6765	5881	5790	5609	5439	5378
Secondary Coal	Thousand Ton	3644	4158	5111	4538	4910	5184	5357
Final Energy Consumption	Thousand Toe	**41611**	**49976**	**60490**	**55083**	**59092**	**62865**	**68501**
Rise	%		**3.7**	**3.9**	**-8.9**	**7.3**	**6.4**	**9.0**

Source: MENR, www.enerji.gov.tr

Table II-7. Energy Demand -Generation- Imports&Exports (Thousand Toe)

	1990	1995	2000	2001	2002	2003	2004
Demand	**52987**	**63679**	**81251**	**75952**	**78711**	**83970**	**87819**
Generation	**25478**	**26719**	**26855**	**25173**	**24727**	**23978**	**24397**
Imports	30936	39779	56280	52702	58553	65192	67817
Exports	2104	1947	1584	2620	3162	4090	4022
Bunker Sales	355	464	467	624	1233	644	631
Net Imports	**28477**	**37368**	**54229**	**49458**	**54158**	**60458**	**63164**
Change (%)		**5.6**	**7.7**	**-8.8**	**9.5**	**11.6**	**4.5**
Domestic (%)	**48.1**	**42.0**	**33.1**	**33.1**	**31.4**	**28.6**	**27.8**

Source: MENR, www.enerji.gov.tr

The sectoral breakdown of energy consumption and primary resource production indicates the growing national imbalances. Primary energy resource production levels had been stable at 25,478 thousand TOE in 1990 and 24,397 thousand TOE in 2004. Although there had been a rise in energy production from hydraulic sources from 23,148 GWh to 46,084 GWh over the same period, the fall in wood, biomass and lignite and hard coal had been responsible for the overall deceleration of production.

Final energy consumption had been increasing, on the other hand, at a rate of about 3.9% in 1995 and 2000; and after the contraction by 8.9% during the 2001 crisis, had again rose by rates of 7.3% in 2002, 6.4% in 2003, and 9.0% in 2004. Final energy consumption has risen from 41,611 thousand TOE in 1990, to 68,501 thousand TOE in 2004. As a result domestic share of total energy demand has continuously fallen over this period from 48.1% in 1990 to 27.8% in 2004. The reliance on imported energy resources is a critical possible bottleneck for the Turkish economy, given the foreign exchange fluctuations that the country is facing.

In Tables II-8 and II-9, the forecasts on demand and supply of energy resources are documented. It is estimated that Turkey will switch to hard coal and lignite as major sources of energy supply. By 2013 hard coal supply is expected to increase by 30% over its 2005 level; and lignite production is expected to increase by 88% over the same period. There is also an optimistic expectation of very sizable increase in electricity generation from wind energy sources. By 2013 wind generated electricity is expected to rise to 5,938 thousand TOE, from its marginal level of 56 thousand TOE currently.

All these reveal a sustained domestic deficit, given the expectations of a very significant rise in final energy demand in the next decade. The Ministry of Energy and Natural Resources (MENR) estimates indicate that total energy demand in Turkey will reach to 135,302 thousand TOE and per capita energy will rise from 1,276 kgpe in 2005, to 1,663 kgpe in 2013. These broad shifts underscore that Turkey has not yet stabilized its energy demand, and pressures of a newly industrialized economy continues to be felt.

Table II-8. Breakdown of Energy Supply by Resources

		2005	2007	2010	2013
Hard Coal	Thousand Ton	23116	18043	23008	30815
Lignite	Thousand Ton	60941	73357	102197	113978
Asphaltit	Thousand Ton	700	700	700	700
Oil	Thousand Ton	33595	33066	37859	42489
Natural Gas	Million m3	24714	31179	38710	42489
Hyraulic	GWh	41889	53195	54608	61314
Geotherm. Elec.	GWh	122	384	384	384
Geotherm. Heating	Thousand Toe	976	1208	1650	2239
Wind	GWh	56	3841	4890	5938
Solar	Thousand Toe	409	441	495	558
Wood	Thousand Ton	13819	12739	11275	10648
Biomass	Thousand Ton	5127	4849	4493	4194
Net Elect. Imports	GWh	**-1432**			

Source: MENR, www.enerji.gov.tr

Table II-9. Sectoral Breakdown of Energy Demand

	2005	2007	2010	2013
Industry	31072	32345	36479	42800
Residances and Services	21649	23300	28994	33564
Transport	14298	16550	19915	23700
Agriculture	3476	3810	4370	4988
Non-energy	2201	2368	2556	2749
Final Energy Demand	72696	78373	92314	107801
Generation Sector	20606	19628	23987	27501
Total Energy Demand	93302	98001	116300	135302
Per Capita kgpe	1276	1303	1482	1663

Source: MENR, www.enerji.gov.tr

The MENR also estimates investment needs for meeting the increased pace of industrialization and needs of new consumption. Accordingly, Turkey will need to invest a total of US$233,339 million over 2005-2020. US$5,109 million of this sum is expected to be spent over coal exploration and production; and US$104,765 million (about 43%) is expected to be spent on electricity generation. (See Table II-10).

Table II-10. 2005-2020 Period Investment Needs (Million Dollar)

Coal- (Exploration-Production)	5109
Oil (Additional reserves abroad&investments)	16000
Natural Gas	2700
Electricity	104765
DSİ	6093
EÜAŞ	458
New Power Plants	91276
Transmission Lines	938
Distribution	6000
TOTAL	**233339**

Source: MENR, www.enerji.gov.tr

The sizable magnitude of these investment expenditures need to be contrasted with the economy's saving-investment balances. In particular the fiscal balances are of importance.

III. Fiscal Balances and Debt Management

Currently Turkey is in the midst of an IMF-led austerity programme that relies primarily on fiscal restraint. The fiscal authority has a clear mandate to generate a primary budget surplus (not counting the interest expenditures) of 6.5 percent for the public sector as a whole[3] as a ratio to the gross national product (GNP). Spanning over a planning horizon 2001 to 2007, the primary surplus target is regarded necessary by the fiscal authorities to reduce the massive debt burden and the fragilities it imposes on the financial and the real commodity markets. Needless to assert, the current fiscal policy administration has important implications on both the macroeconomic environment and the microeconomic mechanisms of resource allocation, employment, and tax incidence.

III-1. Budgetary Equilibrium: Fragilities and Perspectives

We tabulate the selected components of the consolidated budget in Table III-1.

On the revenue side one witnesses a significant effort in raising tax revenues, both in real terms and also as a ratio to the GNP. Much of this effort can be explained by the rise in the share of taxes on goods and services, while the contribution of direct income taxes to the budgetary revenues are observed to fall especially after 2000. We observe that as a ratio to GNP, taxes on goods and services and on foreign trade yield about 70% of total tax revenues. Taxes on foreign trade are around 3.5% of total GNP.

Data reveal a secular rise in the budget deficit through the 1990s. The peak is reached in the aftermath of the 2001 crisis with a ratio of 16.9% to the aggregate GNP. Under the post-crisis administration the deficit is now reduced to 11.2% of the GNP. As discussed above, much of the increase in aggregate budget expenditures is explained by the increased costs of debt servicing. Interest costs on consolidated budget debt were openly 20% of total expenditures in early 1990s. Their share rose continuously to reach 50.6% of total budgetary expenditures in 2001.

[3] The primary surplus target is set at 5 percent for the central consolidated budget.

Table III-1. Selected Indicators on the Consolidated Budget (In Fixed 1987 Prices, Thousands TRY)

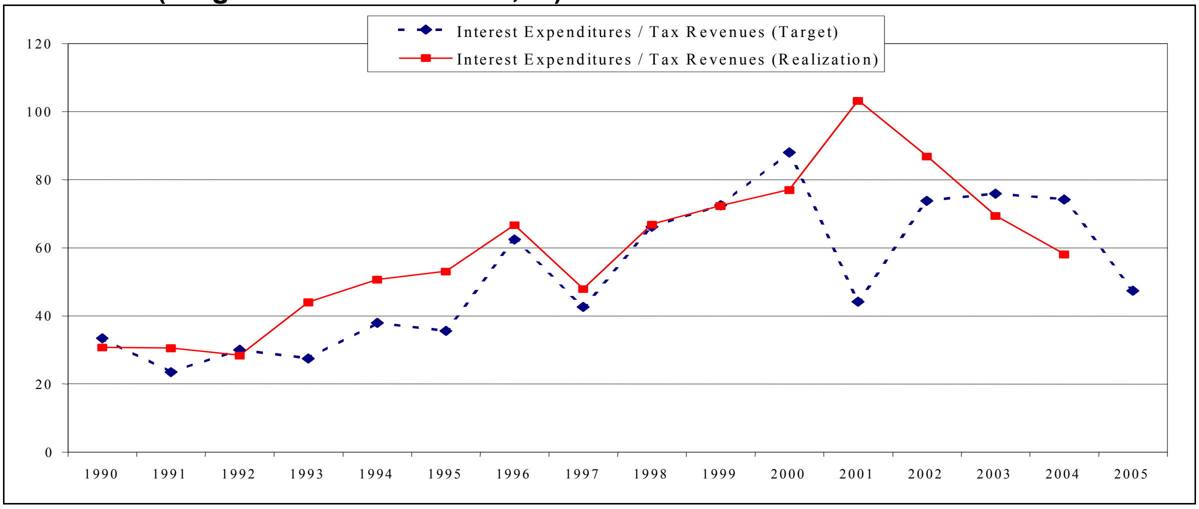
	1988	1995	2000	2001	2002	2003
Total Budget Revenues	**12,576.6**	**24,757.7**	**42,193.3**	**50,912.3**	**39,163.9**	**38,831.8**
Total Tax Revenues	10,518.7	19,257.6	33,638.0	39,408.9	30,920.5	32,670.7
Total Non-Tax Revenues	907.8	1,528.2	4,424.9	7,357.3	5,638.4	3,967.8
Total Expenditures	**15,525.8**	**30,382.9**	**59,613.9**	**80,507.1**	**60,784.5**	**54,256.3**
Current Expenditures	5,815.4	11,440.8	17,247.9	20,232.1	15,852.3	14,883.2
Personnel Exp.	4,048.0	8,926.7	12,664.9	15,086.7	11,972.4	11,699.6
Investment Expenditures	2,008.4	1,630.1	3,512.3	4,758.7	4,373.2	2,775.7
Interest Expenditures	3,679.1	10,232.4	25,941.9	40,724.3	26,896.3	22,704.9
On Domestic Debt	2,335.0	8,445.7	23,850.3	37,185.7	24,270.7	20,423.1
On Foreign Debt	1,344.1	1,786.7	2,091.6	3,538.6	2,625.6	2,281.9
Transfers to SEEs	749.1	807.1	1,124.4	1,098.0	1,125.2	728.7
Transfers to Soc Sec Institutions	553.6	1,921.7	4,094.0	5,069.9	5,810.1	6,168.1
Budget Balance	**-2,949.2**	**-5,625.2**	**-17,420.7**	**-29,594.8**	**-21,620.6**	**-15,424.5**
Share in Total Expenditures (%):						
Current Expenditures	37.5	37.7	28.9	25.1	26.1	27.4
Personnel Exp.	26.1	29.4	21.2	18.7	19.7	21.6
Investment Expenditures	12.9	5.4	5.9	5.9	7.2	5.1
Total Interest Payments	23.7	33.7	43.5	50.6	44.2	41.8
Transfers to SEEs	4.8	2.7	1.9	1.4	1.9	1.3
Transfers to Soc Sec Institutions	3.6	6.3	6.9	6.3	9.6	11.4
Memo:						
Budget Balance / GNP (%)	-3.1	-4.0	-10.9	-16.9	-15.2	-11.2
Interest Payments on Dom Debt / Total Tax Revenues (%)	22.2	43.9	70.9	94.4	78.5	62.5
Interest Payments on Dom Debt / Investment Expenditures (%)	116.3	518.1	679.1	781.4	555.0	735.8
Interest Payments on Dom Debt / Transfers to Soc Sec Institutions (%)	421.8	439.5	582.6	733.5	417.7	331.1
Interest Payments on Dom Debt / Net New Borrowing (%)	102.2	79.3	139.2	43.7	168.9	118.4

a. Deflated by the WPI (1987=100)..

Sources: SPO *Main Economic Indicators* ; Undersecreteriat of Treasury, *Treasury Statistics, 1980-2003.*

Interest burden necessarily claims a big share of the budget revenues. In fact, a comparison of the interest costs as a ratio of aggregate tax revenues –targeted and realized—discloses the structural constraints over the Turkish fiscal policy openly: Interest expenditures as a ratio of tax revenues reached 103.3% in 2001, and 77.1% in 2002. Under the crisis management targets, interest expenditures were fixed as 88.1% of the tax revenues in 2000, and 109% in 2001. In 2004, it was anticipated that the target of interest expenditures would be lowered to 59% of the tax revenue targets. (See Figure III-1 on the evolution of the ratio of interest costs to total tax revenues, both as targeted appropriations and also as end-of-year realizations).

Figure III-1. Interest Expenditures on Public Debt / Tax Revenues (Targets and Realizations, %)



Thus, under conditions of maintaining the debt turnover via only primary surpluses, the fiscal authority has been deprived of any viable funds to sustain public services on health, education, protection of the environment, and provision of social infrastructure.

As a result, the boundaries of the public space are severely restricted, and all fiscal policies are directed to securing debt servicing at the cost of extraordinary cuts in public consumption and investments. We see these trends clearly from Table III-1 above. If one focuses on non-interest expenditures, it can be understood that such expenditures have increased as a ratio to the GNP from 13.4 percent in 1990 to 22 percent in 2003. Much of this increase, however, has been due to the unprecedented rise in the financing requirement of the social security institutions. As a ratio to the GNP, transfers to the social security institutions were marginal until 1999, at less than 1 percent. After then the deficits of the social security institutions rose rapidly and reached 4.5 percent to the GNP in 2003.

All of these meant a heavy toll on the needed public investments on health, education and public infrastructure. Within total expenditures, public investments' share has fallen from 12.9 percent in 1990, to 5.1 percent in 2003. As a ratio to the GNP, public investments stand at less than 2 percent currently. From Table III-1 we calculate that in 2003 interest expenditures reached 7.4-folds of public investments. The burden of interest costs on public funds is immense and needs acute attention.

IV. Foreign balances and Dynamics of External Debt

Turkey has received a sizable amount of foreign finance capital especially after the resolution of the 2001 crisis. The most direct effect of the surge in foreign finance capital over this period was felt in the foreign exchange market. The over-abundance of foreign exchange supplied by the foreign financial arbiters seeking positive yields led significant pressures for the Turkish Lira to appreciate. The structural overvaluation of the TL, not surprisingly, manifests itself in an ever-expanding trade and current account deficits. As traditional Turkish exports lose their competitiveness, new export lines emerge. These are mostly import-dependent, assembled-part industries, such as automotive parts and consumer durables. They use the advantage of cheap import materials, get assembled in Turkey at low value added and then are re-directed for export. Thus, being mostly import-dependent, they have a low capacity to generate employment. As traditional exports dwindle, the newly emerging export industries are not vigorous enough to close the trade gap.

Consequently, both in 2003 and 2004 Turkey has witnessed expanding current account deficits, with the figure in 2005 reaching a record-breaking magnitude of $22.8 billion, or 6.4% as a ratio to the aggregate GDP. The latest data indicate that from February 2005 to February 2006, the cumulative current account deficit has already reached $25 billion. Thus, the strong pressures towards deterioration of the current account balance seem to persist at the time of writing of this report.

The mode of deficit finance relies on a fragile path and places the economy on an unsustainable razor's edge. The recent data on Turkish foreign economic relations are depicted in Table IV-1 below. Here we tabulate the key indicators from the balance of payments (BOP) statistics and draw lessons with regards to debt accumulation.

Table IV-1. Selected Indicators on Balance of Payments and Foreign Debt (Million USS)

	2001	2002	2003	2004	2005	Total over 2003-2005
Exports (fob)	34,373	40,124	51,206	67,047	76,595	194,848
Imports (fob)	-38,106	-47,407	-65,216	-90,925	-109,171	-265,312
Trade Balance	-3,733	-7,283	-14,010	-23,878	-32,576	-70,464
Current Account Balance	3,392	-1,524	-8,037	-15,604	-22,852	-46,493
Finance Account Balance	-14,643	1,161	7,098	17,679	44,069	68,846
Foreign Direct Investment by Residents Abroad	-497	-175	-499	-859	-1,047	-2,405
Foreign Direct Investment by Non-Residents	3,352	1,137	1,752	2,847	9,650	14,249
Non-Residents' Portfolio Investments in Turkey	-3,727	1,503	3,851	9,411	14,670	27,932
Residents' Portfolio Investments Abroad	-788	-2,096	-1,386	-1,388	-961	-3,735
Other Investment, Net	-12,983	792	3,380	7,668	21,757	32,805
Net Errors and Emissions	-1,759	118	4,941	2,267	1,983	9,191
Change in Reserves (-: Increase)	12,924	212	-4,097	-4,342	-23,200	-31,639
Foreign Debt Stock	113,619	130,206	145,022	162,240	170,062	39,856
Short Term Foreign Debt Stock	16,403	16,424	23,013	32,569	38,211	21,787
Ratio of Short Term Foreign Debt Stock to Central Bank Reserves (%)	86.8	60.7	68.2	88.7	88.5	..

Source: TR Central Bank (www.tcmb.gov.tr)

Data reveal that in 2005 Turkey has given a trade deficit of $32.5 billion, and a current account deficit of $22.8 billion. Both magnitudes are record highs for the entire Turkish economic history.

In the meantime, foreign debt stock has increased from $113.8 billion in 2001 to $170.1 billion in the end of 2005. This means an increase of $56 billion over a period of four years. It is striking to note that this extraordinary expansion of the debt stock has very little to do to finance the current account deficit. In fact, summing over the post-2001 crisis period, the cumulative current account deficit reaches to only $21.6 billion. Thus, the expansion of the foreign debt stock was almost twice faster than the foreign exchange needs of the real sector.

Where did the additional demand for foreign exchange come from? The data in Table IV-1 reveals that in the same period *short-term debt* has accumulated rapidly and reached to $38 billion. This means an increase of $22 billion in 2001 to 2005. These developments can only be understood in the context of the speculative transactions of the finance sector. BOP data indicates that the finance account has depicted a net surplus of $10.4 billion over 2001-2004. A significant portion of this inflow was due to non-residents' portfolio investments into Turkey. While the residents export financial capital at the magnitude of $5.4 billion, the net inflow was in positive figures. In addition, we will also interpret the *net errors and omissions* term of the BOP accounts as an indicator of *domestic hot money flows*. Under this interpretation, the total sum of net speculative finance capital flows reach to$17.4 billion over the three years of the post-crisis adjustments.

V. Social Policy and Indicators of Poverty and Social Well-being

Statistical data on the extent of poverty are scarce and quite new in Turkey. The most recent data still indicate important hind sights on the extent of the problem of poverty. In Table V-1 we provide existing data on the poverty measures. The table clearly reveals an increased trend in 2004 over 2003 whatever measure is used. Despite record growth in 2004 (with 9.9 rise of the real GNP), poverty widened and became a social issue of serious concern. Below we report on some of the determinants of poverty.

Table V-1. Indicators of Poverty

	2002		2003		2004	
	Poverty head count (1,000 persons)	Poverty ratio	Poverty head count (1,000 persons)	Poverty ratio	Poverty head count (1,000 persons)	Poverty ratio
Food poverty	956	1.35	894	1.29	909	1.29
Total poverty count (food + non-food)	18,650	26.96	19,458	28.12	17,991	25.61
Per capita, daily 1$ and below	11	0.02	9	0.01	11	0.02
Per capita, daily 2.15$ and below	1,750	3.04	1,655	2.39	1,752	2.49
Per capita, daily 4.3$ and below	18,000	30.3	16,433	23.75	14,681	20.89
Relative Poverty	10,100	14.74	10,370	15.51	9,967	14.18

Source: Turk-Is, Confederation of Turkish Labor Unions, 2005.

V-1. Market-Based Provision of Public Goods and Social Safety Nets

Macro-data on social public spending do not reflect the increasing scope of commercialization and/or private provision of education and health; yet an idea on the relative weights of public vs. private provision of education and health can be obtained from investment data on these sectors. Between 1976 and 1983 the share of the private sector within total investment in education and health had rarely exceeded ten percent. Starting with the 1980's when the government extended generous incentives to investors in these areas, entrepreneurs started to move into these sectors significantly and the private sector's share in total education/health investments reached the 50 percent benchmark by 1996-97. Public investments/GDP shares in the sector which had shown a downward trend up till the mid-1980s, had then picked up and gradually approached the ratios of 1976-77. Hence, thanks to the newly emerging contribution of the private sector, the expansion and modernization of the social (i.e. education & health) infrastructure could be accelerated.

This is, naturally, a favorable development. However, in terms of equity, it has certain adverse implications as well. A dual system in both education and health is gradually becoming dominant in human capital formation. An expensive, modern and, in certain respects, luxurious system of private health care -in part, supported by private health insurance schemes- is servicing the upper classes whereas the population covered by social insurance schemes is using the resources of an over-extended public health system. Public hospitals have, to an increasing degree, started to commercialize their services as well by significantly extending the implementation of users' fees. There is, thus, an increasing and striking polarization in terms of the quality and quantity of health services extended to different segments of the population.

V-2. The Social Security System

Commensurate with the ongoing macroeconomic imbalances and the deterioration of public accounts, one witnesses a dramatic collapse of the fiscal accounts of the Turkish social security system. The state pension system is characterized by a high level of evasion, low levels of pensions, and financial insolvency. [4] As of 1997, the combined cash deficits of the system reach to 2.4% of the gross national product, and it is foreseen that it will accumulate to 10.1% by 2050 (ILO, 1995). Currently, actuarial balances of the system are observed to be in severe disequilibrium with 2.3 active registered employees per retired person. Rough estimates based on the 1985 census suggest, however, that the system can admit an actuarial rate of 9 to 1. In this respect it is clear that most of the current problems of the Turkish social security system is independent of the so-called aging crisis faced by many OECD nations today; and instead, is a direct reflection of the structural deficiencies of the labor market and the overall imbalances of the macroeconomic environment surrounding the 1990s.

Given this background, the Turkish social securitization portrays a very weak structure and reflects the deep marginalization of the labor market. A further reflection of this point can also be made on the basis of private sector employment patterns. Based on 1996 data, we calculate that the private sector average of actively insured persons to total employment is only one-third, and that labor intensive traditional activities such as agriculture and construction display the most intensive informalization (Köse and Yeldan, 1998).

