An Economic Policy Discussion of the GHG Emission Problem in Turkey From a Sustainable Development Perspective within a Regional General Equilibrium Model : TURCO

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1 Introduction

Since the Rio Conference (1992), discussions on sustainable development have occupied an important place in the agendas of developed countries which try to better apprehend the relationship between the society, economics and environment. As a result, reaching a "sustainable and environment friendly" development process has been declared as a priority by the European countries in the Amsterdam Treaty (1997). The origin of this new preoccupation lies in the pressure exercised by the increasing economic growth on the environmental quality of the OECD countries. Despite the fact that Turkey's GDP per capita is significantly inferior to all other OECD countries' (OECD, 2000) and that it has experienced significant economic difficulties (the 1999 and 2000 crises), these discussions concern Turkey because of its classification as an Annex I - OECD country [1]. By postponing the ratification of international conventions on climate change until today, Turkey has become one of the rare exceptions within the OECD countries (with Mexico, South Korea, Poland and the United States[2]).

In the mean time, the conformity to the environmental norms enables the creation of international confidence towards the political authorities in the countries. For example, as the condition to access to the Global Environment Facility (GEF), a country is required to participate to the UNFCCC[3]. It is therefore important, at this point, to give some definitions concerning the concept of sustainable development.

Various definitions of the concept of sustainable development can be found in the Brutland Report [4].

> "The three pillars of sustainable development are thus social (people), economic (livelihoods) and environmental (natural resources) welfare".

The concept is based on the definition of new instruments and a "good governance" process in line with **environmental**[5] and **economic efficiency**[6] criterias. Even though Turkey's contribution to the climate change phenomenon is less than

[1] Annex I consists of "developed" countries, member of OECD more precisely : "Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Island, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Suede, Switzerland, Turkey, U.K. and United States" also "transition countries" : "Belorussia, Bulgaria, Check Republic, Slovakia, Estonia, Latvia, Lithuania, Poland, Hungary, Romania, Russian Federation and Ukraine". Whereas, Annex II consists of Annex I countries except for transition countries.

[2] These countries are not engaged as Annex I nor Annex II countries however they have ratified the UNFCCC (United Nations Framework Convention on Climate Change) and have adopted voluntary agreements on GHG (Greenhouse Gas) reduction.

[3] U.N.F.C.C.C. - United Nations Framework Convention on Climate Change.

[4] "Brutland Report", World Commission on Environment and Development (WCED), in *Our Common Future*, Oxford University Press, (1987), U.K.

[5] Capacity of economic instruments to reach public objectives on environmental quality.

[6] Policy that leads to an optimal allocation of resources.

other OECD countries, it has been continuously increasing since the 1980s. This is the reason why Turkey has to determine a sustainable development policy which conforms to international conventions on climate change. This point becomes a necessary condition for Turkey's objective to integrate to the European Union.

More specifically, I propose an applied general equilibrium model to quantify the impact of various alternatives of national environmental program for the Turkish economy based on energy taxes and a system of tradable emission permits.

I focus the discussion on the intragenerational equity concerns as it applies to Turkey. My aim is to determine the factors of analysis that appear to be significant in the determination of a sustainable development path for Turkey.

Within a detailed framework, I determine the factors to be taken into account in analyzing the potential impact of such a policy, in terms of different socio-professional classes, their geographical situation and their exposition to the GHG (Greenhouse Gas) emissions in order to specify "realistic" and "feasible" policy suggestions for Turkey.

My study should therefore be considered as a first step for a further discussion on intergenerational equity concept in a sustainable development discussion in Turkey.

2 Economic and Environmental Performances in Turkey

It should be noted that in terms of total GHG emissions, Turkey's classified as the 25^{th} among the OECD countries. However its GHG emissions are still below the other OECD countries' level that have not yet ratified the Kyoto Protocol ; South Korea, Mexico, Poland and the United States.

The choice of the GHG indicator appears as a problem during the negotiations between the Turkish authorities and the international organizations. Turkish governments underline the fact that by considering a CO_2 per capita or a CO_2 per GDP classification, Turkey moves to a better classification. In fact, we can observe in the following table that the country is placed as 80^{th} in terms of CO_2 per capita and as 63^{rd} according to the CO_2 per GDP indicators in 1995.

Table 1 Classification of Turkey in terms CO_2 emissions

	1995	1996	1997	1998	1999
CO_2 total	25	25	23	24	23
CO_2/capita	80	79	75	76	75
CO_2/GDP	63	71	70	71	60
CO_2/GDP (purchasing power)	81	84	81	81	55

Source : AIE (2001)

These results can be explained by the fact that the percentage of "high polluting" sectors in the Turkish economy is less significant than in the case of other OECD countries. However, the production process is more "energy intensive" hence "high polluting" than in other countries. These technical characteristics are due to both the technological delay of the production structure and the dependence of the Turkish economy on coal with a high sulfur content. Cheap domestic coal is the most commonly used fuel by households and producers.

More precisely, my research emphasizes the necessity to reconcile the environmental objectives with regional economic priorities. Compared to the European countries, regions within Turkey display important divergences from multiple perspectives. Given this economic diversity, the use of a regional approach is essential in public decision making process and in international negotiations. By using a “multi-regional” approach, my aim is to determine the environmental measures respecting simultaneously the economic realities of the country and the international conventions. In that sense, my approach could represent an example to other developing countries in the determination of their sustainable development policies.

In Turkey, introducing a regional analysis is important since the Turkish government attributes a given mandate of “priority on development” to the Eastern and South Eastern Anatolian regions. The regional development policies are documented in the Eighth Five Year Plan (1996-2000) prepared by the State Planning Organization.

It is important to remember that the Grand Anatolian Project (GAP) - the most important energy production project that has been initiated since the declaration of the Republic - takes place in one of the “high priority” development regions. Certain forms of subsidies on energy prices and investment initiatives are already in practice in order to boost the production in the region. Hence, the determination of a national environmental policy has to integrate these regional development priorities.