Overall, the main attributes of this evasion can be summarized as follows: (i) given the extensive size of the unemployed and the absence of an unemployment insurance scheme, a major share of the labor force is drawn into informal/marginalized jobs for survivals; (ii) the presence of a large informal unrecorded sector itself creates unfair competition for small/medium-sized enterprises, and thus leads to further marginalization of the industrial relations; (iii) in the absence of an age-limit for retirement, those middle-aged pensioners who decide to join the labor force again often accept to work at lower wages. This puts significant downward pressure on wages of younger employees employed under formal status and adversely affects the labor's position in the wage determination process.

Parallel to these observations, a major deformation of the Turkish labor market is known to be the wide-spread employment of child/young labor and the lack of any social securitization for this group. Based on TURKSTAT data, our calculations reveal that, in the private sector, those under 29 years of age constitute 14% of total employment, and that 3% is aged 12-15. Furthermore, of this 14% of "young" labor force, 83% has no social security coverage.

Clearly, the current social security system is unsustainable and is in need of immediate reform. However, neither available private pension arrangements, nor the espoused securitization-based private financing schemes offer viable alternatives. Due to insufficient regulation and lack of formal supervision, the private health and life insurance sectors are characterized by cases of irregularities, high lapses, and unaccounted policy cancellations. Given the structural characteristics of labor markets outlined previously, it is only fair to argue that a viable social security system reform can only be meaningful as part of a comprehensive restructuring package addressing both the informalization of the labor market, and the extensive disequilibria of the domestic macroeconomic environment.

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[4] On current problems of the Turkish social security system, see Teksöz (1998), Köse and Yeldan (1998b), Kenç and Sayan (1998), TÜSİAD (1997), Kenar, Teksöz and Coşkun (1996) and ILO (1995).

Finally we document a comprehensive list of social indicators for Turkey in Table V-2 below.

Table V-2. Selected Development Indicators of Turkey

SELECTED DEVELOPMENT INDICATORS OF TURKEY				
National Accounts	1990	1995	2000	2003
Gross National Product (At 1987 Prices) (Thousand TRY)	84,592	99,028	119,144	123,165
Gross National Product (Current Prices) (Million USD)	152.393	171.979	201.463	238.409
Percentace Change of GNP (At 1987 Prices)	9.4	8.0	6.3	5.9
Deflator of GNP	57.6	87.2	50.9	22.5
Gross Domestic Product (By Expenditures) (Current Prices)	393,060	7,762,456	124,583,458	359,762,926
Gross Domestic Product (By Expenditures) (At 1987 Prices)	83,578	97,888	118,789	125,485
Gross Domestic Product (By Revenues) (Current Prices)	393,060	7,762,456	124,583,458	359,762,926
Growth Rate of Agriculture	6.8	2.0	3.9	-2.5
Growth Rate of Industry	8.6	12.1	6.0	7.8
Growth Rate of Services	10.3	6.3	8.9	6.7
Per Capita GNP (USD) (At Current Prices)	2,712	2,784	2,987	3,390
Per Capita GNP (USD) (At 1987 Prices)	1,760	1,875	2,065	2,046
Per Capita GNP (USD) (PPP)	4,566	5,489	6,820	6,980
Goverment Finances	1990	1995	2000	2003
Budget Revenues (Thousand TRY)	55,239	1,394,497	33,244,345	100,250,452
Bedget Expenditures (Thousand TRY)	67,193	1,710,647	46,970,348	140,454,842
Budget İnterest Expenditures (Thousand TRY)	13,966	576,115	20,439,862	58,609,163
Primary Budget Balance (Thousand TRY)	2,012	259,965	6,713,859	18,404,773
Budget Balance (Thousand TRY)	-11,955	-316,150	-13,726,003	-40,204,390
GSYİH	393,060	7,762,456	124,583,458	359,762,926
Budget Revenues (As of GDP)	14.1	18.0	26.7	27.9
Bedget Expenditures (As of GDP)	17.1	22.0	37.7	39.0
Budget İnterest Expenditures (As of GDP)	3.6	7.4	16.4	16.3
Primary Budget Balance (As of GDP)	0.5	3.3	5.4	5.1
Budget Balance (As of GDP)	-3.0	-4.1	-11.0	-11.2
Public Sector Borrowing Requirement (Thousand TRY)	29,141	390,029	14,848,811	33,676,464
Public Sector İnterest Payments (Thousand TRY)	20,183	743,727	21,956,852	61,123,386
Public Sector Borrowing Requirement (Thousand TRY) (Exc. İnt. Pay)	8,958	-353,698	-7,108,042	-27,446,922
Public Sector Borrowing Requirement (As of GDP)	7.4	5.0	11.9	9.4
Public Sector İnterest Payments (As of GDP)	5.1	9.6	17.6	17.0
Public Sector Borrowing Requirement (As of GDP) (Exc. İnt. Pay)	2.3	-4.6	-5.7	-7.6

Selected Development Indicators of Turkey (cont.'d)

Social and Sectoral Indicators	1990	1995	2000	2003
Employment in agriculture (% of total employment)	46.9	43.4	36.0	33.88
Employment in industry (% of total employment)	20.7	22.3	24.0	22.75
Employment in services (% of total employment)	32.4	34.3	40.0	43.37
Gross national savings, including NCTR (% of GDP)	24.01	24.8	20.23	19.06
Gross domestic savings (% of GDP)	20.06	21.01	17.02	19.68
Gross capital formation (% of GDP)	24.35	25.47	24.51	23.01
Gross fixed capital formation (% of GDP)	22.87	23.84	22.35	15.46
Final consumption expenditure, etc. (% of GDP)	79.94	78.99	82.98	80.32
Household final consumption expenditure, etc. (% of GDP)	68.97	68.2	68.9	66.56
General government final consumption expenditure (% of GDP)	10.96	10.79	14.08	13.76
Exports of goods and services (% of GDP)	13.29	19.89	24.05	27.65
High-technology exports (% of manufactured exports)	1.19	1.25	4.86	2.06
Imports of goods and services (% of GDP)	17.57	24.35	31.53	30.98
Trade (% of GDP)	30.85	44.24	55.58	58.63
Current account balance (% of GDP)	-1.74	-1.38	-4.93	-3.29
Gross foreign direct investment (% of GDP)	0.48	0.59	0.93	0.86
Foreign direct investment, net inflows (% of GDP)	0.45	0.52	0.49	0.65
Private investment in energy (current Million US$)	68	1,760	3,575	..
Private investment in telecoms (current Million US$)	..	116	4,525	142
Private investment in transport (current Million US$)	..	..	115	..
Food production index (1999-2001 = 100)	88.4	90.5	104.6	103
External debt, total (DOD, current Million US$)	49,424	73,781	117,335	145,662
Long-term debt (DOD, current Million US$)	39,924	57,396	84,247	98,558
Central government debt, total (% of GDP)	30.25	35.84	..	..
Present value of debt (% of GNI)	..	..	58.14	81.35
Total debt service (% of GNI)	4.88	6.68	10.32	11.83
Deposit interest rate (%)	47.5	76.02	47.16	37.68
Interest payments (% of expense)	20.77	12.99	..	..
Interest payments (% of revenue)	22.58	15.09	..	..
Consumer price index (2000 = 100)	0.35	6.33	100	280.44
Inflation, consumer prices (annual %)	60.31	88.11	54.92	25.3
Inflation, GDP deflator (annual %)	58.24	87.2	49.9	21.29
Unemployment, total (% of total labor force)	8	7.5	6.6	10.5
Unemployment with primary education (% of total unemployment)	74.43	66.79	62.08	65.05
Unemployment with secondary education (% of total unemployment)	21.04	27.94	28.37	23.31
Unemployment with tertiary education (% of total unemployment)	4.53	5.26	9.55	11.64
Labor force with primary education (% of total)	84.46	77.95	73.88	69.65
Labor force with secondary education (% of total)	10.27	15.39	17.29	19.25
Labor force with tertiary education (% of total)	5.27	6.66	8.83	11.10
Birth rate, crude (per 1,000 people)	24.8	23.8	22.2	20.9
Fertility rate, total (births per woman)	3	2.8	2.57	2.43
Life expectancy at birth, total (years)	65.69	67.1	68.04	68.64
Physicians (per 1,000 people)	0.9	1.1	1.25	..
Literacy rate, adult total (% of people ages 15 and above)	77.85	81.84	86.5	88.3
Urban population (% of total)	61.19	63.69	65.76	67.00
Computer, communications and other services (% of commercial service exports)	47.41	52.4	45.53	16.33
Computer, communications and other services (% of commercial service imports)	49.18	41.66	39.18	25.14
Information and communication technology expenditure (% of GDP)	..	..	7.93	7.35
Air transport, freight (million tons per km)	101.3	214.7	374.8	378.5
Air transport, passengers carried (Thousand)	4,337	7,749	11,513	10,701
Insurance and financial services (% of commercial service exports)	..	1.53	1.98	2.64
Insurance and financial services (% of commercial service imports)	..	8.42	11.87	12.82
Electric power consumption (kwh per capita)	800.51	1,055.01	1,422.03	..
Electricity production from coal sources (% of total)	35.07	32.52	30.57	..
Electricity production from hydroelectric sources (% of total)	40.23	41.21	24.72	..
Electricity production from natural gas sources (% of total)	17.71	19.22	36.08	..
Electricity production from oil sources (% of total)	6.85	6.69	8.37	..
Energy use per PPP GDP (kg of oil equivalent per constant 2000 PPP $)	0.18	0.18	0.18	..
Vehicles (per 1,000 people)	49.6	65.45	87.92	..
Agricultural machinery, tractors per agricultural worker	0.05	0.06	0.06	..
Passenger cars (per 1,000 people)	33.56	52.34	65.18	..
Telephone mainlines (per 1,000 people)	121.5	214.39	281.73	267.52
Fixed line and mobile phone subscribers (per 1,000 people)	122.06	221.48	528.83	661.9
Mobile phones (per 1,000 people)	0.56	7.09	247.09	394.38
Personal computers (per 1,000 people)	5.31	14.92	38.29	..
Internet users (per 1,000 people)	..	0.81	30.63	84.85
Radios (per 1,000 people)	160.27	161.98	443.73	..
Cable television subscribers (per 1,000 people)	0	6.55	13.55	14.77
Research and development expenditure (% of GDP)	4.7	3.8	6.4	6.7
Scientific and technical journal articles	750	1,713.00	3,482.00	..

Source : WDI (Worldbank), SPO and TURKSTAT

VI. General Modeling Analysis of Environmental Policy Alternatives

VI-1. The Algebraic Structure of the Model and Adjustment Mechanisms

Given the overview of the recent macroeconomic developments, fiscal policy and debt management and labor markets under the current macroeconomic prices, we now develop an analytical computable general equilibrium (CGE) model for Turkey to study issues of environmental abatement and its economic impacts. The CGE approach, compared with other modeling techniques (such as linear programming or input-output analysis) for environmental policy evaluation is more attractive with its ability to trace the relationship between fuel costs, production technologies, consumer choices and prices throughout the economy in an internally consistent way.

Increasing complexity of the direct and indirect interrelations among economic, environmental and social variables has been calling for models that allow evaluation of alternative policies. At the same time, these models must take into account market mechanisms, behavior/decision patterns of economic agents, and effectiveness of public policies. The multi-sectoral CGE models are representing the economy of a country in a more realistic way by incorporating market mechanisms in the assignment of resources, by analyzing systematically and quantitatively the evolution of variables related to macroeconomic, social and environmental policy objectives.

The latest innovation in CGE models have developed an analytical apparatus in the context of energy-economy-environment models to simulate the impacts of multilateral internal and external instruments for the regulation of greenhouse gas (GHG) emissions. Because climate change depends on the atmospheric stocks of GHGs and because for most of the gases' residence times in the atmosphere are hundreds (and in some cases thousands) of years, climate change indeed becomes inherently a long-term global environmental phenomenon and any systematic study on the issue has to specify assumptions and projections regarding technological change, adaptation strategies… etc.

The model that we present here should be considered as a first step that establishes a "base-path" against which the socio-economic impacts of alternative policy scenarios are to be investigated. "Dynamics" into the model is integrated via "exogenous" updating of the static model into a medium-run of fifteen (15) years using the average population growth, investment behavior on the part of both private and public sectors and total factor productivity (TFP) growth figures of the Turkish economy as observed.

The supply-side of the economy is modeled as ten (10) aggregated sectors. In line with our focus on environmental policy evaluation, the disaggregation scheme develops into the energy sectors and critical sectors of GHG pollutions in detail.[5] It thus, aggregates a large number of other activities that, although being far more important contributors to total gross output, are not germane to the climate problem. The sectors that we specify are:

- Agricultural production (AG)
- Coal Mining (CO)
- Petroleum and Gas (PG)
- Refined Petroleum (RP)
- Electricity Production (EL)

[5] The model and the results presented here takes only the most important GHG, the carbon dioxide (*CO2*) into consideration, leaving out the effects/policies on other GHGs.

- Cement Production (CE)
- Paper Production (PA)
- Iron and Steel Production (IS)
- Transportation (TR)

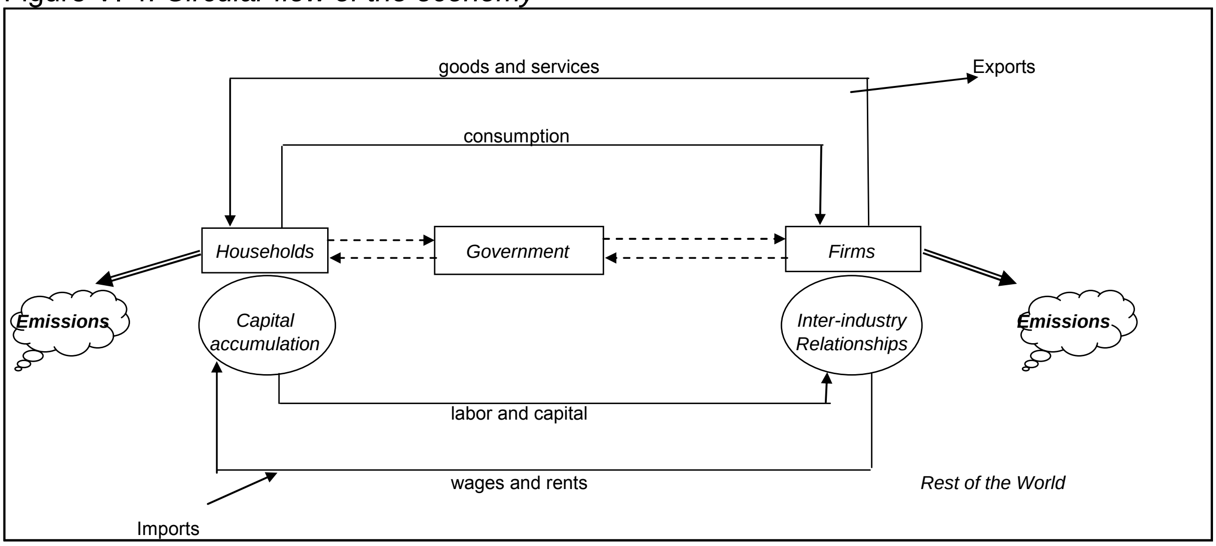
and a composite of remaining manufacturing, services and primary industries sectors of the economy (*OE*). Labor, capital and a composite of primary energy inputs, electricity, petroleum and gas and coal, together with intermediate inputs are the factors of production.

Basic Features of the Model

In general, the model is in the tradition of applied general equilibrium paradigm where the production-income generation-consumption and saving-investment decisions of an economy are depicted within a market equilibrium setting. Optimizing economic agents are modeled as responding to various price signals as affected by a range of government's taxation/subsidy policies. The economy is modeled to operate in an internationally open environment where exchange rate and foreign capital inflows interact with exports and imports of the domestic sectors.

Emissions arising both from production activities and from consumption activities are modeled within the specification of the dynamics of the circular flow of an economy. Figure VI-1 schematically represents the relationships to be modeled by means of our CGE model, based on this circular flow. It includes main economic agents (households, firms, government, and rest of the world), flows of goods and services, payment to factors of production, international trade and relationships with the environment.

Figure VI-1. *Circular flow of the economy*



VI-1-1. Production Structure, Factor Endowments

Figure VI-2 represents the general production structure of the model. Sectoral production is modeled via two-stage production technology where at the second stage, gross output is produced through a Cobb-Douglas technology defining capital (*K*), labor (*L*), intermediate inputs –excluding primary energy inputs (*ID*) and primary energy composite (*ENG*) as factors of production:

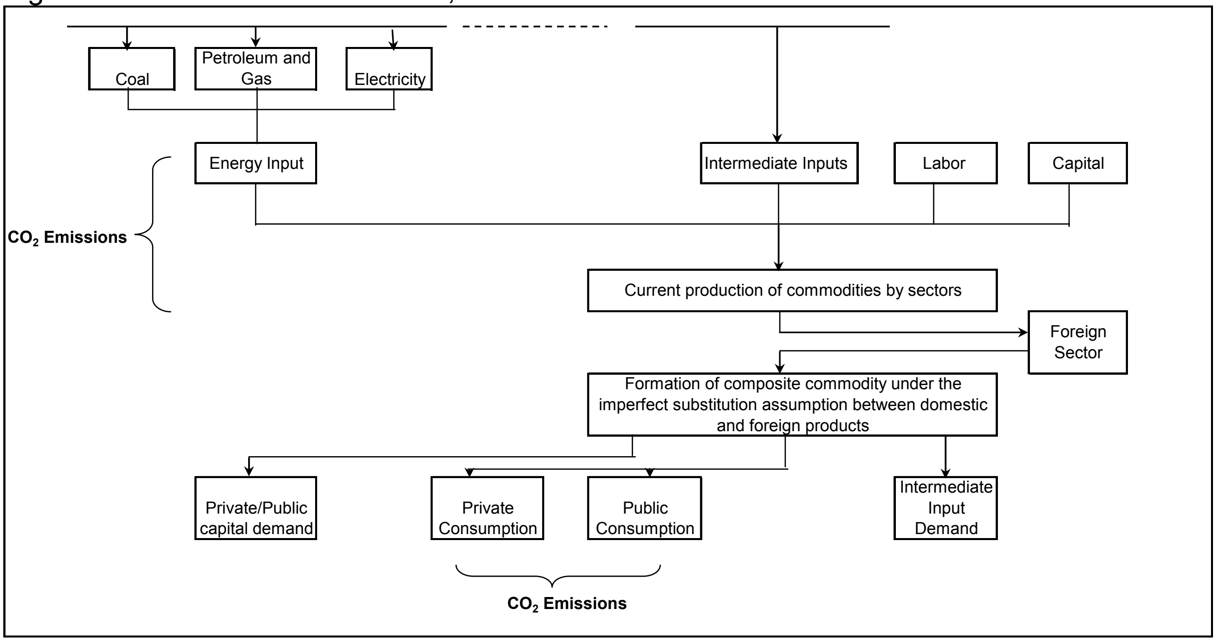
$$XS_i = AX_i\left[K_i^{\lambda_{K,i}} L_i^{\lambda_{L,i}}\left(\prod_j ID^{\lambda_{ID,j,i}}\right)ENG_i^{\lambda_{E,i}}\right] \tag{1}$$

i = AG, CO, PG, RP, EL, CE, PA, IS, TR, OE

In Equation 1, AX is the technology level parameter, $\lambda_{K,i}$, $\lambda_{L,i}$, $\lambda_{E,i}$ denote the shares of capital input, the labor input and the energy input in the value of gross output in sector *i*. Under the assumption of constant returns to scale (*CRS*) technology, for every sector *i*:

$$\lambda_{K,i} + \lambda_{L,i} + \sum_j \lambda_{ID,j,i} + \lambda_{E,i} = 1 \tag{2}$$

Figure VI-2. Flows of commodities, factors and emissions in the model.



At the initial stage of the production technology in each sector, the primary energy composite is produced along a constant elasticity of substitution (CES) production function using the primary energy inputs, coal, petroleum and gas and electricity:

$$ENG_i = AE_i\left[\kappa_{CO,i} ID_{CO,i}^{-\rho x_i} + \kappa_{PG,i} ID_{PG,i}^{-\rho x_i} + \kappa_{EL,i} ID_{EL,i}^{-\rho x_i}\right]^{-1/\rho x_i} \tag{3}$$

Under the above production technology, differentiation of the minimum cost per unit of primary energy inputs gives the sectoral demand for coal, petroleum and gas and electricity:

$$\frac{ID_{CO,i}}{ENG_i} = \left[\frac{\kappa_{CO,i} PEG_i}{AE_i^{-px_i}(1 + CO_2tN_{CO})PC_{CO}}\right]^{1/(1+\rho x_i)} \tag{4}$$

$$\frac{ID_{PG,i}}{ENG_i} = \left[\frac{\kappa_{PG,i} PEG_i}{AE_i^{-px_i}(1 + CO_2tN_{PG})PC_{PG}}\right]^{1/(1+\rho x_i)} \tag{5}$$

$$\frac{ID_{EL,i}}{ENG_i} = \left[\frac{\kappa_{EL,i} PEG_i}{AE_i^{-px_i}(1+CO_2tN_{EL})PC_{EL}} \right]^{1/(1+\rho x_i)} \tag{6}$$

where *PEG* is the cost of energy input composite, and CO_2tN_j is the pollutant's fee (carbon tax rate) on input *j*.

Sectoral demands for labor, capital, energy composite and intermediate inputs arise from the profit-maximization behavior of the representative firm in each sector:

$$K_i = \lambda_{K,i} \left[\frac{(1 - t_{\mathrm{Pr}od,i} - CO_2tP)PX_i XS_i}{r} \right] \tag{7}$$

$$L_i^D = \lambda_{L,i} \left[\frac{(1 - t_{\mathrm{Pr}od,i} - CO_2tP)PX_i XS_i}{(1 + pyrltax)\overline{w}} \right] \tag{8}$$

$$ID_j = \lambda_{ID,j,i} \left[\frac{(1 - t_{\mathrm{Pr}od,i} - CO_2tP)PX_i XS_i}{(1 + CO_2tN_j)PC_j} \right] \tag{9}$$

The equations above governing demand for both primary energy inputs and the other factors of production already provide some indication on the effects of alternative policies on the supply-side of the economy. A tax on the usage of coal for instance, ($tCO2tN_{CO}$) would shift the demand away from coal as a primary source of energy towards other sources, under the allowances of substitutability determined by the production technology.