Meanwhile, environmental problems are more pronounced in Istanbul and its surrounding area. With 12 million population, Istanbul alone presents an almost “self sufficient” economic center and displays environmental problems similar to those of European Countries. From a comparative perspective, the less developed regions mostly specialized in agriculture and have relatively a minor responsibility in GHG emissions, but they have to fulfill more ambitious development objectives.

Clearly, adopting an extremely restrictive environmental policy risks the viability of the economic activities of the developed regions that represent the economic dynamics of the country. This result could mean a slowdown of the entire economy.

The key economic factors to be taken into account in the design of environmental policies in Turkey can be summarized as follows :

– Instability of the energy prices. Turkish economy is highly dependant on imported fuels. Therefore the depreciation of Turkish Lira increases the energy cost for consumers and producers. A policy based on the substitution of the ”highly polluting" domestic coal by its imported equivalent is already in practice in some regions of Turkey. The domestic coal stands as the most demanded fuel because of its low price and the facility of payments granted to the consumers.

– Distortions in the pricing of energy goods is the second factor to be taken into consideration. Since the declaration of the Republic, State Economic Enterprises have dominated the energy producing sector. Different policies have been applied concerning various fuels during the changing economic regimes. Meanwhile, the price of domestic coal and lignite have been subsidized during all periods.
– The lower income workers (that we introduced by unqualified labor in our model) are often the most important consumers of the domestic coal and lignite[7]. As a consequence, the emission problem originating from industrial and transportation activities concentrated in the "industrialized regions" of the country is worsened by the polluting emissions coming from the households' use of energy.
– A privatization process of the energy producing sector has started since the last few years, these changes are expected to lead the national energy prices towards their international levels.
– In the mean time, new kinds of taxes are created and imposed on the energy prices (like the tax on private consumption). Two major problems appear from a sustainable development perspective. On one hand, the imposition of new taxes pushes the country's electricity and oil prices to one of the highest rates practised among the OECD countries. On the other hand, the fiscal revenues obtained from these taxes are not recycled in environmental objectives but they are destined to contribute to the global budget.
– We should remind that the "high priority" development measures are still part of the Turkish government's agenda. These measures concern mainly subsidies in energy prices (more specifically in electricity prices) and the abolition of social security premiums paid by employees in the Eastern and South Eastern Anatolian regions.

3 Methodology

The main advantage of the general equilibrium models from a sustainable development perspective is their capacity to simulate policy results for different categories of economic agents. Our aim was to emphasize the differences concerning the industrialization levels and the contribution to the GHG emissions of different regions of Turkey. This is the reason why our analysis is determined on :

[7] It must be noted that in "modern" neighborhoods, the installation of the necessary infrastructure allows the substitution of the natural gas to domestic coal. This is not the case in the "suburban" areas.

- a division of the Turkish economy into three regions depending on their industrialization levels (according to the SIS's classification),
- a detailed representation of the production structure with a relatively high level of sectorial disaggregation (15 producing sectors in each region)
- a distinction between different use of fuels and corresponding polluting emissions.

We start our literature survey by analyzing the environmental models constructed for Turkey :

- Roe and Yeldan [1993],
- Zaim [1996],
- Arikan and Kumbaroglu [1996], Kumbaroglu [2003].

After discussing the similarities between these models' structure in contrasts to our general equilibrium model, TURCO, we add the regional dimensions to our analysis.

We also refer to economic analysis already modelled in the macroeconomic models constructed for Turkey that would be important in environmental problems. In that perspective, we analyze more specifically models by Mercenier and Yeldan, [1996] and Harrison, Rutherford and Tarr [2000].

3.1 TURCO Model

In order to analyze the interaction between the environmental and economic policies in Turkey, we built a general equilibrium model, TURCO, that is used to simulate the potential impact of two kinds of environmental measures : taxes on energy and tradable emission permit system.

The algebraic structure of the model TURCO resembles in many respects to the general equilibrium model, MEGAPESTES (Beaumais, Schubert, 1994), used in the analysis of France's environmental problems. Putting the emphasis on the regional dimension in the model, I detailed representation of the two most polluting sectors ; transportation and energy. My aim is to suggest environmental measures to the Turkish authorities in line with sustainable development objectives.

I have three types of concern on the choice of the model's specifications. The first objective is to build a "simple" framework in order to test various economic and environmental policies from various perspectives. The model simulates the impact of scenarios on sectorial, regional, national, and international levels. The second objective is to give a detailed, hence a "realistic" description of the Turkish economy and of the possible environmental policies. My final aim to include a variety of analytical factors that will enhance the potential applications of the model.

Concentration of industrial activities is particularly high in Istanbul and its surrounding regions. The pollution level coming from fixed or mobile sources are naturally high in this area. Therefore, we describe the production activities and the pollution levels in a regional perspective. For policy suggestions, I take two important points into account. First, the industrialized region provides the main dynamic sectors of the country. Second, some economic measures in order to promote the production activities are already in practice in rural regions. My ultimate aim is to propose environmental policies in accordance with developmental priorities of the country.

Given the fact that 40 % of the labor force work in the primary agricultural sector, Turkey could be classified as an agricultural economy. Meanwhile recruitment in that sector and the importance of the agricultural production in the economy is limited and has been decreasing during the last years. Actually, agricultural sector represents approximately 14 % of the national production. In these circumstances rural urban migration pressures are quite strong. This has caused problems of urbanization and pollution in big cities. In order to discuss these subjects, two types of consumer are introduced in each region, qualified (skilled) and non-qualified (unskilled).

In policy discussions, we fix an objective of maintaining a minimum welfare level for the "non qualified" consumer living in the less developed region. In that point of view we introduce a least expenditure system consumption function (L.E.S.) with a minimum subsistence level of consumption.

Model Characteristics

MODEL	TURCO
COUNTRY	Turkey
DISAGGREGATION	3 regions : Industrialized, Semi-Industrialized, Rural
YEAR	1990
SOFTWARE	GAMS (PATH)
ANALYSIS	Environmental taxes, tradable emission permit system
HOUSEHOLD	Maximize utility (consumption LES, disutility of pollution)
LABOUR	Exogenous, different proportions of qualified and non qualified labor
PRODUCTION	CES (Labor, capital, energy, manufactured goods and transports)
SECTORS	15 sectors : 7 in energy, 6 in transports, agriculture and manufacture
STATE	VAT, income tax, tax on energy, import tariffs, social security tax
TRADE	3 blocs : European - OECD, non European - OECD, Rest of the world

The TURCO model is based on a three region disaggregation : Industrialized (ID), semi - industrialized (SI) and rural (RR). We use the Turkish Institute of Statistics' (S.I.S.) classification of the regions in terms of economic performances. We define :

- The industrialized region (ID) by the combination of Marmara and Aegean regions. Istanbul and Turkey's most important industrial zone, Izmit, are situated in this area.

- The semi - industrialized area (SI) that corresponds to Central Anatolia, Black Sea and the Mediterranean regions. Agricultural and industrial activities are equally important in that region.

- The rural region (RR) represented by the Eastern and South Eastern Anatolian regions.

In each region, production activities are composed of fifteen sectors. These can be aggregated into four main activities as agriculture Ag, manufacture MN, energy EN and transportation services TR.

Index j corresponds to the sectors , i to goods and services and g to geographical zones. In case where we did not use all indices corresponding to a variable, we sometimes transformed the indices to exponents in order to facilitate the reading.

Specifications of different agents' behaviors are identical in each region but they are represented by specific parameters. This is the reason why we skipped the use of a regional index in the mathematical representation of the model. In the GAMS source code we defined different indices in various subsets.

Index i designs simple goods and services :

$$i : \text{goods and services} \left\{ \begin{array}{c} \text{CAG :Agriculture} \\ \text{CMN :Manufacture} \\ \text{CLPG :Liquefied petroleum} \\ \text{CDIE :Diesel} \\ \text{CNBEN :Oil} \\ \text{CCH :Coal} \\ \text{CGS :Gas} \\ \text{CF : Fuel} \\ \text{CEL : Electricity} \\ \text{CTDUR :Domestic urban transport by road} \\ \text{CTDUO :Domestic urban transport by other ways} \\ \text{CTDIUR :Domestic interurban transport by road} \\ \text{CTDIUO :Domestic interurban transport by other ways} \\ \text{CTRMR : International transport by road} \\ \text{CTRMO : International transport by other ways} \end{array} \right\}$$

Transportation services correspond to *non-tradable* goods and non-transportation services to *tradable* goods. In the literature, some analysts define "exports of transport services" (when a national enterprise works for foreign clients) and "imports of transport services" (when foreign companies satisfy domestic clients' demands). This definition does not correspond to the State National Institute's methodology. Hence we assume that the transportation services can only be "exchanged" between different regions of the country.

In all non-agricultural sectors, we use a C.E.S. production function. We aggregate simple energy and transportation goods within nested C.E.S. structure with simple and composite goods. Composite goods are introduced as intermediate consumption goods CI, investment goods IN and government expenses G. Transportation and energy composites follow the same scheme in their disaggregation into simple goods.

All factors of production, except for the land factor used in the agricultural production such as capital and labour are mobile between regions and sectors. Two labor markets : one for qualified, other one for non-qualified exist at the national level. The base wages are determined by the equilibrium of the corresponding markets. Regional labor prices differ because the initial endowment of labor is different between regions and they obtained by adding social security premium (employer and employee) to the base wage.

Intermediate consumption goods can be exchanged between different regions without any additional travel cost (aggregate transportation cost is taken into account in the production function). Domestically produced and imported substitutes exist for each type of tradable goods. that can be exchanged on national, regional and international markets.

Import price of the good i differs according to trade partners. It is calculated by adding different regional V.A.T. and import tariff rates to the world price (this price is unique due to the perfect competition hypothesis at the international level).

Concerning the domestic prices, we apply the same principle. In order to calculate the regional domestic price of the good i, we apply different V.A.T. rates to the base price (given by the equilibrium of the national commodity market). This detail serves to test certain economic policies, like subsidizing the electricity price in the South East Anatolia Region (Grand Anatolian Project -G.A.P.- region).

We model exports according to Dixon (1982). Imports follow an Armington function between three country blocs : European O.E.C.D. countries, non-European O.E.C.D. countries and the rest of the world.

After having described the headlines of the model structure, we will define the algebraic specifications in detail.

3.1.1 Consumption

In Turkey 40 % of the labor force is employed in the primary agriculture. Meanwhile the percentage of the sector in the G.D.P. has been decreasing since the recent years. This is an explanation of the rural depopulation problem. This phenomena occupied an important place in the Turkish authorities' agenda since the foundation of the Republic.

We assume that the purchasing power of consumers and their sensitivity towards pollution vary in relation to their geographic situation. Expansion of suburban areas next to the big cities increases the pollution problem in these areas, due to the use of cheaper coal with high sulphur content by low income households. In order to analyze these kind of questions, we introduce two types of household in each region. Households are characterized as qualified (skilled) or non-qualified (unskilled) according to their professional occupations. We complement our policy simulations with a welfare analysis of these two kinds of households.

We will first present the households as labor suppliers and then as consumers. In each case two types of labors/consumers, k, exist in each region :

skilled	$k = sk$
unskilled	$k = us$

Utility U, of the consumer depends on one hand on the consumption of goods and services $u(C_k)$ and on the disutility due to the regional pollution POL_{TOT}.

$$\begin{aligned} U_k &= u(C_k) - \Theta_k POL_{TOT} \quad (1) \\ \left[\text{utility of consumer k}\right] &= \left[\text{utility coming from the cons. of goods and services}\right] + \left[\text{disutility of regional pollution}\right] \end{aligned}$$

The regional pollution level weighted by the coefficient Θ_k determines the level of pollution disutility for the consumer k. The parameter Θ_k $(0 \leq \Theta_k \leq 1)$ varies in terms of regions and consumers. As an example, the level of pollution in urban zones are superior to that in rural regions hence we consider that the citizens of the industrialized regions are more sensitive to the pollution (higher Θ_k).