Under the assumption that the nominal wage rate in a given period is fixed, given the aggregate labor endowment of the economy, $\overline{L}^S$, the labor market equilibrium reveals an unemployment rate:[6]

$$w = \overline{w} \Rightarrow \overline{L}^S - \sum_i L_i^D = UNEMP \tag{10}$$

Likewise, given the aggregate physical capital stock of the economy each period, the capital market equilibrium, $\sum_{\mathrm{i}} \mathrm{K_i}$ = $\overline{K}^S$ implies an equilibrium profit rate r for the economy. Thus the physical capital is mobile across sectors of the economy. It is the difference in sectoral profit rates that leads to the sectoral allocation of aggregate investments in within-period dynamics of the model.

VI-1-2. Environmental Emissions and Taxation

Three basic sources of *CO2* emissions are distinguished in the model: (i) due to industrial processes, (ii) due to (primary and secondary) energy usage, and (iii) due to energy use of households. Therefore, total *CO2* emission in the economy is the sum over from all these sources:

[6] The nominal wage rate is updated by the "realized" rate of inflation in between periods.

$$TOTCO2 = TOTCO2IND + TOTCO2ENG + TOTCO2HH \quad (11)$$

Depending on the source of emission, we assume different allocation mechanisms of carbon dioxide. Following Gunther *et al*. (1992), the emissions from industrial processes is regarded to depend on the level of industrial activity, therefore is hypothesized proportional to gross output:

$$CO_2EM_i^{IND} = \bar{\delta}_i XS_i \quad (12)$$

On the other hand, total emissions due to energy usage, *TOTCO2ENG* are generated from two sources: sectoral emissions due to combustion of primary energy fuels (coal and petroleum and gas) and sectoral emissions due to combustion of secondary energy fuels (refined petroleum):

$$TOTCO2ENG = \sum_i \left[\sum_j \left(CO_2EM_{j,i}^{INM} + CO_2EM_{j,i}^{ENG} \right) \right] \quad (13)$$

Under both sources, the mechanism of emission is dependent on the level of pollutant-emitting inputs (energy input at primary and at secondary levels) in each sector:

$$CO_2EM_{j,i}^{ENG} = \varpi_{j,i} \; ID_{j,i} \qquad j = CO, PG \quad (14)$$

$$CO_2EM_{j,i}^{INM} = \bar{\varepsilon}_{j,i} \; ID_{j,I} \qquad j = RP \quad (15)$$

Total emission of $CO2$ in the use of energy by households is given by:

$$TOTCO_2HH = \sum_i \bar{\psi}_i CD_i \quad (16)$$

Here, $\bar{\psi}_i$ is the coefficient of emissions of $CO2$ in private consumption (CD_i) of the basic fuels coal (CO) and refined petroleum (RP) by households.

Carbon tax is introduced via at rates $CO2tP$, $CO2tN_i$ and $CO2tC_i$ per tons of carbon dioxide emitted, on production, on intermediate input usage and on consumption respectively. The revenues are directly added to the revenue pool of the government budget:

$$TOTCO2TAX = \sum_i \mathrm{CO_2tP} PX_i XS_i + \sum_i \sum_j \mathrm{CO_2tN_i} PC_i ID_{i,j} + \sum_i \mathrm{CO_2tC_i} PC_i CD_i \quad (17)$$

VI-1-3. Income Generation and Demand

Returns to labor input, net of social security taxes constitute the private household net labor income:

$$YHWnet = (1 - sstax)\overline{w}\sum_i L_i^D \tag{18}$$

On the other hand, the net profit transfer of the enterprise income to private household is mainly composed of returns to capital as a factor of production:

$$\begin{aligned} EtrHH = (1\text{-}t_{Corp})\sum_{\mathrm{i}} \mathrm{r}\,\mathrm{K_i}\ - EERPtrROW - NFI^{\mathrm{G}} + GtrEE \\ r^D DomDebt^G - r^F eForDebt^E + eForBOR^E \end{aligned} \tag{19}$$

Here, a constant proportion $trrow$, of the total profit income is distributed to the rest of the world to represent the net factor income of foreigners in Turkey:

$$EERPtrROW = trrow\sum(1 - t_{Corp})rK_i \tag{20}$$

In Equation 19, $GtrEE$ is the net transfers of the government to private enterprises, $r^D DomDebt^G$ is the interest income of the enterprises out of government domestic debt and $r^F ForDebt^E$ is the interest payments of the private enterprises for their already accumulated foreign debt. As e represents the exchange rate variable, $ForBOR^E$ is the new foreign borrowing of the private sector in foreign exchange terms.

So, the primary sources of income, together with the secondary sources of income constitute the total private income to the households:

$$YHH = YHWnet + EtrHH + GtrHH + SSItrHH + eROWtrHH \tag{21}$$

In the equation above, $GtrHH$ is government transfers to private households and $SSItrHH$ is the social security institutions transfers to the households. $ROWtrHH$ represents remittances. Private disposable income, is then private income of the households, net of income taxes:

$$YHnet = (1 - t_{Inc})YHH \tag{22}$$

Private households save a constant fraction, s^p of their income. The residual aggregate private consumption then is distributed into sectoral components through exogenous (and calibrated) shares:

$$CD_i = cles_i.\frac{PRIVCON}{PC_i} \tag{23}$$

where PC_{i} is the composite price of product i which consists of the unit prices of domestic and foreign commodities, united under the imperfect substitution assumption through an *Armingtonian* specification.

Likewise, aggregate public consumption is distributed into sectoral production commodities in fixed proportions:

$$GD_i = gles_i.\frac{GOVCON}{PC_i} \tag{24}$$

We assume, the aggregate public consumption is specified to be a constant fraction of aggregate public income:

$$GOVCON = gcrGREV \tag{25}$$

where $GREV$ represents public revenues. $GREV$ composes of direct taxes on wage and profit incomes and profit income from state economic enterprises. The income flow of the public sector is further augmented by indirect taxes on domestic output and foreign trade (net of subsidies), sales taxes and environmental taxes:

$$GREV = \sum_i t_{\mathrm{Prod},i} PX_i XS_i + \sum_i t_{Sal,i} PC_i CC_i + \sum_i tm_i eP_i^w M_i + \sum_i te_i eP_i^w E_i + t_{Inc} YHH + t_{Corp} \sum_i rK_i + \sum_i NFI^G + TOTCO2TAX \tag{26}$$

If government transfer items to the households, to the enterprises and to the social security system are taken as fixed proportions of government revenues net of interest payments, then, under a pre-determined primary surplus/GDP ratio, public investment demand is settled as a residual variable out of the public fiscal accounts.

The public sector borrowing requirement, $PSBR$ then, is defined by

$$PSBR = GREV - GCON - GINV - r_P{}^G e\, ForDebt^G - r^D DomDebt^G - GtrHH - GtrEE - GtrSSI \tag{27}$$

and is either financed by domestic borrowing, $\Delta DomDebt^G$ or by foreign borrowing $\Delta eForDebt^G$.

VI-1-4. General Equilibrium

The overall model is brought into equilibrium through endogenous adjustments of product prices to clear the commodity markets and balance of payments accounts. With nominal wages being fixed in each period, equilibrium in the labor market is sustained through adjustments of employment.

Given the market equilibrium conditions, the following ought to be satisfied for each commodity *i*:

$$CC_i = CD_i + GD_i + IDP_i + IDG_i + INT_i \tag{28}$$

that is, the aggregate absorption (domestic supply minus net exports) of each commodity is demanded either for private or public consumption purposes, private or public investment purposes or as an intermediate good.

The model's closure rule for the savings-investment balance necessitates:

$$PSAV + GSAV + e\ CAdef = PINV + GINV \quad (29)$$

The $CAdef$ in the equation above determines the current account balance in foreign exchange terms and equals to the export revenues, the remittances and private and public foreign borrowing on the revenue side and the import bill, profit transfers abroad and interest payments on the accumulated private and public debt stocks on the expenditures side:

$$\begin{aligned} CAdef = & \sum P_i^W E_i + ROWtrHH + ForBor^E + ForBor^G \\ & - \left[\sum P_i^W M_i + \left(trrow \sum (1 - t_{Corp}) rK_i \right) / e + r^F ForDebt^E + r^F ForDebt^G \right] \end{aligned} \quad (30)$$

The private and public components of the external capital inflows are regarded exogenous in foreign exchange units. The additional endogenous variable that closes the *Walrasian* system is the private investments, *PINV.* Finally, the exchange rate *e*, serves as the *numeriare* of the system.

VI-1-5. Dynamics

The model updates the annual values of the exogenously specified variables and the policy variables in an attempt to characterize the 2006-2020 growth trajectory of the Turkish economy. In-between periods, first we update the capital stocks with new investment expenditures net of depreciation. Labor endowment is increased by the population growth rate. Similarly, technical factor productivity rates are specified in a Hick-neutral manner, and are introduced exogenously. Nominal wage rate is updated by the price level index which is endogenous to the system.

Finally, at this stage we account for the evolution of debt stocks. First, government's foreign borrowing is taken as a ratio to aggregate *PSBR*:

$$e\ ForBor^G = (gfborrat) PSBR \quad (31)$$

Thus, government domestic borrowing becomes:

$$DomBor = (1 - gfborrat)\ PSBR \quad (32)$$

Having determined the equations for both foreign and domestic borrowing by the government, we establish the accumulation of the domestic and foreign debt stocks of the public sector:

$$DomDebt_{t+1} = DomDebt_t + DomBor_t \quad (33)$$

$$ForDebt^G{}_{t+1} = ForDebt^G{}_t + ForBor^G{}_t \quad (34)$$

Similarly, private foreign debt builds up as:

$$ForDebt^P{}_{t+1} = ForDebt^P{}_t + ForBor^E{}_t \quad (35)$$

VI-2.Calibration and the Base Path for 2003-2020

VI-2-1. Data

VI-2-1-1.Macro-economic Data

The model is built-around a multi-sectoral social accounting matrix (SAM) of the Turkish economy based on State 1996 I-O is re-arranged accordingly to give a structural portray of *intermediate flows* at the intersection of commodities row and activities column in the 10-sector 2003 macro-SAM. The SAM constructed for the environmental model is presented in Table VI-1.[7]

As the model described contains a number of economic and environmental parameters, the estimation of them becomes important in evaluating the quantitative results of the alternative policy scenarios. The "calibration" approach is adopted (where possible) in parameter specification of the CGE model.[8]

[7] The matrix is measured in billions TRY. However, as most of the results will be posted in ratio-terms or in relative weights, the measure unit and amount will not be primarily relevant.
[8] See Masur and Whalley (1984) and Deverajen *et al*. (1995) for more on calibration in CGE models.

Table VI-1: Social Accounting Matrix (Turkey, 2003, billion TRY)

		ACTIVITIES									
		AG	CO	PG	PA	RP	C	IS	EL	TR	OE
ACTIVITIES	AG										
	CO										
	PG										
	PA										
	RP										
	C										
	IS										
	EL										
	TR										
	OE										
COMMODITIES	AG	17,882,465	19,316	0	91,883	0	43	317	5,114	76,360	18,471,760
	CO	16,635	149	0	1,227	1,830	235,033	304,620	705,886	4,702	413,991
	PG	0	0	0	0	6,793,020	84,728	0	880,894	19,633	677,213
	PA	107,840	50	1,749	907,538	2,075	104,816	85,323	1,679	68,605	3,865,683
	RP	2,053,497	89,182	10,683	93,824	12,286	181,022	496,354	482,682	10,726,669	4,620,904
	C	50,039	123	1,010	524	310	318,403	10,055	0	0	4,299,255
	IS	15	4,278	16,235	39	2,535	34,012	3,789,101	3,646	2,257	10,738,215
	EL	248,125	62,214	15,901	129,434	123,922	554,399	1,014,055	150,163	86,472	6,421,639
	TR	1,271,039	26,294	23,297	201,332	757,743	285,856	958,434	307,609	3,444,860	14,568,613
	OE	13,014,812	223,135	69,298	760,347	393,572	822,318	2,436,056	514,074	13,372,046	126,751,810
FACTORS	W	9,805,554	1,073,718	35,058	421,348	197,984	508,413	1,330,751	1,477,965	9,752,561	88,123,450
	KP	30,027,548	176,325	960,851	1,614,603	943,919	1,539,035	2,643,558	4,968,337	34,474,926	92,204,690.3130021
HOUSEHOLDS	H										
ENTERPRISES											
SOCIAL SECURITY INST.		1,330,075	145,644	4,755	57,154	26,856	68,964	180,510	200,479	1,322,887	11,953,510
GOVERNMENT		2,967,607	35,311	128,826	60,116	13,606,758	62,131	178,085	73,741	745,009	14,376,432
	VAT										
	IMPTAX										
	PROTAX	2,967,607	35,311	128,826	60,116	13,606,758	62,131	178,085	73,741	745,009	14,376,432
	NONTAX										
	DIRTAX										
	FACINC										
	ENTTAX										
PRIVATE CAPITAL Acc											
PUBLIC CAPITAL Acc											
REST OF THE WORLD											
Total Expenditures		78,775,252	1,855,739.2603963	1,267,662	4,339,367	22,862,810	4,799,172	13,427,220	9,772,269	74,096,986	397,487,164.6413430

		COMMODITIES									
		AG	CO	PG	PA	RP	C	IS	EL	TR	OE
ACTIVITIES	AG	74,313,675									
	CO		1,854,485								
	PG			1,267,661							
	PA				4,123,556						
	RP					22,265,279					
	C						4,529,371				
	IS							10,251,550			
	EL								9,740,572		
	TR									56,936,251	
	OE										324,904,904
COMMODITIES	AG										
	CO										
	PG										
	PA										
	RP										
	C										
	IS										
	EL										
	TR										
	OE										
FACTORS	W										
	KP										
HOUSEHOLDS	H										
ENTERPRISES											
SOCIAL SECURITY INST.											
GOVERNMENT		2,671,949	278,748	11,896	113,537	59,569	136,139	346,914	401,911	2,651,371	23,285,447
	VAT	2,518,759	275,807	9,005	108,232	50,856	130,596	341,831	379,646	2,505,147	22,636,328
	IMPTAX	153,190	2,941	2,891	5,305	8,713	5,543	5,083	22,265	146,225	649,119
	PROTAX										
	NONTAX										
	DIRTAX										
	FACINC										
	ENTTAX										
PRIVATE CAPITAL Acc											
PUBLIC CAPITAL Acc											
REST OF THE WORLD		4,527,951	1,285,114	7,899,849	1,814,128	2,875,709	22,785	6,503,962	26,821	0	85,378,048
Total Expenditures		81,513,574	3,418,347	9,179,406	6,051,221	25,200,557	4,688,296	17,102,426	10,169,304	59,587,622	433,568,399

FACTORS		HOUSEHOLDS	ENTERPRISES	SOCIAL SECURITY INST.	GOVERNMENT	*PUBCONS*	*HHTRA*	*PROSUB*	*DOMINT*	*FORINT*	*SSITRA*	*PUBSAV*	PRIVATE CAPITAL	PUBLIC CAPITAL	REST OF THE WORLD
W	KP														
					0										4,461,577
					0										1,254
					0										2
					0										215,811
					0										597,531
					0										269,802
					0										3,175,670
					0										31,696
					0										17,160,735
					0										72,582,260
		43,634,213.7668202			1,206,476	1,206,476							117,853	7,774	
		1,726,057.9846976			8,216	8,216							0	0	
		0.0016823			0	0							0	723,917	
		799,436.3509131			106,427	106,427							0	0	
		5,396,776.1261108			1,036,679	1,036,679							0	0	
		-0.0028640			8,578	8,578							0	0	
		-0.0104330			2,512,094	2,512,094							0	0	
		948,840.2471728			414,141	414,141							0	0	
		31,666,462.8711444			3,030,369	3,030,369							2,722,102	323,611	
		160,913,660.8175420			35,869,488	35,869,488							63,372,097	15,055,686	
					0										
					0										
104,425,155			197,871,230	37,566,120	19,305,641		19,305,641								1,090,079
	169,553,793				56,375,925			1,579,403	54,796,522						7,196,707
8,301,647					13,973,640						13,973,640				
0	0	28,370,862	30,510,587	0	0								0	0	0
		8,888,866													
		19,481,996													
			20,838,377												
			9,672,210												
		66,212,051			0										
		20,589,863			-19,398,942							-19,398,942			14,920,067
			4,744,608		6,624,215					6,624,215					
112,726,802	**169,553,793**	**360,258,224**	**233,126,425**	**37,566,120**	**121,072,947**	**44,192,468**	**19,305,641**	**1,579,403**	**54,796,522**	**6,624,215**	**13,973,640**	**-19,398,942**	**66,212,051**	**16,110,988**	**121,703,191**

VI-2-1-2. *Environmental Data*

For the Turkish case, the input-output matrix sectors that are considered to be in the set of energy-related sectors are:

- Production of Oil and Natural Gas (PG)
- Coal Mining (CO)
- Refined Petroleum (RP)
- Electricity (EL)

Table VI-2 provides data on emissions by sectors of the Turkish economy. Table VI-3 gives a further detailed picture of the emissions from "electricity production" which is based on the fuel-type.[9]

Table VI-2: CO2 Emissions by Sectors (Turkey, thousand tones),

	2000	2001	2002	2003
Total (000 tones)	228,150	210,787	216,139	230,401
Energy-Fuel Combustion (000 tones)	211,399	194,286	198,658	212,571
Electricity Production	72,320	73,394	65,451	68,970
Industry	67,876	55,925	68,539	72,581
Transportation	36,228	36,171	34,418	37,373
Other (residential, agriculture…etc.)	34,976	28,795	30,249	33,646
Industrial Processes (000 tones)	16,752	16,501	17,482	17,831

***Source*: TURKSTAT**

Table VI-3: Emissions from Energy (Electricity) by Fuel-type (Turkey, thousand tones)

Fuel Type	**2000**	**20001**	**2002**	**2003**
Antracite	3,528	3,940	3,579	7,270
Lignite	40,082	39,306	32,226	26,255
Petroleum	8,517	7,769	7,234	9,268
Natural Gas	20,192	22,380	22,412	26,177
TOTAL	72,320	73,394	65,451	68,970

***Source* : TURKSTAT**

As one of the main sources of CO2 emissions, the model identifies the energy (fuel combustion). The emission coefficients related to this source are considered proportional to the usage of intermediate inputs (Equations 14 and 15). Therefore, the intermediate-flows between sectors become crucial in sector-wise/source-wise distribution of total CO2 emissions. Table VI-4 provides the sectoral input-output flows of the macro SAM presented in Table VI-1.

[9] Tables 3 and 4 are the most detailed information we could get at the time of the construction of our model.

Table VI-4: Intermediate Flows, SAM Turkey 2003 (thousand TRYs)

	Agriculture	Coal Production	Petroleum and Gas	Paper Production	Refined petroleum	Cement production	Iron and Steel	Electricity Production	Transportation	Other Economy
Agriculture	17,882,464.7	19,316.0	0.0	91,882.7	0.0	43.3	317.0	5,113.8	76,360.0	18,471,760.2
Coal Production	16,634.9	149.3	0.0	1,226.6	1,830.1	235,033.1	304,620.1	705,885.6	4,702.0	413,990.8
Petroleum and Gas	0.0	0.0	0.0	0.0	6,793,020.3	84,728.1	0.0	880,894.3	19,633.5	677,212.7
Paper Production	107,839.9	50.0	1,748.6	907,538.1	2,075.0	104,816.1	85,322.9	1,679.4	68,605.2	3,865,683.2
Refined petroleum	2,053,497.0	89,181.8	10,683.2	93,823.5	12,285.9	181,022.0	496,354.2	482,682.1	10,726,668.9	4,620,903.9
Cement production	50,038.9	122.8	1,009.7	524.4	309.6	318,402.7	10,054.7	0.0	0.0	4,299,254.5
Iron and Steel	14.8	4,277.9	16,235.3	38.6	2,534.6	34,011.6	3,789,101.2	3,646.2	2,256.8	10,738,214.8
Electricity Production	248,125.3	62,213.5	15,900.9	129,433.5	123,922.1	554,398.9	1,014,055.0	150,162.8	86,472.0	6,421,639.4
Transportation	1,271,039.4	26,294.2	23,296.8	201,332.3	757,743.3	285,855.7	958,434.3	307,609.1	3,444,859.9	14,568,612.9
Other Economy	13,014,811.7	223,135.0	69,298.2	760,346.7	393,572.2	822,318.2	2,436,056.2	514,073.9	13,372,045.7	126,751,809.8

The table already conveys information on the source and directions of flow of the energy and CO2 emissions in the production sectors of the economy. The electricity production sector creates the highest demand for coal and petroleum and gas as the primary energy inputs (The next two “individual” sectors that generate the highest demand for primary energy inputs are cement production (*CE*) and the iron and steel industries (*IS*)). The energy produced, is demanded by other sectors of the economy as an intermediate input to production (following the row of the electricity production (EL), we can trace the demand generated by sectors of the related column). Apart from the other economy (OE), the largest absorbent of the electricity energy produced arise as cement production (CE) and iron and steel industries (IS).[10] Likewise, transportation sector (TR) is the major source of demand for the refined petroleum in the economy.

We have made use of Tables VI-2, VI-3, and VI-4, as well as any other data available that could allow us to make rational assumptions in distributing the total 230,426 million tons of CO2 emissions to the sectors defined in the model. The general guidelines that we have followed in forming the sectoral distributions portrayed in Table VI-5 are as follows:

- A number of sectors have readily available statistics: CO2 emissions we attach to electricity production (EL) and transportation (TR) are the figures announced by TURKSTAT.
- For the sectors that have data on their energy demand, we have used an approximate proportionality on emissions: The share of agriculture in total energy demand is published as 2.39% (as of year 1999, data from MENR)
- Our related assumption is that, agriculture sector accounts for 2.35% of total CO2 emission from energy consumption. We have followed similar

[10] As announced by the Ministry of Energy and Natural Resources, of the 83.8 million TEP of total energy consumption in Turkey in 2003, with an amount of 26.9 million TEP, the industry sector has a share of 42%. The iron and steel production (IS) with a share of 30%, the cement production with a share of 18% and the chemicals production with a share of 18%, are the major sources of energy demand in industry.

approximation methods for the cement production (CE), paper production (PA), and iron and steel industry (IS).

- Otherwise, we have used the share of a particular sector in total value added, to approximate its emission figure. Coal mining (CO) is one sector that we have assigned the emission value of, under this method.
- The residential emissions are assumed to be equally shared by the final consumption of coal (CO) and refined petroleum (RP).