The specification of the utility u_k follows a L.E.S. function in order to capture the income effect. C_k represents the total consumption of the consumer k. C_{k_i} corresponds to the consumption of household k in good i and $\overline{C}_{k_i}$ the minimum consumption level of good i. The proportion of the expenses in good i in the consumer budget is represented by the budget coefficient β_{k_i}, $\left(0 \leq \beta_{k_i} \leq 1\right)$. The sum of budget coefficients of various goods is equal to one $\left(\sum_i \beta_{k_i} = 1\right)$ and $C_{k_i} - \overline{C}_{k_i} > 0$.

$$u(C_k) = \sum_i \beta_{k_i} \ln(C_{k_i} - \overline{C}_{k_i}) \tag{2}$$

$$\begin{bmatrix} \text{utility of consumer} \\ \text{k coming from the cons. of goods} \end{bmatrix} = \begin{bmatrix} \text{budget coefficient of the good i} \\ *\text{(actual consumption - minimal} \\ \text{consumption in good i)} \end{bmatrix}$$

We classify the consumption of the households in terms of tradable (*non-transport*) and non-tradable goods (*transport*).

3.1.2 Production

We used C.E.S. specifications in the production functions for all sectors except for agriculture where we use a Cobb Douglas specification.

All kinds of production activities exist in all regions meanwhile initial endowments of qualified and non-qualified labors differ. The labor supply in the rural region is mostly composed of non-qualified rather than qualified labor (this kind of labor is demanded by the agricultural sector). Whereas the percentage of the qualified labor is higher in the industrialized and semi-industrialized regions.

3.1.2.1 Agricultural sector Compared with the other sectors, the agricultural sector needs some additional factors of production. Within a four factor Cobb Douglas production function, the farmers use agricultural inputs AG, energy EN, transportation services TR, land and labor LT [8] in their production.

$$Y = A_Y * LT^{\alpha_1} EN^{\alpha_2} TR^{\alpha_3} AG^{(1-\alpha_1-\alpha_2-\alpha_3)} \tag{3}$$

[8] In order to facilitate the reading, we present the variables corresponding to the agricultural sector without index. We use ξ for all non-agricultural sectors. In the GAMS source code, these different indices correspond to different subsets (see Longfgren, 2000).

$$\left[\text{agricultural production}\right] = \text{Cobb Douglas}\left[\text{land - labor, energy, transports, agricultural goods}\right]$$

where A_Y is the efficiency parameter with production elasticity α_i such that $(\alpha_1 + \alpha_2 + \alpha_3) < 1$.

3.1.2.2 Non-agricultural sectors In each region, non-agricultural sectors (index ξ) are specified by the same type of production functions (C.E.S.). We will present the nested production function structure in the following sections.

3.1.2.3 First level For all non-agricultural sectors, we determine a C.E.S. production function with three composite factors KL (capital-labor), EM (energy-manufactured goods) and TR (intermediate consumption of transport services). A_{Y_ξ} is the shift parameter, κ_{1_ξ}elasticity of substitution between the factors of production. ϑ_{1_ξ} and ϑ_{2_ξ} are the share parameters related to different factors of production. The production function is given as follows :

$$Y_\xi = A_{Y_\xi}\left[\vartheta_{1_\xi} KL_\xi^{1-\frac{1}{\kappa_{1_\xi}}} + \vartheta_{2_\xi} EM_\xi^{1-\frac{1}{\kappa_{1_\xi}}} + \left(1 - \vartheta_{1_\xi} - \vartheta_{2_\xi}\right) TR_\xi^{1-\frac{1}{\kappa_{1_\xi}}}\right]^{\frac{1}{1-\frac{1}{\kappa_{1_\xi}}}}$$

$$\left[\begin{array}{c}\text{production of non}\\ \text{agricultural sectors}\end{array}\right] = \text{CES}\left[\text{capital-labor, energy - manufactured good, transport}\right] \tag{4}$$

Producers of non-agricultural sectors maximize their profits under the least cost constraint. Y

3.1.2.4 Second level At the second level of the production structure, the composite factor KL_ξ is disaggregated into the demands of capital K and labor L following a C.E.S. specification :

3.1.2.5 Third level The aggregate labor demand of each sector L_j is composed of the demand for qualified L_{s_j} and non-qualified labor L_{us_j} within a C.E.S. function. A_L represents efficiency parameter, ϑ_4 share parameter, κ_4 elasticity of substitution between qualified L_{s_j} and non qualified labor L_{us_j}.

These two kinds of labor prices p_{L_k} are calculated on the basis of the wage w_k by adding the social security premium rates τ_k^{ep} :

$$p_{L_k} = w_k \left(1 + \tau_k^{ep}\right) \tag{5}$$

Real wages for skilled and unskilled labor are determined in the national labor markets. We proceed with presenting the energy and transport demands.

3.1.3 Disaggregation of the energy demand

Nested structure of the composite energy good EN is identical for the households CN_{EN}, producers CI_{EN} and investors I_{EN}.

Energy demand EN can be divided into two according to their uses : energy used in the transportation activities ETR, and for other uses EOT.

- Energy used for transportation activities ETR are diesel DI, Liquefied Petroleum Gas LP, and oil NB ("Normal Benzin" in Turkish).
- Other types of energy EOT are composed of electrical EL and non-electrical NEL.
- Non-electrical energy can be disaggregated into the gas-fuel composite GF and coal CH.
- Gas- fuel composite GF is an aggregation of the demands in gas GS and fuel F.

For each type of energy we have domestic and imported components (e.g. : domestically produced fuel FD or imported fuel FM). The origin of imported goods can be European O.E.C.D. countries, non-European O.E.C.D. countries, or the rest of the world ROW. (For example, different origins of the imported fuel are represented by $FM - eu$, $FM - neu$ and $FM - row$).

We present the nested production structure of energy goods for all sectors[9]. The first distinction appears between the energy demanded for the transport activities ETR and other uses of energy EOT. Intermediate consumption of energy EN is specified within a C.E.S. function between these two types of energy :

3.1.4 Polluting emissions

In our discussion about Turkey's contribution to the climate change phenomena, we introduced five types of Greenhouse Gas (G.H.G.) emissions to our model, which were actually published by the State Institute of Statistics (S.I.S). We don't have any other information about the rest of the greenhouse gases (G.H.G.).