Table VI-5: Sectoral *CO2* Emission Allocations

CO_2 Emissions from Energy-Fuel Combustion (Gg)

	Electricity Production	Industry	Transportation	Other (Residential, agriculture..etc.)	Total
1990	30,325	41,224	26,420	29,205	**127,174**
1991	33,035	44,064	25,123	30,691	**132,914**
1992	37,959	43,271	25,842	32,094	**139,166**
1993	36,119	46,176	31,516	32,925	**146,736**
1994	42,459	41,798	29,946	29,571	**143,775**
1995	43,752	45,543	33,440	33,221	**155,955**
1996	47,290	56,683	35,584	34,505	**174,062**
1997	53,232	61,954	34,227	37,141	**186,554**
1998	59,100	60,555	32,456	33,928	**186,039**
1999	64,538	54,577	34,254	32,792	**186,161**
2000	72,092	64,976	36,231	35,013	**208,311**
2001	74,516	52,100	36,171	29,232	**192,020**
2002	68,815	63,322	34,418	30,771	**197,325**
2003	***68,970***	***72,581***	***37,373***	***33,646***	***212,571***
2004	70,498	73,989	41,553	37,337	**223,377**

Sectoral CO_2 Emissions in the Model (Gg)

Agricultural production (*AG*)	**5,000**
Coal Mining (*CO*)	**12,774**
Petroleum and Gas (*PG*)	**1,895**
Refined Petroleum (*RP*)	**44,178**
Electricity Production (*EL*)	**68,970**
Cement Production (*CE*)	**7,174**
Paper Production (*PA*)	**6,487**
Iron and Steel Production (*IS*)	**20,073**
Transportation (*TR*)	**37,373**
Other Economy (*OE*)	**8,646**
TOTAL	***212,571***

VI-3. Base Run

All alternative policy scenarios analyzed in this project are portrayed with respect to a base-run reference scenario. Having calibrated the parameter values, we have constructed a benchmark economy for the 2003-2020 period, under the following assumptions:

- Constant technology (calibrated parameters in the production functions are fixed)
- 2% annual total factor productivity growth rate on average (differentiated for agriculture and industry sectors)
- Exogenously determined foreign capital inflows
- Exogenous real interest rates
- Endogenous real exchange rate under the constraint of the current account balance
- Constant real wage rate
- Fiscal policy in accordance with the announced policy rule of targeted primary surplus.
- No specific introduction of environmental policy action/taxation/quota

Figure VI-3 and VI-4 portray the likely path of the real gross domestic product and total CO_2 emissions under the base-run, the reference model. As observed, the annual real GDP growth rate stays around 6% throughout the 2003-2020 period and the real GDP reaches to a value of 952.7 billion TRY (in constant 2003 prices) by 2020. Such a growth path is projected to generate an aggregate CO_2 emission level of 656.4 mtons in 2020.

As the decomposition analysis of Lise (2006) documents that, as in any other relatively fast growing economy, the biggest contributor to the rise in CO_2 emissions in Turkey is the expansion of the economy (scale effect). Therefore the growth projections become crucial in the analysis of CO_2 emissions. The recent projections of the OECD show that Turkey has an annual growth potential of above 7% (OECD, 2004). UNDP and the World Bank (2003) provide a projection of a six-fold increase in greenhouse gas emissions by 2025 with respect to 1990 level. The study foresees an annual increase of 5.9% in final energy consumption.

Figure VI-3: Base-run Real GDP (billion TRY, fixed 2003 prices).

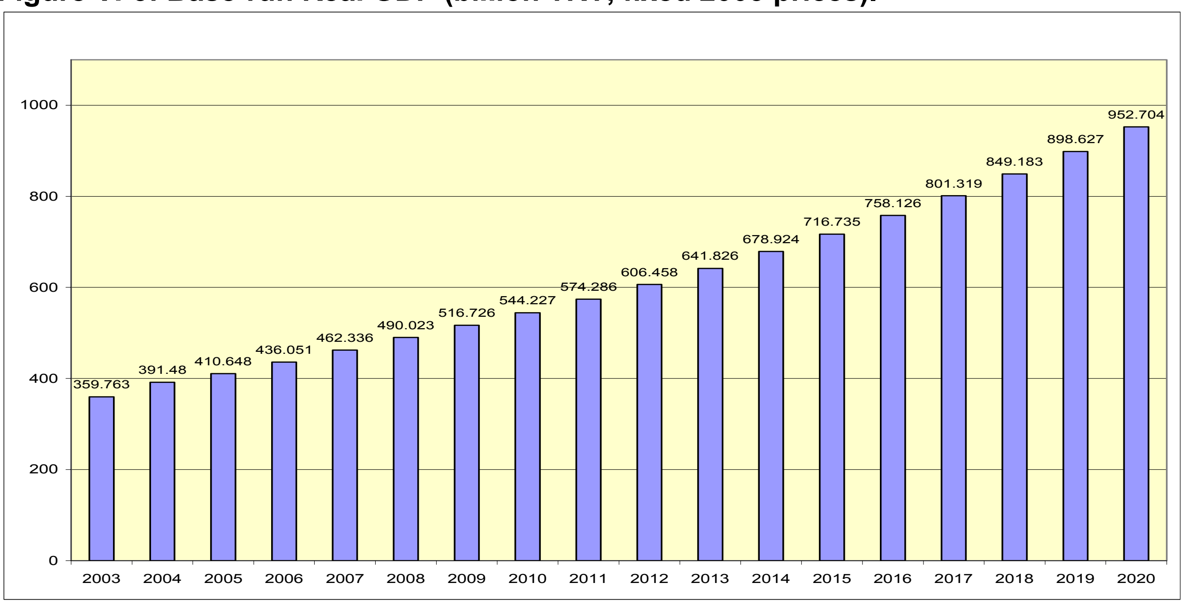


**Figure VI-4: Base Run Total CO2 Emissions from Energy (million tones)
(Model and TURKSTAT Projection**

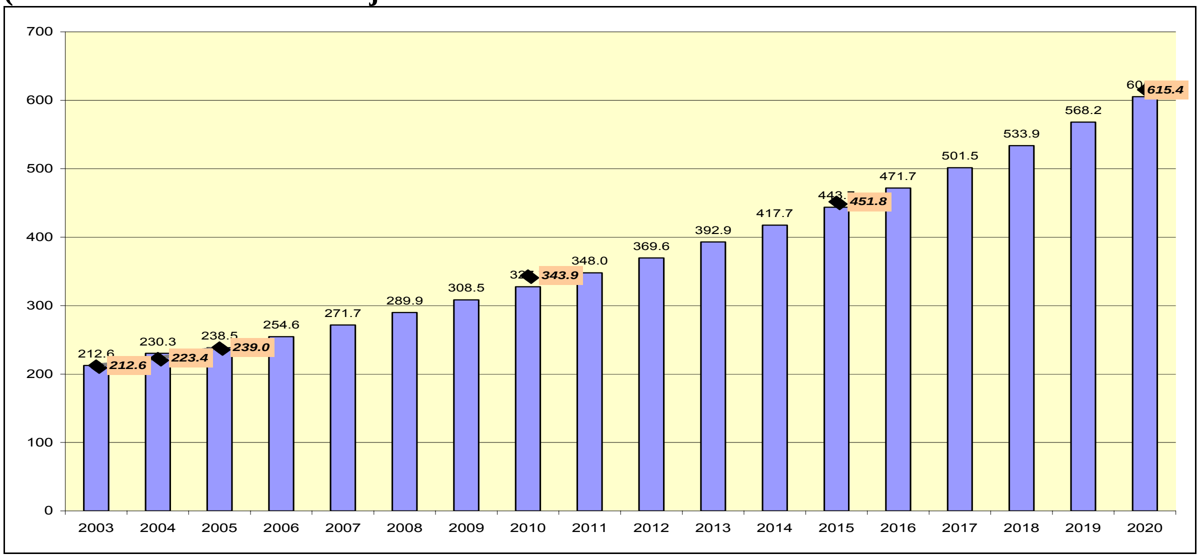
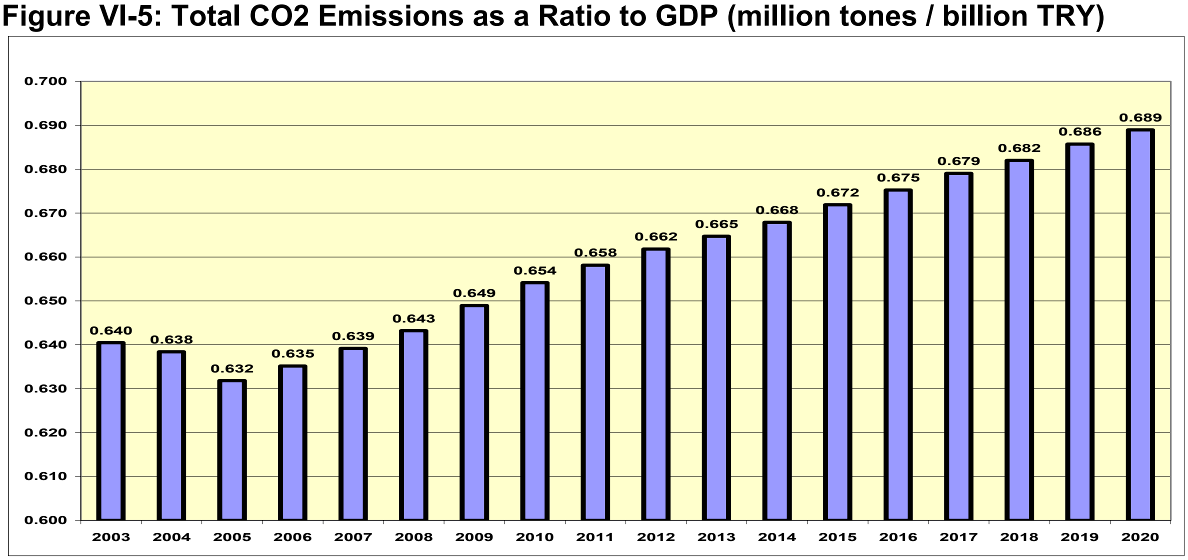


Figure VI-4 illustrates the CO2 emissions from energy (fuel combustion) as compared to point estimates of the same variable by the Turkish Statistical Institute (TURKSTAT). As the figure clearly indicates, the values are comparable to that of TURKSTAT, reported to reach 615.4 mtons of CO_2 by 2020. TURKSTAT's available projections are indicated as boxed values in Figure 6. For 2010 TURKSTAT's estimate is 343.9 mtons, and it is slightly higher than the model's projection of 324.2 mtons. For 2015 the model's projected emission level is 443 mtons, and is only 1.8% different from the TURKSTAT's estimate of 451 mtons. Thus, the model's base-run trajectory can be claimed to reflect the official emission estimates very closely.

Figure VI-5: Total CO2 Emissions as a Ratio to GDP (million tones / billion TRY)



Likewise, we can observe that with the projected economic growth, the sectoral emission values show an increasing trend throughout. To portray the evolution, Table VI-6 presents the sectoral CO2 emission values for a few selected years.[11]

Table VI-6. Base Run CO2 Emissions by Sectors (million tones)

	2004	2010	2020
AG -Agriculture	5.2	7.5	14.3
CO - Coal Mining	2.9	4.4	9.0
PG - Crude Petroleum, Gas	2.0	2.9	5.6
PA - Paper and Paper Products	6.9	10.7	21.9
RP - Refined Petroleum Products	37.1	51.8	94.0
CE - Cement Production	7.8	11.4	21.1
IS - Iron and Steel	22.0	35.3	75.6
EL - Electricity Production	76.1	105.9	182.2
TR - Transport Services	39.4	57.5	112.2
OE - Other Economy	9.3	14.1	27.0
TOTAL	**208.8**	**301.5**	**563.1**

The reference base-run path, also provides a number of other statistics, such as CO2 emissions per output in emission-critical sectors or CO2 emissions per electricity output produced. Figures VI-6-8 present a set of such graphics available.

[11] Table VI-6 only presents emissions that result from energy usage through production, leaving out emissions from final consumption and from industrial processes.

Figure VI-6. CO2 Emissions per Output in Steel Manufacturing (million tones / billion TRY)

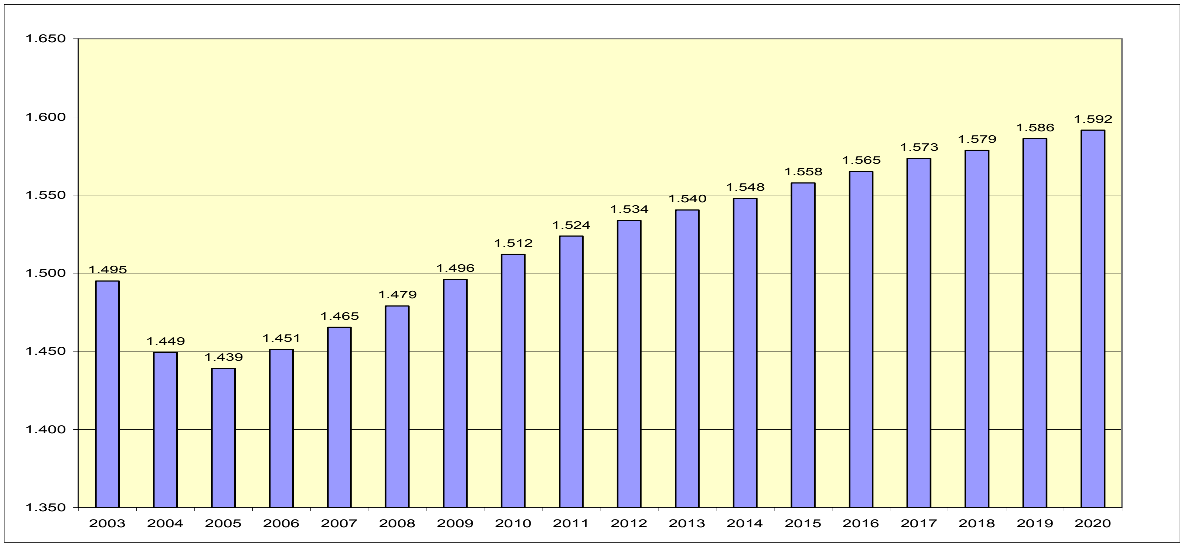


Figure VI-7. CO2 Emissions per Output in Cement Sector (million tones / billion TRY)

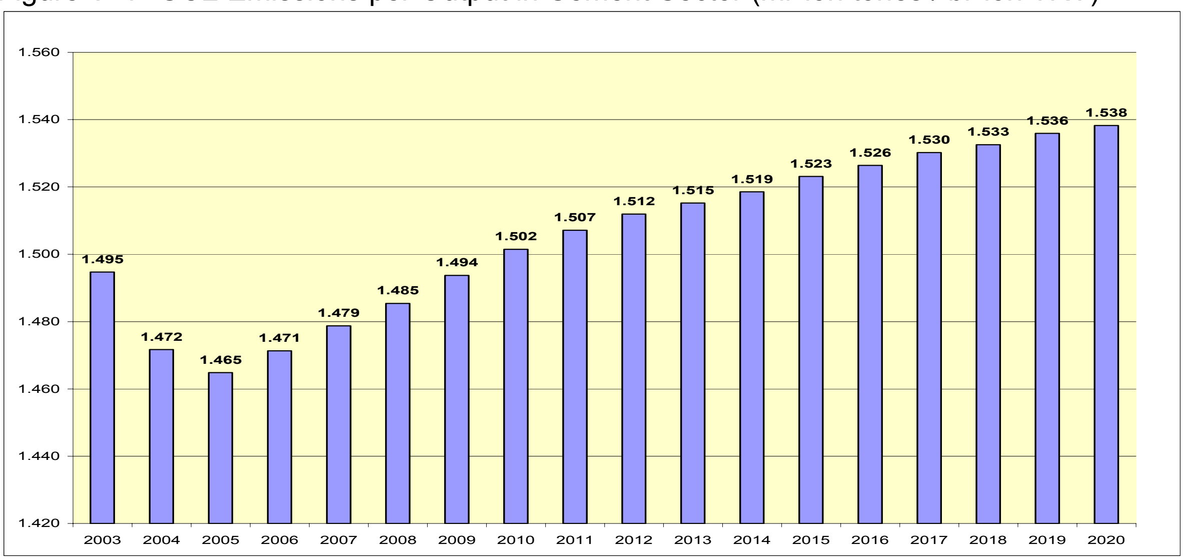
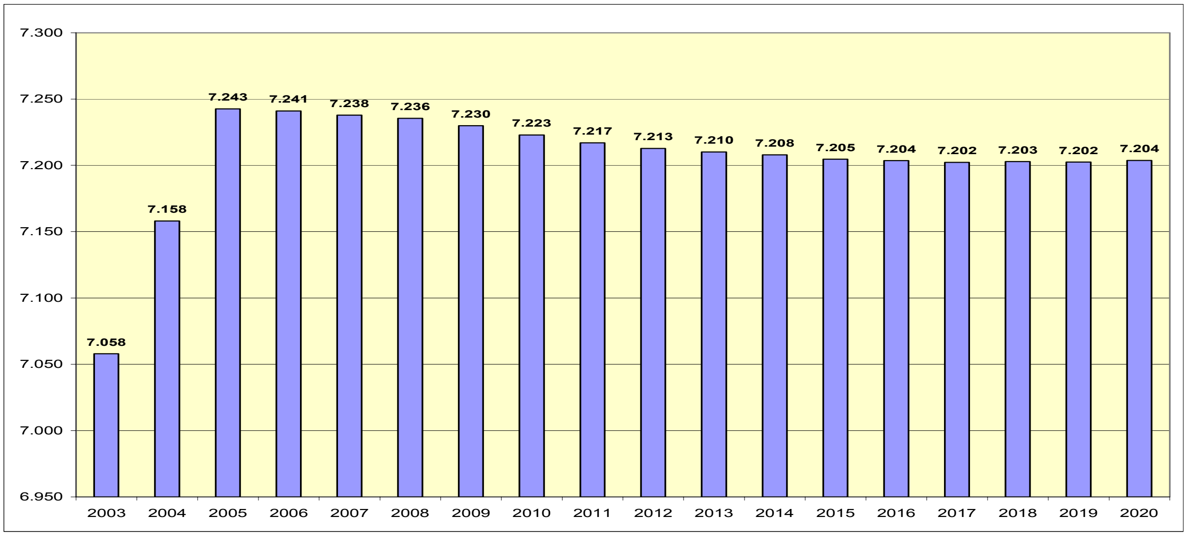


Figure VI-8: CO_2 Emissions per Output in Electricity Sector (million tones / billion TRY)



VII. ANALYSIS OF ALTERNATIVE ENVIRONMENTAL POLICY SCENARIOS

Now we turn to implementing alternative environmental policy scenarios using our modeling framework. Given our model's algebraic structure and the key parameter specifications, the purpose here is to answer "what if?" type of questions to achieve possible environmental objectives.

As stated in our modeling framework, energy-related CO_2 emissions represent the dominant GHG pollutants in Turkey. On the other hand, CO_2 emission trajectory suffers from large uncertainties, considering the complexities of the production-transformation processes, and the sequence of economic interactions that are likely to be materialized over the long run. Under these conditions the econometric methods can be hardly reliable in the design of energy consumption and CO_2 emission scenarios. Given these conditions, sensitivity-based analyses offer one possible method on how to design and implement CO_2 abatement strategies. The algebraic model at hand offers a variety of choices and yields a menu of substitution possibilities among alternative environmental policy strategies and as such will offer important guidelines to the policy makers on the likely consequences of their policy choices.

A wide range of possible alternatives can be envisaged given our methodology. Such alternatives include, but not limited to, emission taxes, abatement subsidies, emission quotas, tradable emission allowances, environmental investment promotion and performance standards. These policies can be used individually or together and can be designed in a direct or indirect fashion.

In what follows, we will group our policy interventions into two broad categories: *first,* we will implement tax and quota based instruments with no additional abatement investments. That is the production-emission structure of the economy will remain as it is. The environmental tax revenues (or subsidy costs) will be administered through the central fiscal budget with no further design on investments to change the energy use and production structure of the economy. Under the *second* categorization a more active environmental policy stance will be taken and the implemented policy instruments will be complemented with an active abatement investment policy. The abatement investment will be funded from either environmental tax revenues or from other sources, such as foreign credit and/or national savings.

VII-I. Environmental Policy Instruments with No Further Abatement Investment

First we will have a straight approach and ask the question of "what will the economic impacts of maintaining lower CO2 emissions in the aggregate for the Turkish economy?" As was indicated in our characterization of the "base-run" path, our estimates for the Turkish economy over 2005-2020 reveal that the annual rate of growth will be around 6% and the aggregate CO2 emissions will likely to reach to 356 million tones in 2010 and to 656.4 million tones by the end of 2020. This CO2 emission level originates fro three main sources: (i) from energy-related consumption during production activities; (ii) from industrial processes not related with energy use directly; and (iii) from private household consumption of CO2 polluting goods and services. The energy-related production emissions, in turn, are derived from three sources: coal burning, oil and gas burning, and utilization of refined petroleum products (see above section on model description and the accompanying data).

VII-1-1. Implement Carbon Emission Quotas Directly

What if one imposes a straightforward and direct quota on the Turkish industries complemented by pollutant fees?

What happens to the economic variables of direct quotas on aggregate CO2 emissions over the 2005-2020 time horizon?

Assuming that such quotas are enforced with the accompaniment of pollutant fees, what will be the tax burden of such fees? How will this burden affect the producers and investors in their production plans? And Consumers?

What will be the net effect of this policy framework on government's fiscal balances, on trade balance and on unemployment?

These are the questions that we would kike to tackle in this first set of scenarios. To this end, we impose a straight aggregate quota of three alternative levels on the 2005-2020 growth path of the Turkish economy:

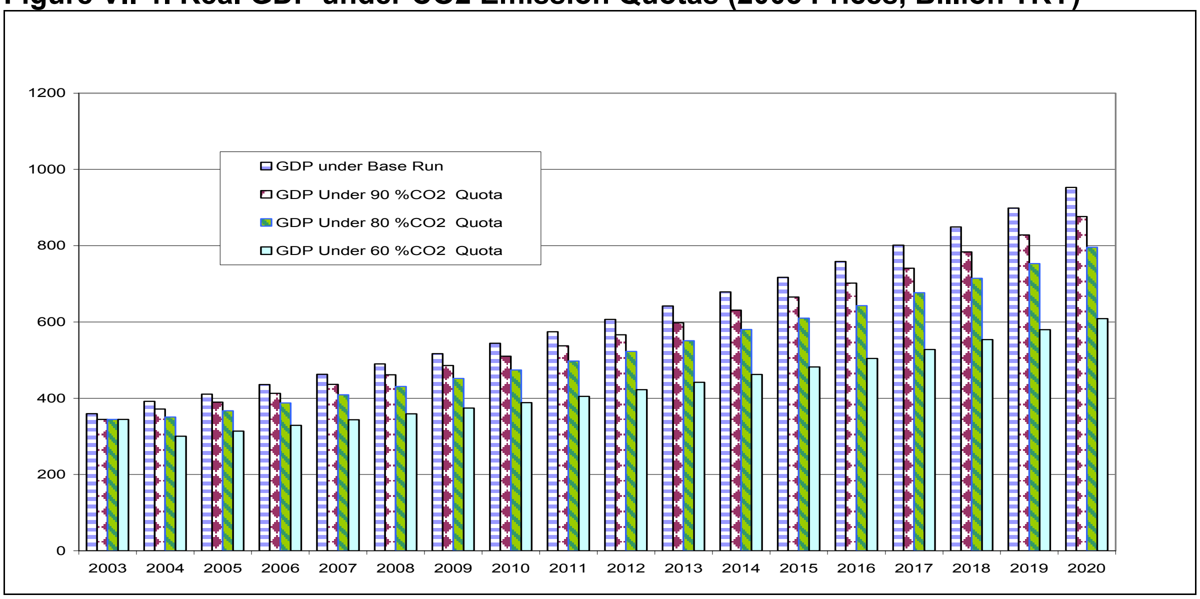
(i) 90% quota;
(ii) 80% quota;
(iii) 60% quota

Thus under the first scenario the aggregate CO_2 emissions are planned to be reduced to 90% of the projected 656 mtons, i.e to 590 mtons; and under the second scenario to 524 mtons, so on. To enforce the quotas, a pollutant fee system is activated. The fees are to be paid by the *polluter pays principle* and are to be collected by the fiscal authority directly. No other possible use of such funds for further environmental policy such as abatement investments or any subsidization is envisaged. Thus in a nutshell, this scenario gives the very basic, direct approach in achieving CO_2 emission targets. The simplicity of this scenario is desirable as its results will offer us the most direct and basic outcomes of a very clear policy instrument to achieve the CO_2 goals in the most straightforward manner. We then build over this simple framework and reach more complex policy packages, yet at each level the outcomes derived from this basic framework will be used as a guideline and a reference point.

Production and emission effects of CO2 quotas

In Figure VII-1 we portray the likely paths of the real gross domestic product (in 2003 prices) under the base path and the three alternative CO2 emission quota levels. As observed the GDP rate of growth is slower under the pure CO2 quota scenarios. If a quota of 90% is envisaged the rate of growth of GDP is reduced an total GDP falls to 852 billions TRY (in 2003 prices). This is a reduction of 10.5% in comparison to the base run 2020 value. In contrast, if the quota is set at 60% of aggregate emissions of the base path, the GDP of 2020 is observed to fall to 602 billion TRY. This implies a reduction of 36.8%.

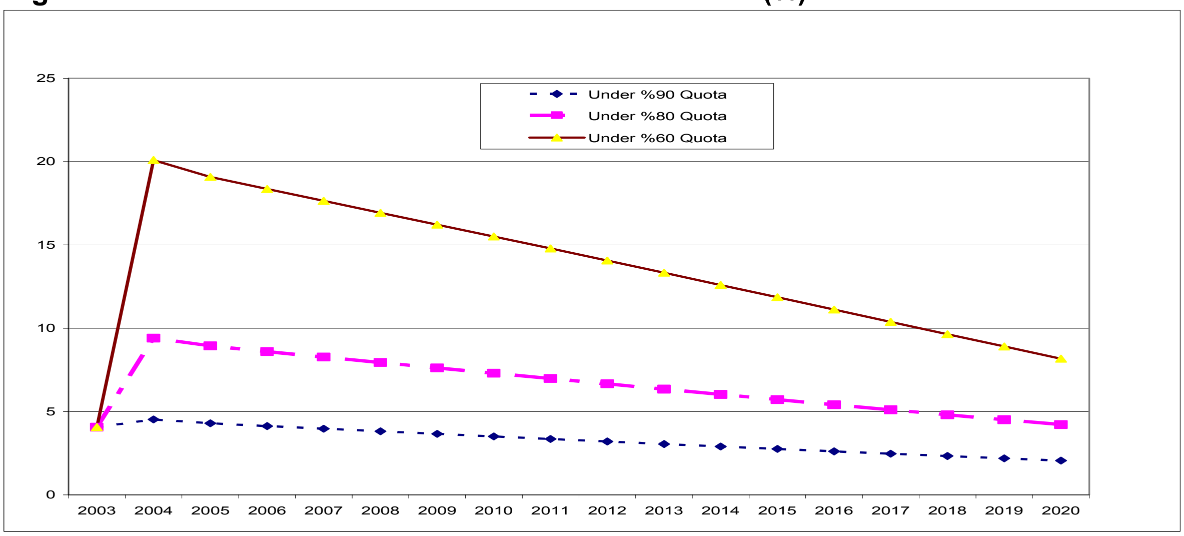
Figure VII-1. Real GDP under CO2 Emission Quotas (2003 Prices, Billion TRY)



Thus, our results indicate that the CO_2 quotas affect the economy in a non-linear fashion. Higher rates of CO_2 restrictions have an increasingly higher burden with subsequent production losses. The overall elasticity of emission gains to GDP losses is -1.1, that is a 40% reduction in CO_2 emissions through an outright quota is associated with a 36.8% loss of GDP. In this case, summing over the whole analyzed period, 2006 – 2020, *the cumulative loss of GDP amounts to 1,145 billions 2003 TRY*.

The scenario is accompanied with a CO2 tax to enforce the emission quotas. In Figure VII-2 we display the path of the fiscal revenues from CO2 pollutant fees (CO2 taxes) as a ratio to the GDP. The figure discloses the tacit dilemma face by the Turkish environmental policy very clearly: restricting CO2 emissions in a growing economy is very costly and very difficult. Given strong population pressures and the high rates of return to capital investment, Turkey is still on its upward path towards rapid industrialization, with consequent high rates of CO2 emissions. Attempts to restrict the rate of growth of this path using fiscal measures alone will generate very high tax rates. In other words the sensitivity of the production units to fiscal tax measure is very low.

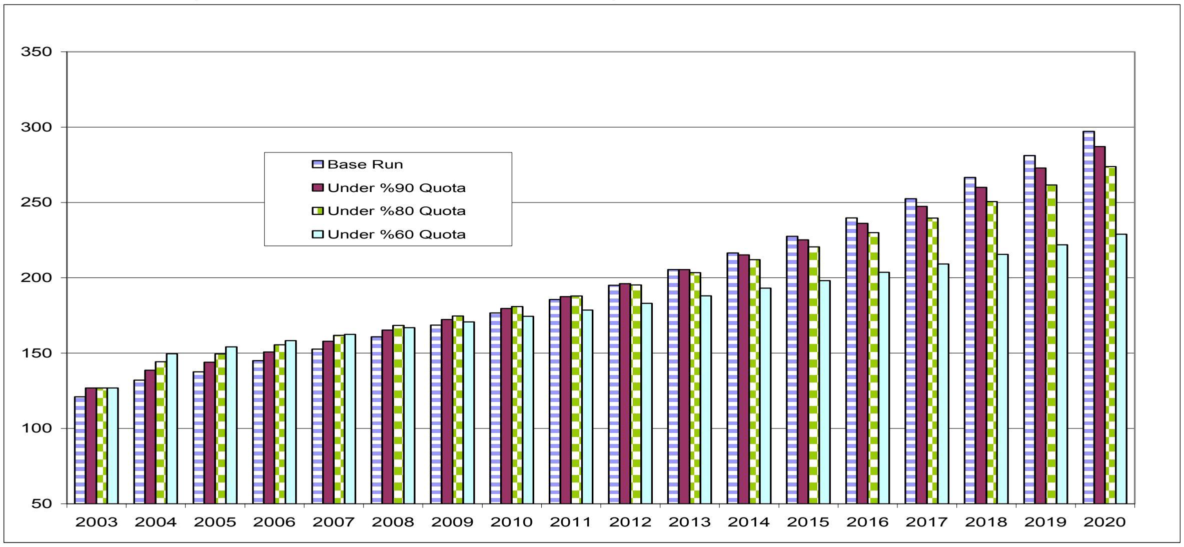
Figure VII-2. CO2 Tax Revenues as a Ratio to the GDP (%)



As the figure discloses, total CO2 tax revenues as a ratio to the GDP is marginal for the 90% quota target. Yet, for enforcing a quota of 80% the necessary tax burden is10% upon implementation and remains above 5% for the remaining of the projected time horizon. If a quota of 60% is envisaged the tax burden is 20% to the GDP and falls only to 12% in 2020. Thus, the model results suggest that for a return of 40% reduction in aggregate emissions in 2020, a CO2 tax of 12% to the GDP is to be implemented. No wonder, this is an important interference to the economy.

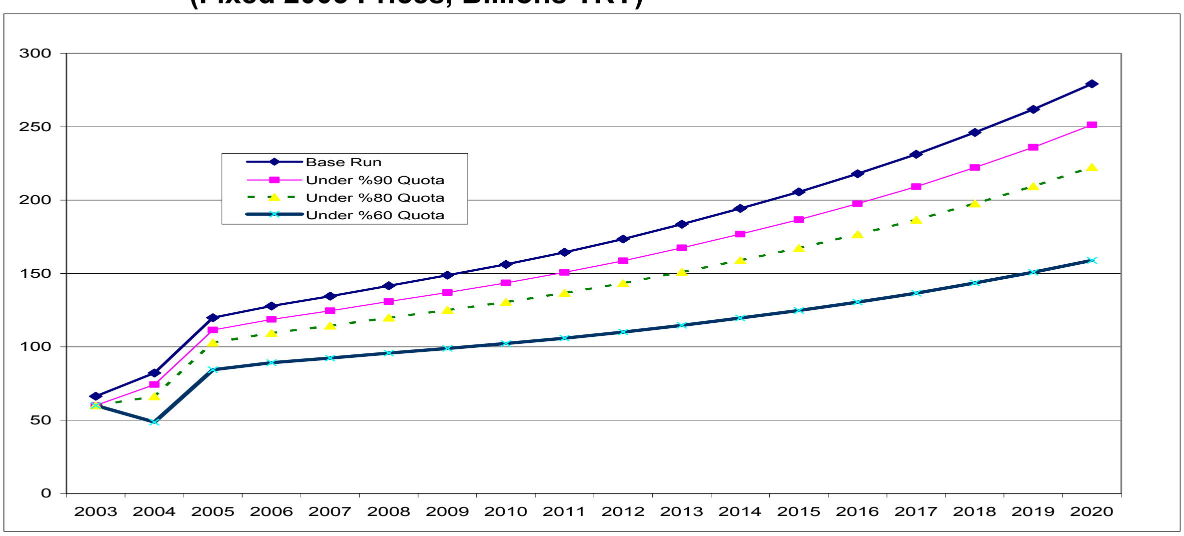
The tax revenues are transferred directly to the fiscal budget with no further environmental policy in this set up. Thus the government receives a substantiall gain in its aggregate tax revenues. Figure VII-3 gives the extend of this transfer.

Figure VII-3. Government Revenues under Alternative CO2 Quotas (Real 2003 Prices Billions TRY)



The increase of the fiscal revenues generates strong crowding-out effects and calls for reductions in private investments. Private investment expenditures are cut by 4% under the 90% quota but the rate of reduction is very non-linear as before. Under the 60% CO_2 quota, the private investment expenditures are reduced almost by half. We depict these developments in Figure VII-4 below.

Figure VII-4. Private Investment Expenditures under Alternative CO2 Quotas (Fixed 2003 Prices, Billions TRY)



The fall in private expenditures is the major reason of the fall in aggregate GDP and the consequent rise of unemployment. These macroeconomic outcomes of course are very crude approximations of reality. Needless to mention, the outright transfer of CO2 tax monies to the central budget with no further environmental policy in action clearly is inferior to one that can be complemented with further alternatives. The current scenario at hand is designed entirely for this purpose: to show the economic costs of simplistic environmental policy approaches and the need for a comprehensive policy package. By displaying the explicit costs of the quota regime, the model results suggest hints towards the design of the first best alternatives.

Before turning towards that issue, however, it would be informative to study the microeconomic (sectoral) results of the CO2 policy at hand. In Table VII-1 below we display the sectoral outputs levels of the production sectors distinguished in our model economy.

One observes that the most significant fall in production is felt by the “Refined Petroleum Products” sector. In 2020 this sector contracts by 47% if a quota of 60% is implemented. The “Iron and Steel” production is also adversely affected in a very significant fashion. Under the same setting the sectoral production is observed to contract by 40% The cement production likewise falls by 40.9% and the electricity production loss reaches to 40% as well.

Agriculture and paper and paper products sectors suffer similar losses at the rate of 37%. Clearly the loss in production and the decline in investment expenditures reinforce each other and result in a significant GDP loss for the economy.

Table VII-1. Sectoral Output Under Alternative CO2 Quotas (Fixed 2003 Prices, Billions TRY)

	Base Run			Under 90% Quota			Under 80% Quota			Under 60% Quota		
	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020
AG -Agriculture	82.1	110.0	191.2	76.3	101.6	174.9	70.3	92.8	158.0	57.3	74.1	121.9
CO - Coal Mining	2.0	2.5	4.0	1.8	2.2	3.6	1.6	2.0	3.2	1.2	1.5	2.3
PG - Crude Petroleum, Gas	1.3	1.9	3.6	1.2	1.8	3.4	1.2	1.7	3.2	1.1	1.5	2.7
PA - Paper and Paper Products	4.9	6.8	12.5	4.5	6.2	11.4	4.1	5.7	10.2	3.3	4.4	7.8
RP - Refined Petroleum Products	26.0	35.5	65.0	22.4	30.8	57.4	18.9	26.2	49.8	12.0	17.5	35.6
CE - Cement Production	5.6	7.6	13.7	5.1	6.9	12.4	4.6	6.2	11.0	3.5	4.6	8.1
IS - Iron and Steel	16.0	23.3	47.5	14.4	20.8	42.4	12.7	18.4	37.3	9.4	13.3	26.8
EL - Electricity Production	11.2	14.7	25.3	10.3	13.4	22.9	9.3	12.0	20.3	7.3	9.2	14.9
TR - Transport Services	80.2	109.4	199.2	75.7	102.5	183.9	71.0	95.3	168.1	60.5	79.4	133.6
OE - Other Economy	467.5	612.3	1058.4	433.8	563.0	961.5	398.7	511.6	860.4	322.0	398.4	634.6

In the next table, we display the savings of CO2 emissions at the sectoral level. The sectoral emission paths follow the production paths very closely, yet significant substitution effects are also observed. Such substitution effects are the direct result of price effects signaling the producers' possibilities for cost minimization under alternative input use.

Table VII-2: Sectoral CO2 Emissions Under Alternative CO2 Quotas Million tones)

	Base Run			Under 90% Quota			Under 80% Quota			Under 60% Quota		
	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020
AG -Agriculture	5.2	7.5	14.3	4.9	7.0	13.2	4.6	6.5	12.1	3.9	5.5	9.9
CO - Coal Mining	2.9	4.4	9.0	2.8	4.2	8.4	2.6	3.9	7.8	2.3	3.4	6.6
PG - Crude Petroleum, Gas	2.1	2.9	5.6	1.8	2.5	4.9	1.5	2.1	4.3	0.9	1.4	3.1
PA - Paper and Paper Products	7.2	10.7	21.9	6.7	10.0	20.3	6.3	9.4	18.6	5.4	7.9	15.1
RP - Refined Petroleum Products	38.2	51.8	94.0	32.6	44.7	82.7	27.2	37.8	71.7	17.0	24.9	51.5
CE - Cement Production	8.3	11.4	21.1	7.5	10.3	19.0	6.7	9.2	16.8	5.0	6.8	12.4
IS - Iron and Steel	23.0	35.3	75.6	21.1	32.2	68.4	19.2	29.0	61.1	15.1	22.4	46.2
EL - Electricity Production	81.1	105.9	182.2	71.2	93.0	160.8	61.4	80.1	139.5	42.4	55.1	97.3
TR - Transport Services	39.9	57.5	112.2	37.7	54.1	104.1	35.5	50.6	95.8	30.6	43.3	78.8
OE - Other Economy	9.9	14.1	27.0	9.4	13.2	24.9	8.8	12.3	22.7	7.6	10.3	18.0

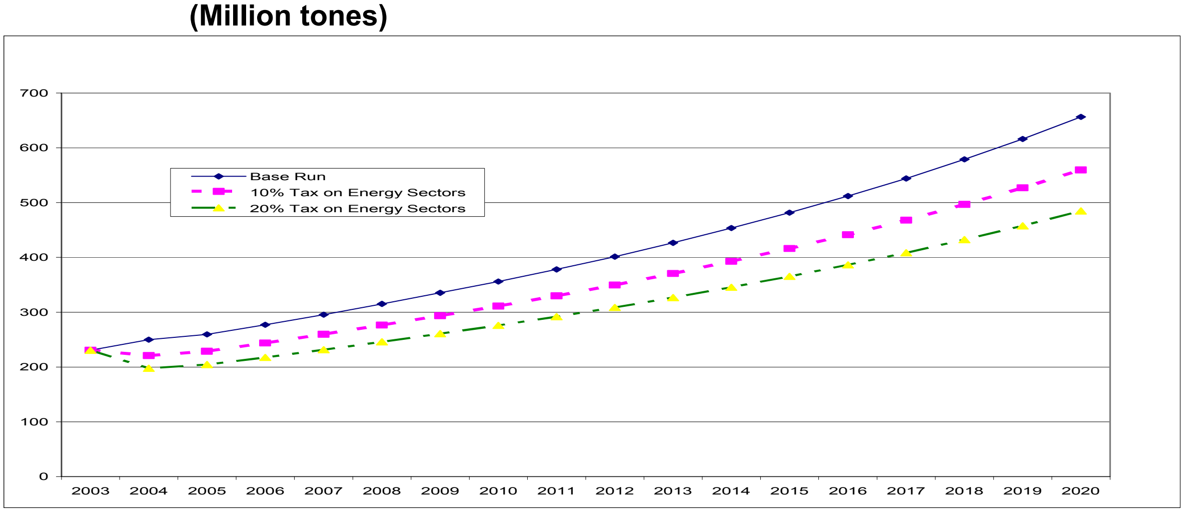
To study such micro substitution possibilities we next turn our attention to an energy tax, rather than carbon tax.

VII-1-2. *Economic effects of taxing energy input use in production*

Now we switch to taxing energy input use. As recalled, our framework admits three sources of energy inputs: coal, petroleum and gas, and electricity. Given the substitution possibilities between energy sources and factor use (capital and labor), the cost minimization procedures will signal the producers to save on energy utilization and thereby reduce CO2 emitted. We implement the energy taxation policy at two levels: 10% tax and 20% tax. As before all tax revenues are transferred to the central budget with no further environmental policy design.

The energy taxation at 10% leads to a reduction of total CO2 emissions by 14.8% by 2020. If the tax rate is set at 20%, the abatement rate reaches to 25.8%. Figure VII-5 below depicts the path of aggregate CO2 emissions under alternative taxation of energy input use.

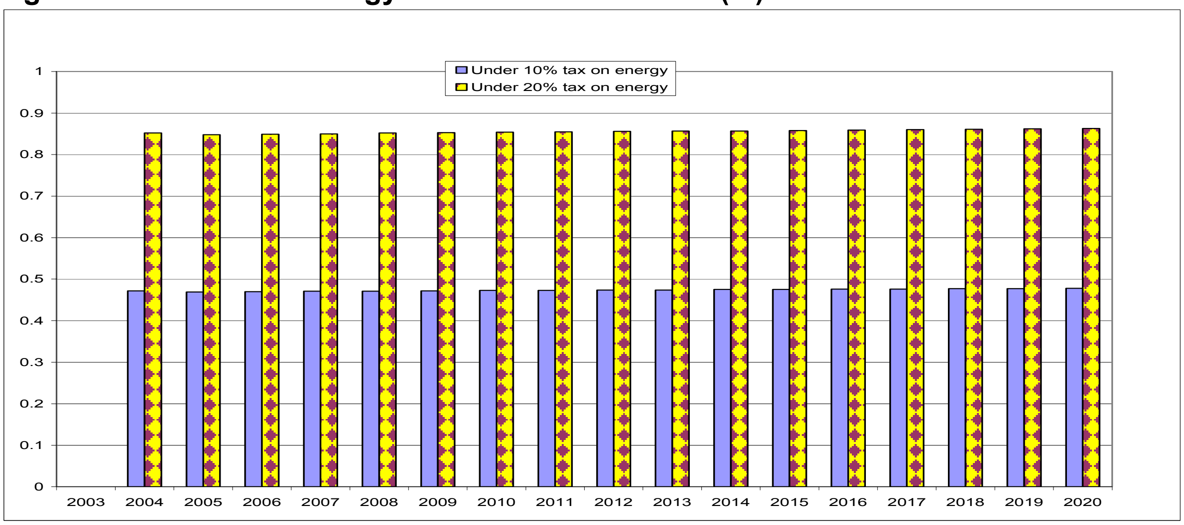
Figure VII-5. Total CO2 Emissions Under Alternative Energy Tax Scenarios (Million tones)



Thus, the energy taxation seems to have higher efficiency in combating CO2 pollution at the aggregate level in contrast to taxing overall emissions. Since the major source of CO2 pollutants originate from energy use, a taxation policy destined to economize on energy intensities seem to produce more efficient results to this end.

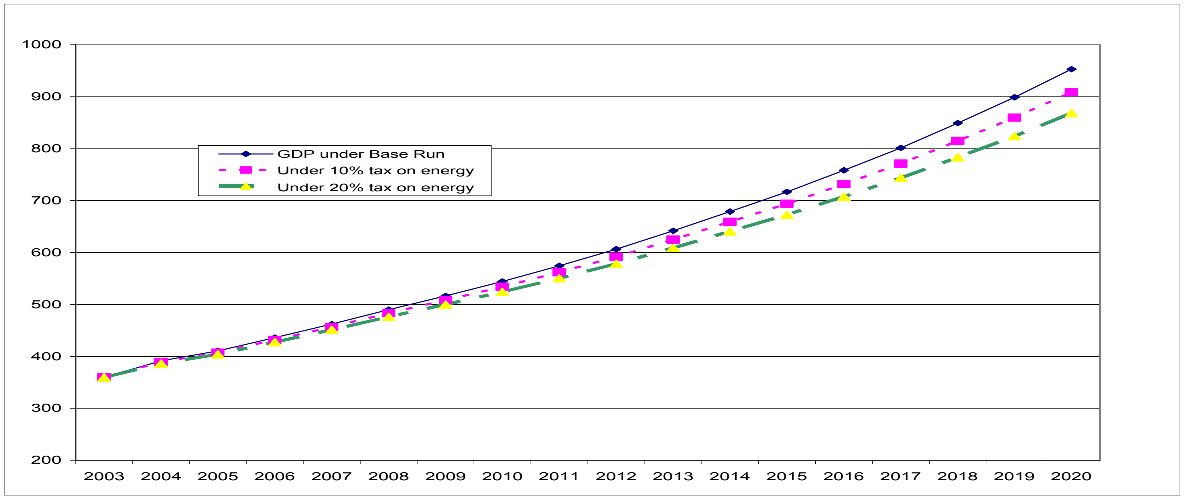
The overall tax burden of the current policy further illustrates this point. The model results suggest that the fiscal tax revenues from a 10% energy tax reach to only 0.48% of the GDP, and that from the imposition of 20% tax is 0.85% of the GDP. Thus in contrast to the significant burden of overall carbon taxes experienced in the previous scenarios, the energy taxation seem to carry lesser distortion to the domestic economy. See Figure VII-6.