Polluting emissions used in the TURCO model

CO_2	Carbon dioxide
CH_4	Methane
CO	Carbon monoxide
NO_x	Nitric oxide
NMVOC	Particles

[9] The agricultural sector is different from the remaining sectors, in the sense that it does not use any manufactured good in its production (or its demand is a negligeable according to the I-O table of 1990). Meanwhile, land appears as a main factor in that kind of production. It is because of these differences that we used a common index $\Im$ for all non agricultural sectors. From the second level of the production functions, the demands of all sectors (with agriculture) are calculated in the same way. We use the index j from that point on.

Because of the insufficient measures of the G.H.G., we take the publication of the S.I.S. as a basis and we calibrate emission coefficients in order to reproduce the same level of pollution from the energy consumption of the agents.

By analyzing the National Environmental Action Program published by the State Planning Organization, we differentiated different emission factors for each type of energy. We separated the emission coefficients of different types of energy used for transport activities ETR and for other uses EOT. In order to put the emphasis on the origin of the emissions, we preferred to classify the polluting emissions as follows :

- The first distinction appears between the energy users : we separate the emissions coming from the energy uses of **consumers** and the **producers**.
- The second distinction concerns the uses of energy. We differentiate between energy used in **transport activities** and in **other uses**.
- As defined earlier, three types of energy are used in motor vehicles : diesel DI, liquefied petroleum gas LP, oil NB. They are at the origin of the pollution type POL_{ETR}.
- Other uses of energy concern coal CH, gas GS, fuel F and electricity EL. They generate the POL_{EOT} type of pollution.

We present the emissions related to the transport activities and other uses of energy in the following section.

3.1.5 Importations

We have already mentioned that the last stage of the nested demand structure is about an arbitrage between the imported and domestic goods. In order to facilitate reading, we define an aggregate import account combining the demands in imported goods of the consumers, producers and investors.

3.1.6 Exports

We retained the Wilcoxen (1988) and Dixon and al. (1982) for the export specification. The exportation of every good i is determined by the ratio of the base price q_i on the world price $\overline{pw}_i$ converted in national money by the exchange rate tc, applied to the initial level of exports $\overline{EXO}_i$ of the good i :

$$EX_i = \overline{EXO}_i \left[\frac{q_i}{tc\,\overline{pw}_i} \right]^{\varsigma_i} \tag{6}$$

3.1.7 Government expenses and revenues

Principal government revenues consist of different types of tax revenues meanwhile the social security account is represented separately. Government expenses are determined exogenously. Introducing this budget deficit is one of the TURCO's specificity when compared to the models built for developed countries. This hypothesis can be justified by a simple analysis of the Turkish governments' budget accounts during the 1990s.

As mentioned earlier, in the absence of a domestic saving, Turkish government covers its deficit by external borrowing.

We proceed now by an analysis of the public sector's specifications.

3.1.8 Government budget

The level of the government expenses $\overline{GD}$ are determined exogenously. Most of the time in Turkey, as the government expenses are higher than the government revenues, a budget deficit problem appears.

Following our hypothesis on the absence of a domestic saving, Turkish government covers its deficit by foreign borrowing DP :

$$\begin{aligned} DP &= GR - \overline{GD} \\ \left[\text{foreign debt/budget deficit}\right] &= \left[\text{government revenue}\right] - \left[\text{government expenses}\right] \end{aligned} \tag{7}$$

3.1.9 Government expenses

As in the importation account, in order to facilitate the reading, we define two variables for the government expenses. $\overline{G}_i$ stands for the government expense in good i, while the aggregate government expense level (in value and at the national level) $\overline{GD}$ is fixed and exogenous. The distribution of the government expense in simple goods $\overline{G}_i$ is also determined exogenously within a nested structure similar to production or investment structure.

3.1.10 Government revenues

Main components of the government revenue GR are import tariffs DD_{tot}, income taxes IR, tax on energy TEN and value added tax TVA :

$$GR = TVA + DD_{tot} + IR + TEN \tag{8}$$

We will now present in detail different components of the government revenue.

3.1.11 Private investment

The level of national private investment I (in value) depends on the aggregate demand of capital K.

Before presenting the structure of the private investment we have to remind some theoretical characteristics of this account.

Private investment level is determined by applying a depreciation rate δ to the aggregate capital demand of the sectors $\sum_j K_j$:

$$\begin{aligned} I &= \delta \sum_j K_j \\ \left[\text{aggregate investment}\right] &= f\left[\text{depreciation of capital, capital demand}\right] \end{aligned} \tag{9}$$

Capital price p_K is determined by the equilibrium of the capital market (Walras rule) and it depends on the price of the composite investment good p_I, interest rate r and depreciation rate δ (exogenous) :

$$\begin{aligned} p_K &= (r+\delta)\, p_I \\ \left[\text{price of capital}\right] &= \left[\text{interest rate + depreciation rate}\right] \\ &\quad * \left[\text{aggregate price of investment}\right] \end{aligned} \tag{10}$$

3.1.12 Labor market

Two different labor markets exist : first one corresponds to the qualified labor and the second one to the non qualified labor.

The supply of these two kinds of labor, $\overline{Q}_k$ is distributed exogenously across regions. The following table summarizes our hypothesis about the regional initial endowments.

Assuming that the non-qualified labor is mostly used in the agricultural activities, the percentage of qualified and non-qualified labor employed in each region represents for us an indicator of the industrialization level. We qualify the regions as **I**ndustrialize**d** (ID), **S**emi-**i**ndustrialized (SI) or **Rur**al (RR) according to these proportions.