Figure VII-6. Ratio of Energy Tax Revenues to GDP (%)



The GDP level likewise is affected less. The loss in GDP from the imposition of a 20% energy tax rate is 8.8% in 2020 in comparison to the base run (business-as-usual). Thus to summarize, the model results suggest that the 20% energy taxation reduces overall CO2 emissions by 25.8% and is accompanied by a loss of aggregate GDP by 8.8% over the base run by 2020. In contrast the same figures were 14.8% CO2 abatement rate in return to 10% energy tax and a loss of 4.6% in GDP level in 2020. Figure VII-7 below depicts the path of the gross domestic product under alternative energy tax scenarios.

Figure VII-7. GDP under Alternative Energy Tax Scenarios (2003 Prices, Billions TRY)



The energy taxation policy succeeds in reducing the overall CO2 emission levels, yet targeting reductions in the composition of CO2 emission sources prove more difficult. In Figure VII-8 and VII-9 below we portray the model solutions of the sources of CO2 emissions under the base run versus the 20% energy taxation policy over time. The figures suggest that although the overall CO2 emissions could have been reduced, the distribution of the sources of CO2 emissions across energy use, household consumption and from industrial processes remain relatively stable. This relative stability is not surprisingly related with the existing techniques of production and the relative shortness of the modeled time span. Simply put, the time horizon is not sufficient for the producers to adjust to the new policy environment and to administer the necessary changes in their input mix. Over a longer time horizon surely one should expect a more diversified composition of CO2 emissions.

Figure VII-8. Sources of CO2 Emissions under Base Run (Million tones)

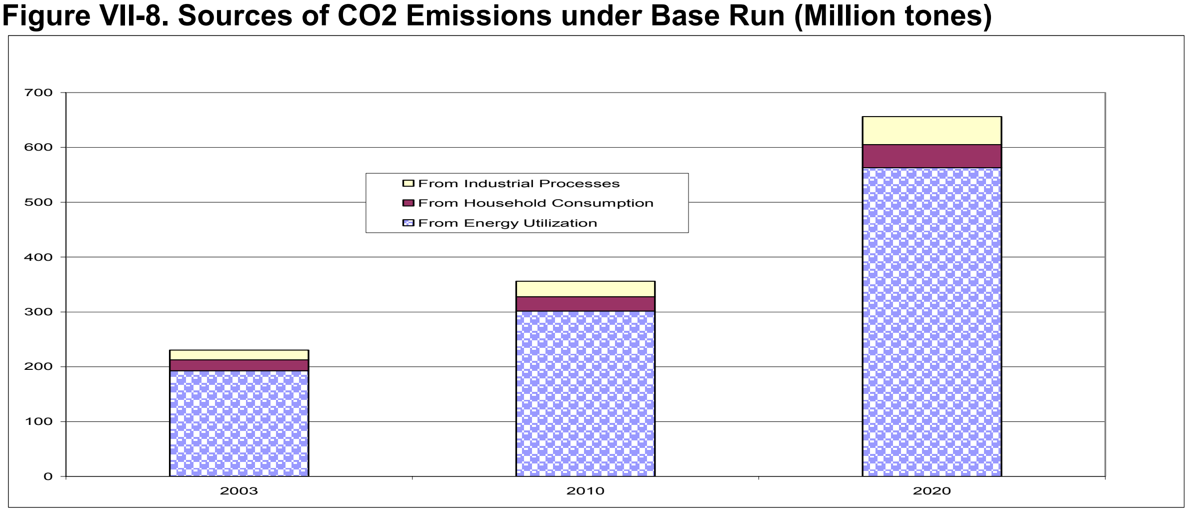
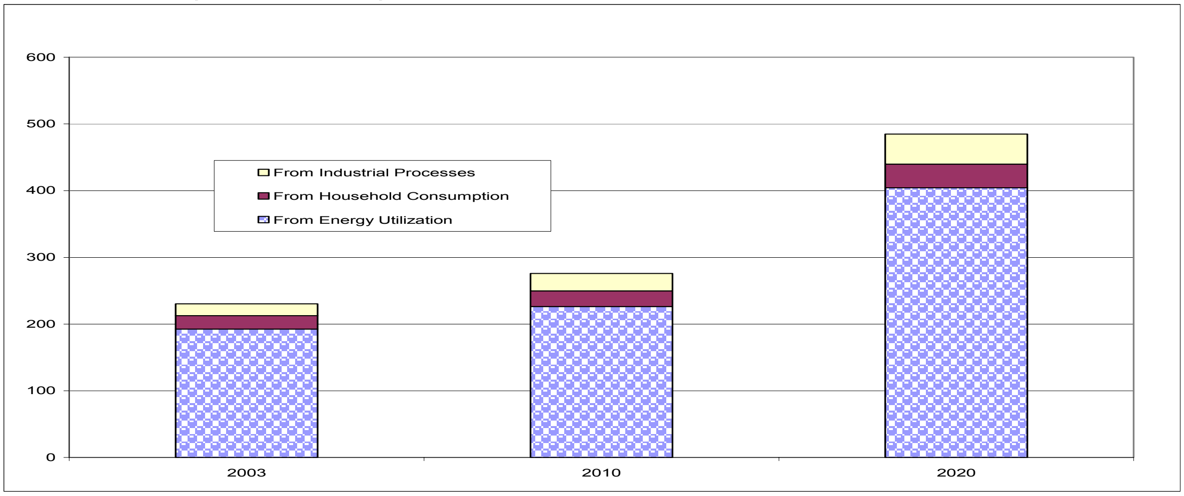


Figure VII-9. Sources of CO2 Emissions under 20% Tax on Energy Utilization (Million tones)



The sectoral incidences of the energy tax scenarios are given in Table VII-3. It is shown that due to a taxation of 20% for instance, the sectoral output loss is relatively less. In comparison to the base run values of 2020, "Iron and steel" production is reduced by 16%; and its emissions are reduced by 28.2%. (See Tables VII-3 and VII-4 below). Similar analyses report that for the Cement production output loss is 12.4% with a sectoral emission reduction of 25.1% in return to the same taxation policy.

With the same policy, the output loss incurred in Refined Petroleum Products is 22% together with a 23.8% reduction in the sector's CO2 emissions. Comparable results can be further read from Tables VII-3 and VII-4 below which summarize the sectoral output reductions observed in exchange for the CO2 abatement rates achieved under the alternative energy taxation policy regimes.

Table VII-3. Sectoral Output Under Alternative Tax Rates on Energy Use (Fixed 2003 Prices, Billions TRY)

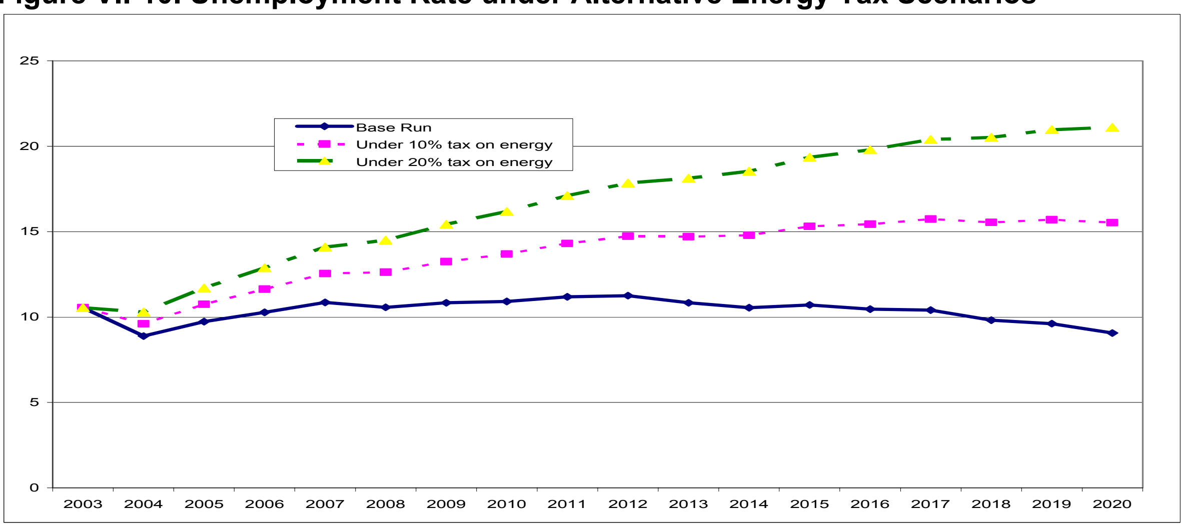
	Base Run			Under 10% tax on energy use			Under 20% tax on energy use		
	2005	2010	2020	2005	2010	2020	2005	2010	2020
AG -Agriculture	82.1	110.0	191.2	81.9	108.8	184.4	81.6	107.6	178.1
CO - Coal Mining	2.0	2.5	4.0	1.8	2.2	3.4	1.7	2.0	3.0
PG - Crude Petroleum, Gas	1.3	1.9	3.6	1.2	1.7	3.2	1.1	1.5	2.9
PA - Paper and Paper Products	4.9	6.8	12.5	4.9	6.7	12.0	4.9	6.6	11.6
RP - Refined Petroleum Products	26.0	35.5	65.0	23.6	32.0	57.1	21.7	29.1	50.7
CE - Cement Production	5.6	7.6	13.7	5.5	7.3	12.8	5.3	7.0	12.0
IS - Iron and Steel	16.0	23.3	47.5	15.3	22.0	43.3	14.7	20.8	39.9
EL - Electricity Production	11.2	14.7	25.3	10.1	13.1	21.9	9.2	11.8	19.2
TR - Transport Services	80.2	109.4	199.2	79.0	107.0	190.4	77.9	104.8	182.6
OE - Other Economy	467.5	612.3	1058.4	463.7	599.9	1005.5	460.0	588.3	958.2

Table VII-4. **Sectoral CO2 Emissions under Alternative Tax Rates on Energy Use (Million tones)**

	Base Run			Under 10% tax on energy use			Under 20% tax on energy use		
	2005	2010	2020	2005	2010	2020	2005	2010	2020
AG -Agriculture	5.2	7.5	14.3	4.6	6.6	12.4	4.1	5.9	10.9
CO - Coal Mining	2.9	4.4	9.0	2.4	3.6	7.2	2.0	3.0	5.9
PG - Crude Petroleum, Gas	2.1	2.9	5.6	1.7	2.4	4.6	1.5	2.1	3.8
PA - Paper and Paper Products	7.2	10.7	21.9	6.4	9.5	19.1	5.7	8.4	16.7
RP - Refined Petroleum Products	38.2	51.8	94.0	34.2	46.0	81.6	30.9	41.3	71.6
CE - Cement Production	8.3	11.4	21.1	7.3	10.1	18.2	6.6	9.0	15.8
IS - Iron and Steel	23.0	35.3	75.6	20.0	30.4	63.6	17.6	26.5	54.3
EL - Electricity Production	81.1	105.9	182.2	67.8	87.5	145.9	57.6	73.6	119.1
TR - Transport Services	39.9	57.5	112.2	35.3	50.7	97.5	31.6	45.2	85.6
OE - Other Economy	9.9	14.1	27.0	8.8	12.4	23.3	7.9	11.1	20.4

These results need to be contrasted with the very adverse effects of the current policy on the employment levels. The results indicate significant unemployment rates under the taxation regimes. The rate of open unemployment is observed to reach 15% under the 10% tax rate, and remains above 20% for the imposition of the 20% tax rate on energy use. In contrast, the base run path reveals a rate of unemployment of around 10% for most of the modeled time horizon.

Figure VII-10. Unemployment Rate under Alternative Energy Tax Scenarios



The rise of the unemployment rate under this scenario is due to the imposed distortions on cost minimization by introducing input taxes. To the extend that labor is complementary to energy use, the consequent rise in the costs of energy use leads fall in the demand for labor as well. With limited substitution possibilities in factor mix in the medium run, producers meet the increased energy costs by cutting demand not only for energy use, but also for labor employment, as well. The former reduction achieves in reducing CO2 emissions, yet at the cost of increased unemployment of labor.

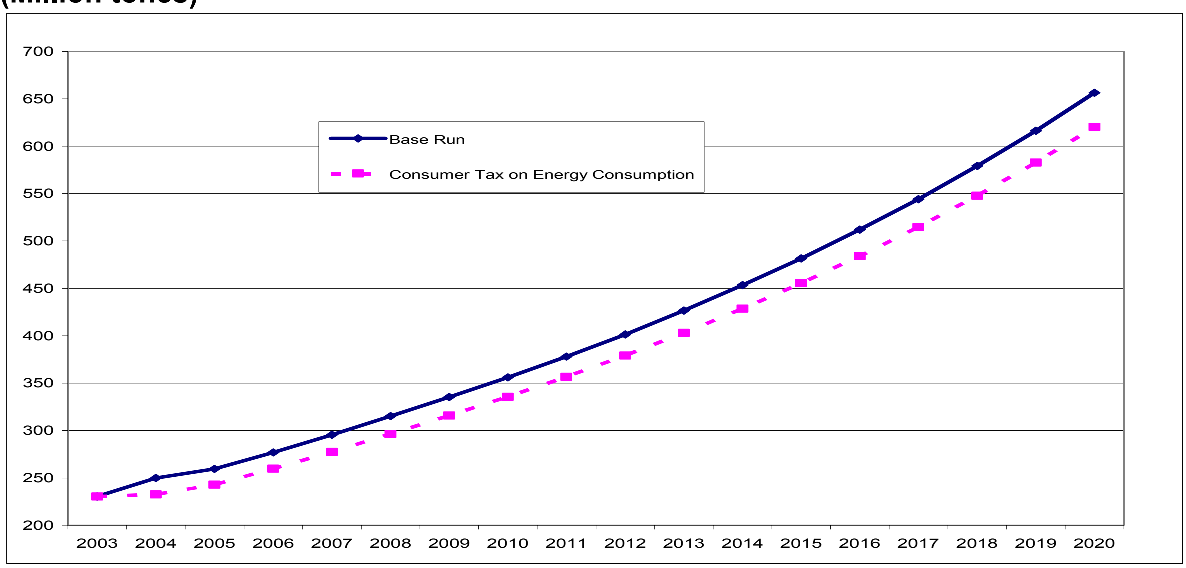
These results suggest that a proper mix of environmental taxation should be accompanied with *reductions in labor taxes* and/or *increased subsidization to labor employment.* Such a policy mix seems to be a superior policy in achieving both CO2 abatement targets and maintaining employment rates across sectors.

VII-1-3. *Economic effects of Consumption tax on Energy use*

We now turn to the consumption activities and implement a similar taxation policy on consumers. Given our findings thus far suggesting that taxing energy use in production would have strong effects on CO2 abatement, we would like to test whether similar results can be obtained by imposition of a similar tax on consumers. To this end we impose a 100% tax on energy demand by the private consumers. As before the tax revenues are assumed to accrue directly to central budget.

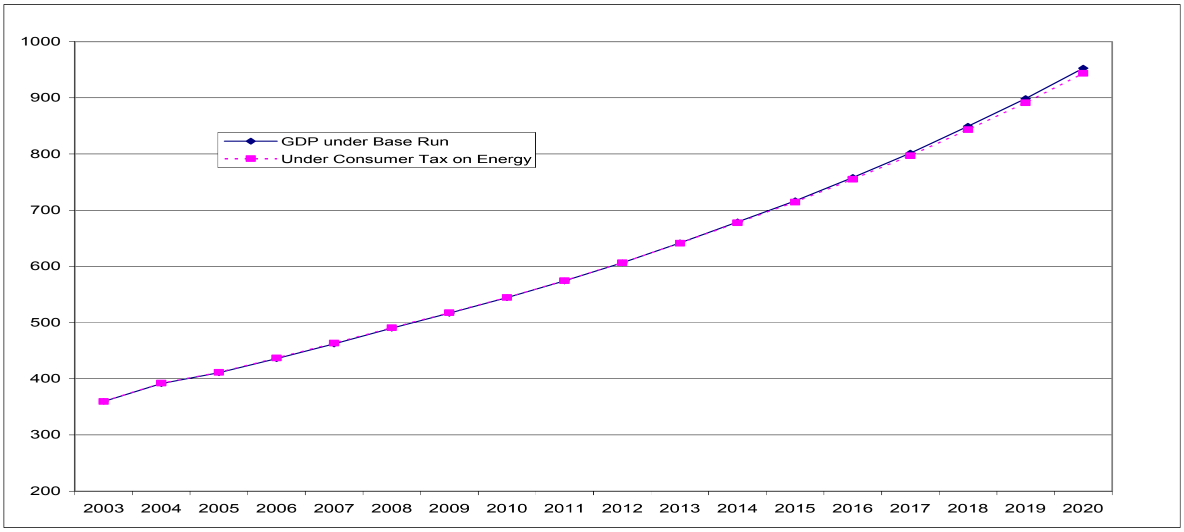
The CO2 emissions out of this policy are portrayed in Figure VII-11. We observe that aggregate CO2 emissions could have been reduced by only 5.5% over the base path by 2020.

Figure VII-11. Total CO2 Emissions under Consumption Tax on Energy Sectors (Million tones)



Considering that the extent of tax rate is 100%, the returns to COP2 abatement of 5.5% remains below expectations. The policy does not produce much of a GDP effect either. The path of the GDP is marginally affected, if any.

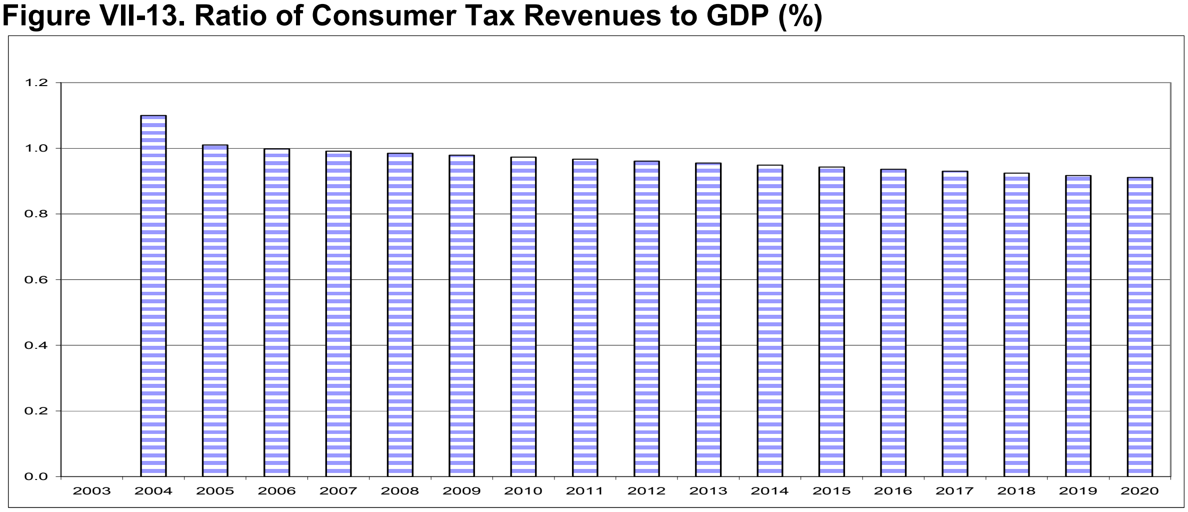
Figure VII-12. GDP under Consumer Tax on Energy Consumption



These results signal that the consumers' marginal abatement in returns to further taxation of energy consumption is rather low. At present the current tax rates on sectoral consumption through VATs and direct consumption taxes are significantly high. Thus a further increase in the sectoral consumption rates does not seem to produce much of an economic impact.

This result can also be obtained form an analysis of the aggregate ax burden inflicted by the consumption tax. As a ratio to the GDP, energy consumption taxes bring an additional tax burden of close to 1%. Yet its CO2 abatement incidence is quite low. Even though aggregate tax revenues on consumption far exceed those originating from taxation of producers, the environmental effects are not so pronounced.

Figure VII-13. Ratio of Consumer Tax Revenues to GDP (%)



VII-2. *Policy Conclusions on CO2 abatement tax alternatives*

One can obtain several policy insights from the analysis of alternative taxation regimes experimented thus far:

- Model results suggest that the burden of imposition of direct carbon emission quotas would be quite high. This burden will necessitate a significant tax imposition on the producers to enforce the CO2 quotas. According to our results, imposition of CO2 quota at 60% level to the base run calls for a carbon tax of 20% – 15% over 2005 to 2020. The GDP loss incurred under this scenario is above 30%.

- Such a tax burden will likely lead to tax evasion practices, encourage the underground economy and will lead to increased informalization of he production activities. The already high levels of producer tax incidences reduce the effectiveness of additional carbon taxation opportunities significantly.

- In contrast to a direct "CO2 quota-*cum*-carbon tax" policy, taxation of energy use in sectoral production seems to produce viable results. In returns to 20% energy tax for producers, aggregate CO2 emissions are reduced by 25.8% with a loss of GDP of 8.8% by the end of 2020. The energy taxation policy suffers strongly, however, from its very adverse employment effects. Unemployment rates rise significantly as a result of the introduced energy taxes. With limited substitution possibilities in input mix among labor and energy inputs, producers are bound to cut back labor employment as they are faced with increased energy costs.

- We found that the overall effectiveness of taxing consumers on their energy demand is of limited effect in reducing CO2 emissions. Consumer taxes are already very high in Turkey and administering a consumer-based environmental taxation strategy is likely to produce little abatement effort at the margin.

- The taxation policies suggest very clearly that possible interventions of new environmental taxes would have adverse outcomes either on employment or on sectoral output levels directly. A *first-best* policy would necessarily call for a simultaneous reduction on the existing tax burden on producers elsewhere together with introduction of environmental taxes. A reduction of employment taxes can be envisaged along with the imposition of energy tax use. Such a policy would be conducive in attaining CO2 abatement targets together with employment incentives. Various studies show that using such tax revenues to finance reductions in the already existing (and mostly distortionary) taxes on employment, production, or sales can achieve superior outcomes with attaining environmental targets at lower cost – perhaps even at a positive net gain (see for example, Goulder *et al*, 1999; Perry *et al*, 1999; and Parry and Oates, 2000).

- Overall, however, a first best environmental policy has to call for further incentives towards reducing energy intensities in production through more efficient production methods. By itself this is no easy task and certainly comes at significant investment cost. In the next set of policy scenarios we will study various alternatives on how to meet the investment expenditures designed towards implementation of abatement technologies.

VII-3. Environmental Policy Instruments with Abatement Investments

An important issue in developing policies for the mitigation of greenhouse gas emissions is to determine a "feasible" set of policies to generate emission reductions and to make investments in energy-saving technologies. Estimating both the costs and effectiveness of these policies in emission-reduction is very important, yet a challenging issue. For instance, a recent study on the "Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change"[12] conducted for EU countries project a marginal cost as low as 20-25 per tCO_2 eq. in 1999 €s for the EU countries.[13] Such a marginal cost is estimated to reach $€_{99}$ 3.7 billion annually during the first budget period of the protocol (2008-2012), which is equivalent to about 0.06% of EU gross domestic product in 2010. One other major conclusion of this study is that, in terms of emission reduction potential, the energy sector is one of the most important and fuel shift currently holds greatest reduction potential up to first commitment period of the protocol.

For the Turkish case, the importance of the energy sector in reducing the GHG emissions is also emphasized in the report of the General Directorate of Electrical Power Resources Survey and Development Administration (EIE) under Coordination Board on Climate Change (CBCC). Also stated in the report, the cost of achieving reduction, especially under some headings like waste recovery and recycling will be much higher, compared to the cost for the EU countries.[14]

Table VII-5 provides an informative summary of this project for the EU-15 countries.

[12] Developed by the National Technical University of Athens, Ecofys and AEA Technology and analysed with the GENESIS database.
[13] The projection is based on EU-wide allocation of least-cost objective for different sectors.
[14] The report of the workgroup on GHG Emission Reduction in Industry, Construction and Services and the Waste Management, coordinated by the EIE (2006).

Table VII-5. Distribution of Direct and Total Emissions of GHGs in 1990/1995, in the 2010 Baseline and in the Most Cost-effective Solution for 2010 where Emissions Are Reduced by 8% Compared to 1990/1995.

EU-15 Emission Breakdown per Sector	Direct Emissions (MT CO_2 eq.)				
	Emissions in 1990/1995	*Baseline emissions in 2010*	*Cost-effective objective*	*Change from 1990/1995 (%)*	*Change from baseline (%)*
Energy Supply	1190	1206	1054	-11	-13
CO2 (energy-related)	1132	1161	1011	-11	-13
Non-CO2	58	45	42	-27	-6
Non-CO2 Fossil Fuel	95	61	51	-46	-16
Industry	894	759	665	-26	-12
Transport	753	984	949	26	-4
Households	447	445	420	-6	-6
Services	176	200	170	-3	-15
Agriculture	417	398	382	-8	-4
Waste	166	137	119	-28	-13
TOTAL	4138	4190	3807	-8	-9

Source: Table 2 in Blok et al. (2001).

The main conclusions of the study listed as:

- The European Union Kyoto target is achievable at a low cost (the marginal cost about 20-25 per tCO2 eq. in 1999 €s). The result is based on an EU-wide allocation of least-cost objective for different sectors.
- Cost-effective implementation of the Kyoto protocol calls for different sectors to make differing quantitative contributions to reduce GHG emissions. Giving every sector, or even every actor within each sector the same reduction objective may be perceived as “fair”. However, using a different definition of “equity”, where “effort” of each sector is the same rather than the emission reduction percentage, differentiated sectoral reduction objectives may be identified. The study has shown that such differentiated reduction objectives are, from economic perspective, highly desirable.
- By setting objectives in a least-cost manner, Kyoto protocol compliance cost for the EU is estimated to be $€_{99}$ 3.7 billion annually during the first budget period of the protocol (2008-2012), which is equivalent to about 0.06% of EU gross domestic product in 2010.
- In terms of emission reduction potential, the energy sector is one of the most important. Fuel shift currently hold greatest reduction potential up to first commitment period of the protocol. It should be carefully considered what policies would ensure fuel-switch. Carbon taxation would ensure further shift to low-carbon fuels.

For the Turkish case, the importance of the energy sector in reducing the GHG emissions is also emphasized in the report of the General Directorate of Electrical Power Resources Survey and Development Administration (EIE) under Coordination Board on Climate Change (CBCC). Also stated in the report, the cost of achieving reduction, especially under some headings like waste recovery and recycling will be much higher, compared to the cost for the EU countries.[15]

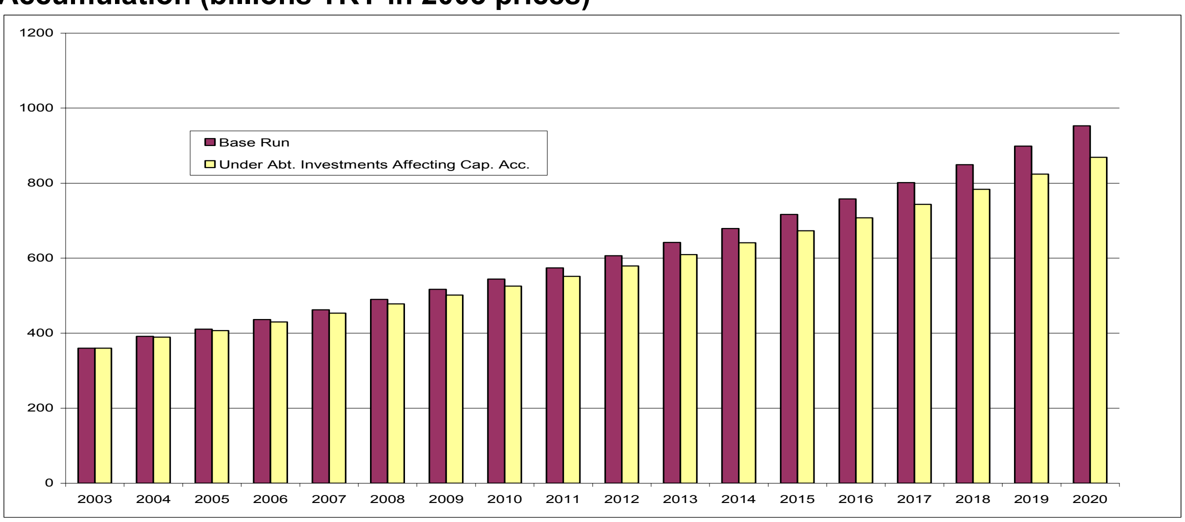
For the Turkish economy a similar study to address the issues of estimating the costs of feasible policies to make investments in especially energy-saving, emission-reducing and cost-effective technological change that would be attractive to producers has yet to be tackled. In the absence of precise technological cost-benefit estimates of such investments, what we try to do in this section is to compare alternatives of burden-sharing between different groups in the economy, under a reference abatement-investment scenario.

VII-3-1. Abatement Investments Affecting Capital Accumulation

Specifically, in the reference abatement-investment scenario, we assume energy-saving, therefore CO2 emission-reducing abatement-investments about 1.5% of the GDP in 2006-2020. The next assumption we have is that such investments will help reducing the energy-input related emission coefficients by 5%.

The question we are asking in this simulation exercise is "what will happen, if total abatement investments (which we assume will cost around 1.5% of GDP, annually in 2006-2020), are undertaken by both private and public production units to achieve 5% reduction in emission coefficients of the primary-energy inputs. As the cost is undertaken totally by the investing sectors of the economy, we assume abatement investments will absorb a portion of funds away from physical capital accumulation. Thus, compared to base-run, the aggregate capital stock of the economy will be reduced by the amount of these abatement investments. Figure VII-14 presents the likely paths of the real GDP in comparison to base-run.

Figure VII-14. Real GDP under Abatement Investments Affecting Capital Accumulation (billions TRY in 2003 prices)

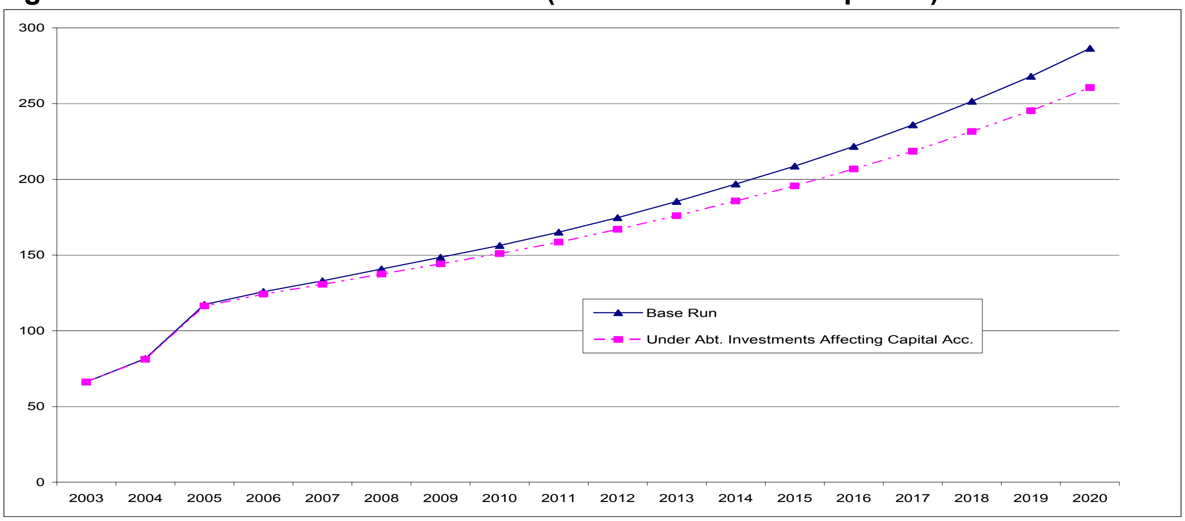


[15] The report of the workgroup on GHG Emission Reduction in Industry, Construction and Services and the Waste Management, coordinated by the EIE (2006).

As observed, the real GDP under the scenario is on average 5% lower than the corresponding value under base-run. Thus, the GDP growth rate is lower as well. The average annual GDP growth rate under the base-run reference path stays around 6% whereas it drops down to 5.3% under this scenario. This lower growth performance of the economy under abatement investments emerges as a result of the fall in the pace of capital accumulation, since a portion of investment now has been allocated for energy-saving, emissions-reducing technological change.[16]

Figure VII- 15 portrays private investment behavior (in 2003 prices) under the base-run and under the new circumstances and Figure VII-16 gives the total stock of physical capital accumulated through 2003-2020. The figures clearly demonstrate the effects of funds flowing away from capital accumulation for abatement investments.

Figure VII-15. Real Private Investments (Billions TRY in 2003 prices)



The effects of abatement investments on total CO2 emissions of the economy are further portrayed in Figure VII-17. As investments cause more efficient use of energy, such that emission coefficients on primary energy usage start dropping, the total CO2 emissions are reduced. Such an application brings a total reduction of 549.275 million tones of CO2 throughout 2003-2020 period. This value amounts to almost 7.5% of total emission level of the base-run. The annual reduction values indicate an average of 7.2% throughout the period, but as the reduction technology settles in, gains from emissions become more visible reaching as high as 15% of the baseline in 2020 (See Figure VII-18).

[16] Because we have kept a positive growth rate for the change in total factor productivity growth at a rate of 2% we have assumed no additional (ad hoc) effects of the abatement investments on further improvements in the rate of growth of technology.

Figure VII-16. Aggregate Capital Stock

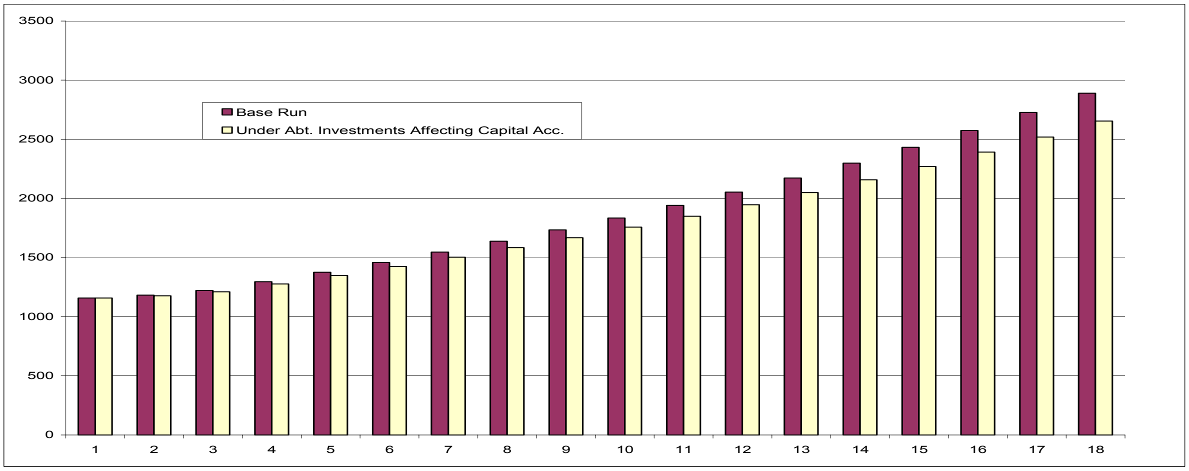


Figure VII-17. Total CO2 Emission (million tones)

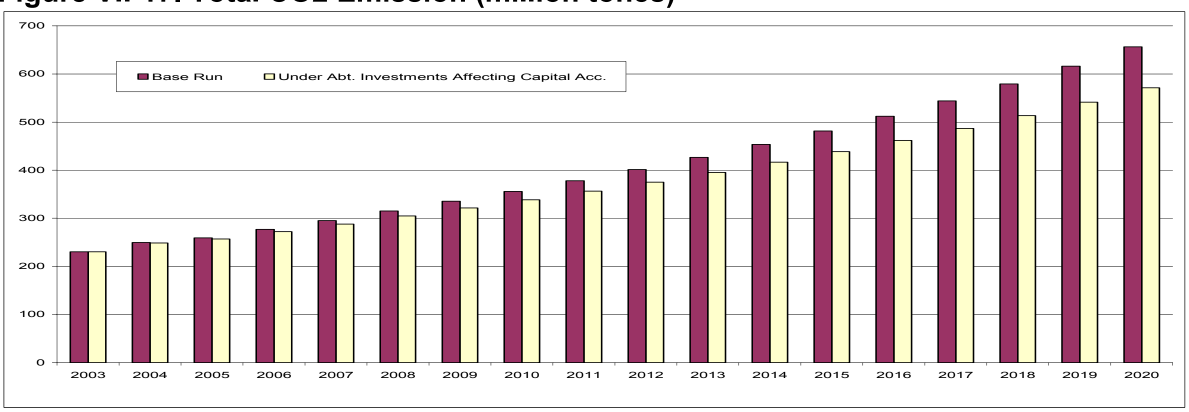
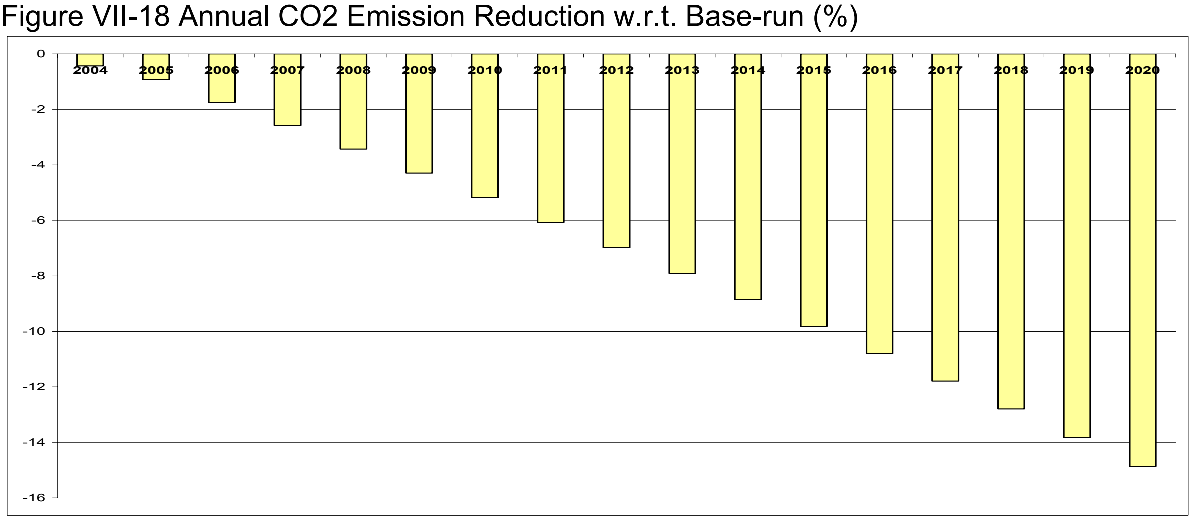


Figure VII-18 Annual CO2 Emission Reduction w.r.t. Base-run (%)



Having observed the (potential) trade-off effects in allocation of funds towards abatement investments and away from capital investments (causing reduction in GDP), we search for alternatives to finance the abatement investments. One alternative is that the government carries out the investment (amounting to 1.5% of GDP, annually between 2006-2020), yet imposes additional taxes on the usage of polluting energy inputs (primary and secondary) in the production sectors of the economy to finance the project.

The other alternative that we explore in this study is roughly inspired by one "flexible" mechanism of the Kyoto protocol: the joint implementation (JI) mechanism that may be used by Annex I parties to fulfill their own Kyoto targets.[17] We assume the the *JI mechanism* would offer incentives for the developed countries (Annex II) to be actively involved in projects; towards emission reduction. So, in the last scenario, we assume the abatement investments are financed by some form of foreign aid.

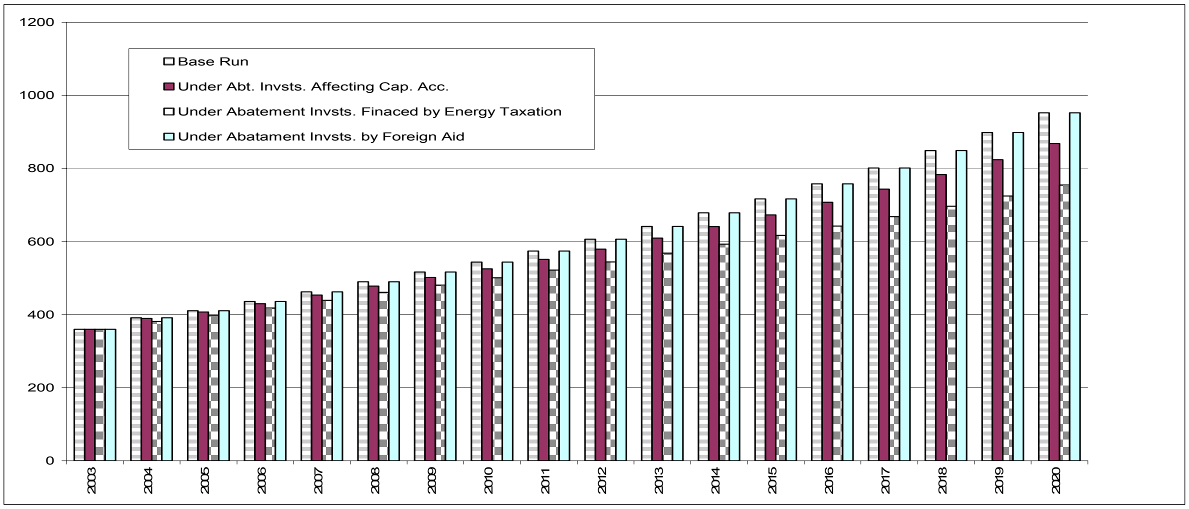
VII-3-2. Abatement Investments under Domestic-financing and Foreign Aid Policies

The intermediate energy usage tax policy results in a tax rate of 23% on the usage of refined petroleum (RP), petroleum and gas (PG) and coal (CO) in the production sectors.[18] We present the effects of such policies on both the CO2 emissions (total and sectoral distribution) and on the overall economic performance of the economy, in comparison to both the baseline and the first scenario under abatement investments affecting capital accumulation.

Figure VII-19 represents the likely paths of the real GDP under the base-run, under abatement investments affecting capital accumulation, under abatement investments financed by energy-input taxation and under abatement investments financed by foreign aid. On the other hand, Figure VII-20 portrays the related total CO2 emissions under the same scenarios. Figures VII-19 and VII-20 noticeably display the trade-off and offer a set of policy ideas towards emissions reduction alternatives.

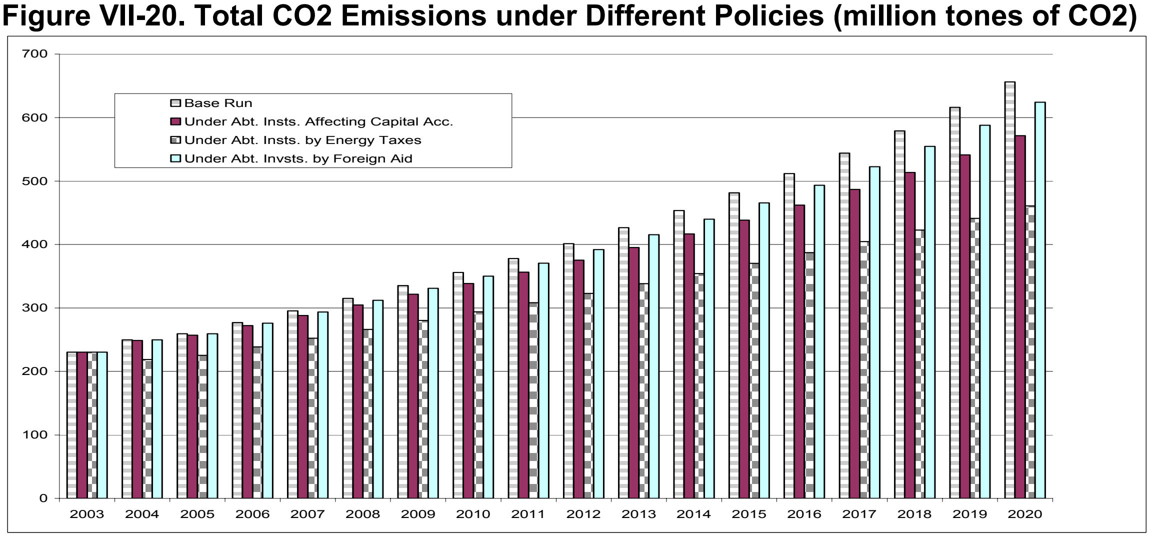
[17] The basic principles of the JI mechanism are defined in Article 6 of the protocol: "For the purpose of meeting its commitments… any party included in Annex I may transfer to, or acquire from, any other such party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of GHGs in any sector of the economy.", provided that certain (participation) requirements are fulfilled.
[18] We assume no further taxation on the final consumption of these commodities.