Labor endowments at the regional level

Regions	**Type**	**of labor**
	Qualified	Non Qualified
Industrialized	60%	40%
Semi-industrialized	50%	50%
Rural	40%	60%

Meanwhile we introduce the perfect mobility hypothesis of the labor between regions and sectors. The supply $\overline{Q}_k$ (k =qualified, non qualified) and aggregate demand $\sum_j L^D_{k_j}$ of these two kinds of labor reach the equilibrium on the national labor markets k :

$$\overline{Q}_k = \sum_j L^D_{k_j} \tag{11}$$

$$\begin{bmatrix} \text{supply of labor type k} \\ \text{at the national level} \end{bmatrix} = \begin{bmatrix} \text{labor demand of sector j} \\ \text{in k type of labor} \end{bmatrix}$$

These two equilibriums determine the base wages w_k corresponding to the qualified and non qualified labors [10]. By applying the corresponding social security taxes to the base wage w_k, we calculate the price for qualified p_{L_s} and non-qualified labor $p_{L_{us}}$.

3.1.13 Budget balance and foreign debt

As we mentioned in Chapter II, State Enterprises in Turkey has played an important role in the economy during the foundation of the Republic. Even after the liberalization and privatization process introduced in the 1980s, their importance remains in the energy sector. In our model, we reflected this specificity of the Turkish economy in the formulation of the government expenses.

Given the importance of the government expenses compared to its revenues, Turkey often faces a budget deficit problem. We define public deficit DP by the disequilibrium between government revenues GR, and expenses $\overline{GD}$. Under the hypothesis that domestic saving is inexistent, budget deficit DP is covered by foreign debt :

$$DP = GR - \overline{GD} \tag{12}$$

$$[\text{foreign debt/budget deficit}] = [\text{government revenue}] - [\text{government expenses}]$$

[10] During the calibration, we chose the unskilled labor wage as *numéraire*.

4 Environmental Measures in TURCO : Specifications and Policy Simulations

In this section, we present two environmental measures : a tax on energy and a tradable emission permits system. In each case, we first define the theoretical specifications of the measures and then we present simulation results of the suggested environmental policies.

As underlined earlier, the objective of the thesis is to propose environmental measures which will work in conformity with the economic measures already in place. The first type of scenario that we have tested concerns taxes on energy. In the sustainable development framework, the economic loss of the measure is often compensated by a decrease of V.A.T. or import tariffs on energy.

The detailed structure of the model allows us to simulate various economic policies. As an example, a decrease of V.A.T. can be tested on consumer or producer prices. It is also possible to introduce tax rates specific to each region. We should note that applying different V.A.T. rates on production and consumption goods is a policy already in practice in Turkey. Also, a higher V.A.T. rate is applied to the imported goods.

The model allows us to calculate the V.A.T. revenues collected on the imported goods from different blocs and shows the impact of environmental measures on the economic performance of the country.

The second type of scenario concerns implementation of a tradable emission permit system. Once again, the detailed structure of the model allows us to create tradable permits market at sectorial, regional and national levels. It is also possible to simulate a tradable emission market on a specific gas (like CO_2). The impact of the policies on the emission level differs depending on their origins. The first distinction concerns emissions coming from transportation activities or from other energy consumptions. The second one is related to the consumption of energy ; we differentiate between the emissions coming from the energy use of the households or the enterprises. This detail is introduced to enlighten the debates on emission sources and the responsibilities of different economic actors in the climate change phenomena.

Our scenario results are first articulated in terms of national indicators, next from regional and sectorial point of views. In each step, we define the variables on different dimensions. We start by a focus on the aggregate levels of consumption, production, balance of trade and emissions. Furthermore, we disaggregate these accounts in terms of goods, regions, types of consumer or by source of emission.

Tables including detailed results (aggregate goods, types of households and regions) can be found at the end of the section.

For all scenarios, the reference case corresponds to the "business as usual" scenario, referring to the state of the economy in 1990. Scenario results are presented as the percentage variations of the results, “expost” to the policy shock, with respect to the reference case.

4.1 Fiscal and environmental measures

In this section, we test two types of fiscal policies that consist of imposing a tax on the consumption of energy goods[11]. The policy shock is implemented at the bottom level of the price structure ; in other words on the domestic and import prices that consumers and producers pay for energy goods. Our objective is to promote the substitution of highly polluting energy goods with less polluting ones.

We present two scenarios :

- The first scenario (PN) concerns a 20% taxation of the intermediate consumption of domestic or imported energy goods,
- The second measure ($PN - CN$) simulates the imposition of a uniform tax of energy goods used in the production process or in private consumption. As it is indicated by the title of the scenario, this policy concerns energy demands of both consumers and producers.

It is also important to note that the above mentioned tax scenarios simulate the imposition of a uniform level of tax on energy goods. We also tested the case of a differentiated tax rate on energy goods. The corresponding results are displayed in the *Comparison of tested environmental policies* section.

Finally, our choice of an inelastic[12] price demand concerning energy goods can find its justification in a simple observation of oil demand in Turkey. Oil demand has been increasing steadily since the last decade despite the imposition of a 100 % tax on the world oil prices (*ozel tuketim vergisi - private consumption tax*).

4.1.1 Imposition of an uniform environmental tax of 20% on the energy price

The PN scenario is introduced by the imposition of tax t_e on the domestic and imported intermediate consumption price of energy goods. In that scenario, we defined the tax rate t_e, that is identical for all kinds of energy goods ($t_e = 20\%$).

According to the energy tax policy t_e, the **domestic price of the energy good** pd_e is now calculated by applying a producer V.A.T. rate τd_e^{pr} and an energy tax on t_e to the base price q_e. The price of domestic energy goods paid by the producers

[11]Energy goods are divided into two categories as energy components used in transport activities (NB : oil, LP : L.P.G., DI : Diesel) and in other uses (EL : Electricity, CH : Coal, GS : Gas, FL : Fuel) .