Figure VII-19. Real GDP under Different Policies (billions TRY in 2003 prices)



The financing of abatement investments by producers (both private and public) investing in capital accumulation of the economy, as well as relying on taxation of energy inputs, slow down the pace of economic activity towards producing a value-added, compared to both the baseline scenario and the scenario under foreign aid. On the other hand, under both scenarios of financing abatement investments from production units create lower levels of CO2 emissions due to slowing-down of the production activities in the overall economy. The scenario under foreign aid generates much favorable growth rates compared to the other two cases, nevertheless since the economic activity is higher, the total CO2 emissions also rise. Yet, the abatement investments (which we assume effective in emission reduction) give way to 3% lower total CO2 emissions, compared to base-run for 2006-202 period. The scenario is also important for it creates much favorable unemployment rates compared to the ones which leave the burden to production sectors of the economy.

Figure VII-20. Total CO2 Emissions under Different Policies (million tones of CO2)



Before making commitments on possible policy alternatives, we find it informative to study the microeconomic sectoral) results of the scenarios we analyze. In Table VII-6 below, we display the outputs of the production sectors represented in our model economy. In the next table, we demonstrate the sectoral CO2 emissions under different policies.

Table VI-6. Sectoral Outputs Under Alternative Scenarios (in 2003 Prices, Billions TRY)

	Base Run			Under Abatement Inv. Affecting Capital Acc.			Under Abatement Inv. Financed by Energy Taxes		
	2005	2010	2020	2005	2010	2020	2005	2010	2020
AG -Agriculture	82.1	110.0	191.2	81.4	106.4	175.0	80.7	104.5	161.1
CO - Coal Mining	2.0	2.5	4.0	1.9	2.4	3.6	1.9	2.2	3.1
PG - Crude Petroleum, Gas	1.3	1.9	3.6	1.3	1.8	3.3	1.0	1.4	2.6
PA - Paper and Paper Products	4.9	6.8	12.5	4.9	6.6	11.4	4.8	6.4	10.4
RP - Refined Petroleum Products	26.0	35.5	65.0	25.8	34.3	59.5	17.9	23.5	37.6
CE - Cement Production	5.6	7.6	13.7	5.6	7.4	12.5	5.3	6.8	10.5
IS - Iron and Steel	16.0	23.3	47.5	15.8	22.5	43.3	14.6	20.1	34.7
EL - Electricity Production	11.2	14.7	25.3	11.1	14.2	23.1	9.5	11.7	16.9
TR - Transport Services	80.2	109.4	199.2	79.5	105.8	182.6	73.2	96.4	155.7
OE - Other Economy	467.5	612.3	1058.4	463.2	590.8	963.1	455.5	563.7	828.3

In comparison to the base-run, the sectoral output productions and sectoral emission reductions are quite parallel under the first scenario of abatement investments financed by funds away from capital accumulation, since the producing sectors are one way or another forced to take this measure towards CO2 emission reductions in an indiscriminate manner. Therefore, the overall economy is affected proportionally. On the other hand, financing of abatement investments by energy-input taxation works quite selectively: the sectors that experience the highest reduction (in comparison to base-run), in their output levels are the most energy-intensive sectors. For 2006-2020, the output reduction in agriculture (AG) is around 7.5% on average whereas it reaches to 16.5% in iron and steel industry (IS), 22.9% in electricity production (EL), 24.8% in petroleum and gas (PG) and 35.7% in refined petroleum production (RP) sectors. Then again, the largest savings from CO2 emissions also take place in these sectors. The overall emission reduction reaches to 53% in coal mining (CO) and 23.2% in iron and steel (IS) by 2020. Note that the proportions of output and CO2 emissions reductions are not comparable in a linear fashion, since both variables depend on the substitution possibilities of both energy inputs in production among themselves and with the other inputs as well. A 23% tax on coal would be more effective on sectors that are heavily dependent on coal for their supply of energy if there is no substitution possibility with the less-polluting natural gas, for instance.

The scenario under foreign aid has no direct effect on output/investment/input demand decisions of the production sectors, yet by offering funds to finance abatement investments, produce proportional decrease in the sectoral CO2 emissions of the economy.

VII-4. *Policy Conclusions on Abatement Investment Alternatives*

The insights that one can get from the analysis of policies with abatement investments could be interpreted as follows:

- Model results suggest that leaving the burden of the abatement investments to production sectors alone create severe results in terms of the overall economic performance of the economy. According to our results, abatement investments that amount to 1.5% of GDP annually call for 23% tax rate on energy (primary and secondary) input usage.
- Further indirect taxes on the production sectors of the economy would likely trigger unfavorable dynamics of the economy. Parallel to the reduction in output, one observes adverse outcomes on already high unemployment rates of the economy.
- The advantageous environment likely to be produced by the foreign aid on abatement investments displays high economic growth attained together with reductions in CO2 emissions. By way of a caveat, it should be clear that designing such an international aid/credit system for the developing countries in their efforts towards abatement investments is by no means an easy task, and one should be aware that international coordination and cooperation, although crucial, could be difficult to achieve. The *Protocol*, as an international attempt itself, has been criticized for defining mechanisms that are too bureaucratic and cumbersome. Aldy *et al* (2003), for instance, point out to ambiguities in the existing institutional framework at the global scale, and identify more than a dozen competing approaches with regards to international carbon taxation and international technology standards.
- The policies leaving the burden on production sectors suggest that possible interventions of new environmental taxes would have adverse outcomes either on employment or on sectoral output levels directly. Subsidies to emissions-reductions or to new, "best available technologies" will have a cost-disadvantage associated with the need to raise distortionary taxes to finance these policies.
- In general, welfare losses are expected to be smaller when a price-based instrument like carbon tax is employed, as opposed to a quantity-based instrument like emission quotas (Weitzman 1974).
- Finally, it should be noted that the model fails to identify the welfare benefits and possible productivity gains from reduced CO_2 emissions. Reductions in gaseous pollutants, for instance, are likely to lead to improved health conditions, enabling increases in labor productivity. Likewise, reductions in gaseous emissions would likely lead to further productivity gains in, say agriculture and food availability, due to improved climatic conditions. In the absence of detailed cost-benefit analysis of reducing CO_2 emissions on a micro level, we had to abstain from making *ad hoc* assumptions on such favorable external incidence of abatement investments.

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APPENDIX. MODEL EQUATIONS

I. Within-period system of equations

ENDOGENOUS VARIABLES

PRICE BLOCK

P_i^m	Domestic Price of Imports
P_i^e	Domestic Price of Exports
e	Exchange Rate
PC_i	Composite Price
PD_i	Domestic Price
PX_i	Gross Output Price
PEG_i	Price of Composite Energy Input
$PINDEX$	Price Index

OUTPUT AND FACTORS OF PRODUCTION BLOCK

XS_i	Gross Output Supply
ENG_i	Primary Energy Composite Input
K_i	Capital Demand
L_i	Labor Demand
$ID_{j,i}$	Intermediate Good Demands
$UNEMP$	Unemployment
r	Average Profit Rate

ENVIRONMENTAL POLLUTION AND CO2 TAXES

$CO2EM_i$	CO2 Emissions
$CO_2EM_{j,i}^{INM}$	CO2 Emissions caused by non-primary energy input usage
$CO_2EM_{j,i}^{ENG}$	CO2 Emissions caused by combustion of primary energy inputs
$CO_2EM_i^{IND}$	CO2 Emissions caused by industrial processes
$TOTCO2ENG$	Total CO2 Emissions from Primary and Non-primary Energy Input Usage
$TOTCO2IND$	Total CO2 Emissions from Industrial Processes
$TOTCO2HH$	Total CO2 Emissions from final private consumption by households
$TOTCO2$	Total CO2 Emissions
$CO2tN_j$	CO2 Tax Rate on Intermediate Input Use of j
$CO2tP$	CO2 Tax Rate on Sectoral Output
$\mathrm{CO2tC_j}$	CO2 Tax Rate on Private Consumption good i
$TOTCO2TAX$	Total CO2 Emissions Tax

TRADE BLOCK

CC_i	Composite Good
DC_i	Domestic Sales of Domestic Good
E_i	Exports
M_i	Imports

INCOME GENERATION AND DEMAND BLOCK

EtrHH	Enterprise Profit Transfers to Households
EERPtrROW	Profit Transfers Abroad
NFI^G	Net Factor Income from Enterprises to Government
YHWnet	Private Household Net Labor Income
YHnet	Net Private Income (Private Disposable Income)
YHH	Private Income

PUBLIC SECTOR BALANCES

GREV	Public Revenues
GPRMBAL	Primary Budget Balance
GTrans	Government Transfers
GCON	Public Consumption
GtrHH	Government Transfers to Households
GtrEE	Government Transfers to Enterprises
GtrSSI	Government Transfers to Social Security Institutions
revSSI	Revenues of Social Security Institutions
SSItrHH	Social Security Institution Transfers to Households

FINANCIAL ACCOUNTS

PSAV	Private Savings
GSAV	Government Savings
$ForDebt^G$	Government Foreign Debt Stock
$DomDebt^G$	Government Domestic Debt Stock
$ForBor^G$	Government Foreign Borrowing

SECTORAL DEMANDS

PRIVCON	Private Consumption
PINV	Private Investment
GINV	Public Investment

CD_i	Private Consumption
GD_i	Government Consumption
IDP_i	Private Investment Demand by Sector of Origin
IDG_i	Government Investment Demand by Sector of Origin

MARKET CLEARING

INT_i	Intermediate Input Uses
$CAdef$	Current Account Deficit
GDP	Gross Domestic Product

EXOGENOUS VARIABLES AND PARAMETERS

PRICE BLOCK

PW_i^m	World Price of Imports
PW_i^e	World Price of Exports
$pwts_i$	Price Weights
t_i^m	Import Tariff
t_i^e	Export Tax Rate
$t_{Sal,i}$	Sales Tax Rate

OUTPUT AND FACTORS OF PRODUCTION BLOCK

$\overline{w}$	Nominal Wage Rate of Formal Labor
$\overline{L}^S$	Total Formal Labor Supply
$\overline{K}^S$	Total Formal Capital Supply
AX_i	Production Function Shift Parameter
$\lambda_{K,i}$	Cobb-Douglas Production Function Capital Share Parameter
$\lambda_{L,i}$	Cobb-Douglas Production Function Formal Labor Share Parameter
$\lambda_{ID,j,i}$	Cobb-Douglas Production Function Intermediate Good Share Parameter
$\lambda_{E,i}$	Cobb-Douglas Production Function Energy Share Parameter
$t_{\mathrm{Pr}od,i}$	Production Tax Rate
AE_i	Primary Energy Composite Production Function Shift Parameter
$\kappa_{j,i}$	Primary Energy Composite Production Function Coal Share Parameter (*j =CO, PG, EL*)
ρx_i	Primary Energy Composite Production Function Exponent

ENVIRONMENTAL POLLUTION AND CO2 TAXES

$\overline{\varepsilon}_{j,i}$	Coefficient for emissions created by non-primary energy intermediate input usage

$\varpi_{j,i}$	Coefficient for emissions created by primary energy intermediate input usage
$\bar{\delta}_i$	Coefficient for emissions created by industrial processes
$\bar{\psi}_i$	Coefficient for emissions created by final private consumption

TRADE BLOCK

α_i	CET Function Shift Parameter
β_i	CET Function Share Parameter
ρt_i	CET Function Exponent
φ_i	Armington Function Shift Parameter
θ_i	Armington Function Share Parameter
ρc_i	Armington Function Exponent
t_i^m	Import Tariff rate
t_i^e	Export Tax rate

INCOME GENERATION AND DEMAND BLOCK

trrow	Profit Transfers abroad ratio
$shrg_i$	Government Profit ratio
t_{Corp}	Corporate Tax rate
t_{Inc}	Income Tax rate
ROWtrHH	Workers Remittances

PUBLIC SECTOR BALANCES

prbrat	Primary Balance Ratio (of GDP)
gcr	Government Consumption Ratio (of non-interest expenditures)
gtrs	Ratio of Government Total Transfers to Government Revenues
pyrltax	Payroll Tax Rate
sstax	Social Security Tax (Rate?) Paid by Formal Labor
rtgtrhh	Rate of Government Transfers to Households to Total Government Transfers
rtgtree	Rate of Government Transfers to Enterprises to Total Government Transfers

FINANCIAL ACCOUNTS

s^P	Marginal Propensity to Save
r^F	Foreign Interest Rate on Public Debt
r^D	Domestic Interest Rate on Public Debt

$ForBor^E$	Enterprise foreign borrowing
Gfborrat	Government Foreign Borrowing Rate

SECTORAL DEMANDS

s^P	Marginal Propensity to Save
$cles_i$	Sectoral Private Consumption Shares
$gles_i$	Sectoral Government Consumption Shares
$iples_i$	Private Investment Demand Shares
$igles_i$	Government Investment Demand Shares

EQUATIONS

PRICE BLOCK

$$\mathrm{P_i^m} = ePW_i^m(1+t_i^m)$$

$$\mathrm{P_i^e} = ePW_i^e(1-t_i^e)$$

$$PC_iCC_i = [PD_iDC_i + P_i^m M_i](1+t_{Sal,i})$$

$$PX_iXS_i = PD_iDC_i + P_i^e E_i$$

$$PINDEX = \sum_{\mathrm{i}} \mathrm{p}wts_{\mathrm{i}}\ \mathrm{PC_i}$$

OUTPUT AND FACTORS OF PRODUCTION BLOCK

$$XS_i = AX_i\left[K_i^{\lambda_{K,i}} L_i^{\lambda_{L,i}}\left(\prod_j ID_{j,i}{}^{\lambda_{ID,j,i}}\right) ENG_i^{\lambda_{E,i}}\right]$$

$$(1+CO_2tN_j)PC_jID_{j,i} = \lambda_{ID,j,i}(1-t_{\mathrm{Pr}od,i} - CO_2tP)PX_iXS_i$$

$$(1+pyrltax)\overline{w}L_i = \lambda_{L,i}(1-t_{\mathrm{Pr}od,i} - CO_2tP)PX_iXS_i$$

$$w = \overline{w} \Rightarrow \overline{L}^S - \sum_i L_i = UNEMP$$

$$rK_i = \lambda_{K,i}(1-t_{\mathrm{Pr}od,i} - CO_2tP)PX_iXS_i$$

$$\sum_{\mathrm{i}} \mathrm{K_i} = \overline{K}^S$$

$$PEG_iENG_i = \lambda_{E,i}(1-t_{\mathrm{Pr}od,i} - CO_2tP)PX_iXS_i$$

$$\lambda_{K,i} + \lambda_{L,i} + \sum_j \lambda_{ID,j,i} + \lambda_{E,i} = 1$$

$$ENG_i = AE_i \left[\kappa_{CO,i} ID_{CO,i}^{-\rho x_i} + \kappa_{PG,i} ID_{PG,i}^{-\rho x_i} + \kappa_{EL,i} ID_{EL,i}^{-\rho x_i} \right]^{-1/\rho x_i}$$

$$\frac{ID_{CO,i}}{ENG_i} = \left[\frac{\kappa_{CO,i} PEG_i}{AE_i^{-px_i}(1 + CO_2 tN_{CO}) PC_{CO}} \right]^{1/(1+\rho x_i)}$$

$$\frac{ID_{PG,i}}{ENG_i} = \left[\frac{\kappa_{PG,i} PEG_i}{AE_i^{-px_i}(1 + CO_2 tN_{PG}) PC_{PG}} \right]^{1/(1+\rho x_i)}$$

$$\frac{ID_{EL,i}}{ENG_i} = \left[\frac{\kappa_{EL,i} PEG_i}{AE_i^{-px_i}(1 + CO_2 tN_{EL}) PC_{EL}} \right]^{1/(1+\rho x_i)}$$

$$PEG_i ENG_i = PC_{CO} ID_{CO,i} + PC_{PG} ID_{PG,i} + PC_{EL} ID_{EL,i}$$

ENVIRONMENTAL POLLUTION AND CO2 TAXES

$$CO_2EM_i = \sum_j CO_2EM_{j,i}^{INM} + CO_2EM_{j,i}^{ENG} + CO_2EM_i^{IND}$$

$$CO_2EM_{j,i}^{INM} = \bar{\varepsilon}_{\mathrm{j,i}}\ ID_{j,i} \qquad j = RP$$

$$CO_2EM_{j,i}^{ENG} = \varpi_{\mathrm{j,i}}\ ID_{j,i} \qquad j = CO,\ PG$$

$$CO_2EM_i^{IND} = \bar{\delta}_{\mathrm{i}} XS_i$$

$$TOTCO2ENG = \sum_{\mathrm{i}} \left[\sum_j \left(CO_2EM_{j,i}^{INM} + CO_2EM_{j,i}^{ENG} \right) \right]$$

$$TOTCO2IND = \sum_i CO_2EM_i^{IND}$$

$$TOTCO_2HH = \sum_i \bar{\Psi}_i CD_i$$

$$TOTCO2 = TOTCO2ENG + TOTCO2IND + TOTCO2HH$$

$$TOTCO2TAX = \sum_{\mathrm{i}} \mathrm{CO_2tP} PX_i XS_i + \sum_{\mathrm{i}} \sum_{\mathrm{j}} \mathrm{CO_2tN_i} PC_i ID_{i,j} + \sum_{\mathrm{i}} \mathrm{CO_2tC_i} PC_i CD_i$$

TRADE BLOCK

$$XS_i = \alpha_i \left[\beta_i E_i^{\rho t_i} + (1-\beta_i) DC_i^{\rho t_i}\right]^{1/\rho t_i}$$

$$\frac{E_i}{DC_i} = \left[\frac{P_i^e}{PD_i}\frac{(1-\beta_i)}{\beta_i}\right]^{\frac{1}{\rho t_i - 1}}$$

$$CC_i = \varphi_i \left[\theta_i M_i^{-\rho c_i} + (1-\theta_i) DC_i^{-\rho c_i}\right]^{-1/\rho c_i}$$

$$\frac{M_i}{DC_i} = \left[\frac{PD_i}{P_i^m}\frac{\theta_i}{(1-\theta_i)}\right]^{\frac{1}{1+\rho c_i}}$$

INCOME GENERATION AND DEMAND BLOCK

$$EtrHH = (1-t_{Corp})\sum_i r\, K_i - EERPtrROW - NFI^G + GtrEE$$

$$r^D DomDebt^G - r^F eForDebt^E + eForBOR^E$$

$$EERPtrROW = trrow \sum (1-t_{Corp}) rK_i$$

$$NFI^G = (1-t_{Corp})\sum_i shrg_i\, rK_i$$

$$YHWnet = (1-sstax)\overline{w}\sum_i L_i$$

$$YHH = YHWnet + EtrHH + GtrHH + SSItrHH + eROWtrHH$$

$$YHnet = (1-t_{Inc})YHH$$

PUBLIC SECTOR BALANCES

$$GREV = \sum_i t_{Prod,i} PX_i XS_i + \sum_i t_{Sal,i} PC_i CC_i + \sum_i tm_i ePW_i^m M_i + \sum_i te_i ePW_i^e E_i + t_{Inc} YHH + t_{Corp}\sum_i rK_i + \sum_i NFI^G$$

$$+ TOTCO2TAX$$

$$GPRMBAL = GREV - GCON - GINV - GTrans$$

$$\mathrm{GPRMBAL} = prbrat \cdot GDP$$

$GCON = gcr\ GREV$

$GtrHH = rtgtrhh\ .\ GTrans$

$GtrEE = rtgtree\ .\ GTrans$

$GTrans = gtrs\ GREV$

$GTrans = GtrHH + GtrEE + GtrSSI$

$$revSSI = (pyrltax + sstax)\overline{w}\sum_i L_i$$

$GtrSSI = SSItrHH - revSSI$

FINANCIAL ACCOUNTS

$PSAV = s^P\ YHnet$

$GSAV = GREV – GCON - r^F eForDebt^G - r^D DomDebt^G – GtrHH – GtrEE – GtrSSI + eForBor^G$

$PSAV + GSAV + e\ CAdef = PINV + GINV$

SECTORAL DEMANDS

$PRIVCON= (1 - s^P)YHnet$

$$CD_i = cles_i.\frac{PRIVCON}{(1 + CO_2tC_i)PC_i}$$

$$GD_i = gles_i.\frac{GCON}{PC_i}$$

$$IDP_i = iples_i.\frac{PINV}{PC_i}$$

$$IDG_i = igles_i.\frac{GINV}{PC_i}$$

MARKET CLEARING

$CC_i= INT_i + CD_i + GD_i + IDP_i + IDG_i$

$$INT_i = \sum_j \mathrm{ID}_{i,j}$$

$$CAdef = \sum P_i^W E_i + ROWtrHH + ForBor^E + ForBor^G$$
$$-\left[\sum P_i^W M_i + \left(trrow \sum (1 - t_{Corp}) rK_i\right) / e + r^F ForDebt^E + r^F ForDebt^G\right]$$

$$GDP = \sum_i \left[\mathrm{PC_i (CD_i + GD_i + GID_i + ID_i) + PW_i^e\, e\, E_i - PW_i^m eM_i}\right]$$

II. Dynamics

Dprt	Depreciation Rate
Popgr	Population Growth Rate
$tfpGR_i$	Total Factor Productivity Growth Rate

Evolution of government and private debt

Public Sector Borrowing Requirement

$PSBR = GREV - GCON - GINV - r^F eForDebt^G - r^D DomDebt^G - GTrans$

Government's Foreign Borrowing is a ratio of PSBR:

$eForBor^G = (gfborrat)PSBR$

$DomBor = (1 - gfborrat)PSBR$

Government Domestic Debt
$DomDebt_{t+1} = DomDebt_t + DomBor_t$

Government Foreign Debt

$ForDebt^G{}_{t+1} = ForDebt^G{}_t + ForBor^G{}_t$

Private foreign debt

$ForDebt^E{}_{t+1} = ForDebt^E{}_t + ForBor^E{}_t$

$$\overline{K}_{t+1}^S = (1 - dprt) K_t^S + \sum_i \left(IDP_i + IDG_i\right)$$
$$\overline{L}_{t+1}^S = (1 + popgr_t) \overline{L}_t^S$$

$$AX_{t+1}^i = (1 + tfpGR_i) AX_t^i$$