[12]See Birol&Sahin (1998), on the price elasticity estimation of demand in Turkey.

pd_e can be therefore defined as :

$$pd_e = q_e \left(1 + \tau d_e^{pr}\right)\left(1 + t_e\right) \tag{13}$$

$$\begin{bmatrix} \text{domestic price} \\ \text{of the energy good} \end{bmatrix} = \begin{bmatrix} \text{base price of the} \\ \text{energy good} \end{bmatrix} \begin{bmatrix} \text{VAT rate applied to} \\ \text{domestic int. cons. goods} \end{bmatrix} \begin{bmatrix} \text{tax on energy} \\ \end{bmatrix}$$

Concerning the **price of imported energy goods**, we apply a tax rate t_e on the bottom level of the price structure. The price paid by the producers for the energy good imported from the importation zone g, pm_e^g is, from now on, determined by applying an import tariff $\top_{g_e}^{pr}$ and a V.A.T. rate $\tau m_{g_e}^{pr}$ (specific to the producer's demand of energy goods imported from the bloc g), to the the world price of energy $\overline{pw}_e$:

$$pm_e^g = \overline{pw}_e \left(1 + \top_{g_e}^{pr} + \tau m_{g_e}^{pr}\right)\left(1 + t_e\right) \tag{14}$$

$$\begin{bmatrix} \text{price of energy good} \\ \text{imported from the bloc g} \end{bmatrix} = \begin{bmatrix} \text{world price of the} \\ \text{energy good} \end{bmatrix} \begin{bmatrix} \text{import tariff and VAT rate applied to} \\ \text{imported int. cons. goods} \end{bmatrix} \begin{bmatrix} \text{tax on energy} \\ \end{bmatrix}$$

In the $PN - CN$ scenario, both producer and consumer energy prices are taxed by 20%. The results are presented in the next section in a comparative perspective.

5 Tradable emission permit system : EN

After having discussed on the impact of a potential environmental fiscal policy in Turkey, we now present policy scenarios on the adoption of a tradable emission permits system. This kind of environmental measure have started bo be used very recently in the world economy. Thus, first we integrate to our analysis a methodological discussion on the possible configurations of such a structure. Our model aims to measure the impact of the adoption of a tradable emission system on the Turkish economy from national, regional, and sectorial perspectives.

The tradable emission permits are added to our model following the "primal approach" defined in Mc Kibbin and Wilcoxen (1992). This approach consists of introducing the tradable emission permits as factors of production. In this exercise, we were inspired by the European models with similar structures, like Beaumais, Schubert (1994) and Bréchet (1998). Even if the theoretical specifications of the tradable permits bloc are identical, our model displays differences concerning the price determination on the tradable permits market. Meanwhile, in our reference models, the first one integrates permits to the economy as an environmental tax (dual approach) while the second one uses an econometric estimation to determine the equilibrium price of the permits. In our model, we add an independent national market where the demand of permits meets supply. The initial permit quota is distributed following a "grandfathering"[13] method.

In our policy simulations, we assume that the public authorities decide on an objective on G.H.G. reduction and allocates the initial emission quotas to all sectors. The initial allocation of permits at the sectorial level $\overline{POL_j}$ is determined exogenously. Following the grandfathering method, each sector receives freely an emission quota $\overline{POL_j}$ in direct proportion of their actual emissions POL_j to total emissions POL.

$$\frac{POL_j}{POL} = \mu_j = \frac{\overline{POL_j}}{\overline{POL}} \tag{15}$$

where μ_j corresponds to the percentage of the sectorial emissions in the national emissions, POL_j initial level of the sectorial emissions, POL national level of the emissions, $\overline{POL}$ initial national emission quota, $\overline{POL_j}$ initial sectorial emission quota.

In the first scenario EN, we impose the same constraint of emission reduction on all energy producing sectors. In this objective, we decrease the emission ceiling of each energy producing sector e by 50% ($\overline{POL_e} = 0.5 * POL_e$). Energy producing sectors (concerning propellants ETR and heating fuels EOT) are constrained by sectorial emission quotas $\overline{POL_j}$.

[13] Free distribution of the initial permit quotas.

The demand in additional permits of each sector j is calculated by the emission level POL_j corresponding to a "business-as-usual" scenario minus the initial emission quota $\overline{POL_j}$. In terms of their depollution cost, enterprises decide either :

- to substitute consumption of energy goods by other factors of production (they are depolluting) and sell their unused emission permits,
- to buy additional emission permits since they can not reduce their pollution levels. We therefore determine S_j the permits exchange between sectors as :

$$S_j = (POL_j - \overline{POL_j}) \tag{16}$$

$S_j < 0$ if sectors buy permits and $S_j > 0$ if they sell permits.

The necessary conditions in the modelling of a tradable emission permits system can be summarized in three points :

- In the first instance, we integrate the additional "charge of permits" (we define as the traded permit quantity S_j times the permit price p_{pet}) in the zero profit condition of the enterprises :

$$p_{Y_j} Y_j = p_{KL_j} KL_j - p_{EM_j} EM_j - p_{TR_j} TR_j - p_{pet} S_j \tag{17}$$

with the usual definitions of p_Y production price, Y production level, KL composite capital-travail factor, EM energy - manufactured good, TR transportation services, p their corresponding prices, p_{pet} price of permits and S_j permit trade (in volume).

In other terms, concerning the "less polluting" sectors (their actual emissions are less than their initial quotas), permit trade increases the sectorial profit. On the contrary situation, the purchase additional permits means an increasing energy cost for these "high polluting" enterprises.

In each case, we impose emission *caps* for all sectors, these sectors give their names to the scenario.

- In the second instance, we add the additional emission charge to the energy price. Under the perfect competition hypothesis, we assume that the energy producers reflect the increasing energy cost to the energy production price. Hence, the aggregate propellant price p_{ETR_j} and heating energy price p_{EOT_j} are now defined as :

$$p_{ETR_j} ETR_j = p_{NB_j} NB_j + p_{LP_j} LP_j + p_{DI_j} DI_j + p_{pet} S_j \tag{18}$$

and

$$p_{EOT_j} EOT_j = p_{EL_j} EL_j + p_{CH_j} CH_j + p_{GS_j} GS_j + p_{FL_j} FL_j + p_{pet} S_j \tag{19}$$

Aggregate energy prices p_{ETR_j} and p_{EOT_j} are calculated by the budget equilibrium condition[14] further including the charge of permits. We should underline that the point of imputation of the permits is different from the energy tax case. In this fiscal policy, we applied the energy tax to the bottom level of the energy price structure (both on domestic and imported energy prices). Following the imposition of an emission constraint, the aggregate energy cost increases and encourages the substitution of the energy factors EN by other factors of production (K : capital, L : labour, M : manufactured goods, TR : transportation services). Meanwhile, the policy "shock" does not concern imported energy products. We will analyze in detail the policy consequences of this measure in the following section.

– Finally, we add to our model a tradable permit system defined at the national level. Emission permits are traded between less polluting and high polluting sectors. In the equilibrium, the emission surplus in volume is zero and determines the national permit price p_{pet} :

$$\sum_j S_j = 0 \tag{20}$$

In the following section, we describe the policy results of imposing an emission cap on the economy.

[14]The aggregate energy price is calculated by the product of the "simple" intermediate consumption prices with the consumption level of the "simple" energy goods, over the aggregate energy consumption.

6 Comparison of the scenario results

Investment decreases by -0.1% due to a decrease of capital demand in the economy. At the same time, the decomposition of the aggregate investment into goods and services displays a preference for the less polluting energy goods (investment in L.P.G. increases by +100% despite a generalized fall in investment demand in energy).

The cumulated diminution of investment and net exports explains a G.D.P. reduction of (-0.15 %) despite a slight increase in consumption. The G.D.P. decrease in percentage is very close to the production fall displayed in the PN scenario (-0.12%). The difference between the two scenario results can be explained by a less important decrease of the importations account (-0.09%) in the permit scenario EN compared to the fiscal scenario PN (-0.22%).

FIG. 1 – Comparison in terms of production and polluting emissions

Scénario	PN	PN-CN	EN
Production	-0.12	-0.49	-0.15
Emissions	-3.34	-2.25	-2.34

Nevertheless, in terms of emission reduction, the EN scenario results (-2.34 %) converge to those of the $PN - CN$ (-2.25%) scenario.

6.1 Regional and sectorial aspects

The variations concerning production activities differ between regions :

– We observe an augmentation of the transport sector's production TR in the industrialized region ID by +1.55% that boosts the regional production (+0.05%).

FIG. 2 – Regional production

	NATIONAL	ID	SI	RR
PRODUCTION	-0.15	0.05	-0.54	-0.16
AGRICULTURE	-0.93	-0.31	-2.90	-0.34
ENERGIE	2.10	-1.72	10.15	0.58
MANUFACTURE	-0.36	-0.03	-1.18	0.04
TRANSPORT	-0.19	1.55	-3.18	-1.66

– An expansion of the energy sector EN in the SI and RR regions (respectively +10.15% and +0.58%) satisfy the **consumer energy demand increase** of all regions. It should be noted that the energy demands of consumers rose by +0.003% in the industrialized region ID, +0.05% in the semi-industrialized SI and +0.2% in the rural RR regions.

FIG. 3 – Regional consumption

	NATIONAL	ID	SI	RR
CONSOMMATION	0.03	-0.01	0.12	-0.02
AGRICULTURE	-0.05	-0.06	0.01	-0.08
ENERGIE	0.04	0.003	0.05	0.20
MANUFACTURE	0.06	0.0002	0.15	0.08
TRANSPORT	-0.03	-0.03	0.01	-0.19

In the mean time, the **producers' energy demand** is reduced in all regions (-3.52% in SI and -1.51% in RR) except for the industrialized region ID (+0.82%).

FIG. 4 – Regional intermediate consumption

	NATIONAL	ID	SI	RR
CONSO INTERMEDIAIRE	-0.71	0.34	-3.47	-1.14
AGRICULTURE	-2.19	-1.63	-3.08	-1.12
ENERGIE	-0.71	0.82	-3.52	-1.51
MANUFACTURE	-0.23	-1.63	-4.57	1.11
TRANSPORT	-1.23	-0.23	-3.48	-0.48

Similar to the case of fiscal measures, in the EN scenario, the energy producing sectors are delocalized towards semi-industrialized SI and rural RR regions. The initial level of energy production being low in the semi-industrialized region SI, this increase of +10.15% is not sufficient to compensate the fall of production activities of other sectors in the region (-2.9% in AG, -1.18% in MN and -3.18% in TR). Finally, the aggregate production of the semi-industrialized region SI decreases by -0.54% (figure 2).

- We observe a slight increase in the manufacturing sector's activity MN in the rural region RR (+0.04%). This responds to the increasing demand in the intermediate consumption of the manufactured goods CI_{MN} of the same region (+1.11%).

We should also note that consumer and producer demands in energy goods are satisfied, on one hand, by the increase of production in the regions SI and RR, on the other hand, by the rise of importations. As a consequence, the demand in imported energy coming from the industrialized region ID increases by +0.85% (it should be taken into consideration that the aggregate demand of intermediate energy goods CI_{EN} increases by +0.82% and the consumer's energy demand CN_{EN} grows by +0.003% in the region). However, the fall of the imported energy goods demand (-0.77%) and imported agricultural goods demand (-0.26%) cause a reduction of imports at the national level (-0.09%).

FIG. 5 – Regional importations

	NATIONAL	ID	SI	RR
IMPORT	-0.09	0.18	-0.47	-0.18
AGRICULTURE	-0.26	-0.13	-0.58	-0.04
ENERGIE	-0.77	0.85	-3.56	-1.26
MANUFACTURE	0.02	0.10	-0.09	-0.04

We also note that the rural region's RR economic activities do not expand as it was the case in the PN scenario. It should be noted that a decrease of -0.16% in the production activities concerning the EN scenario while the rural region's production increases by +0.7% in the fiscal scenario PN. This phenomenon can be explained by different reactions of the energy producers. We observe an energy production increase in both scenarios : in the tradable permits scenario, rural RR region's energy production increases by (+0.58%) compared to a (+8.59%) growth in the fiscal scenario PN. The reason lies in a higher decrease of the high polluting sectors' productions like the coal CH and the diesel DI sectors. Their production levels are reduced by -33.63% and -58.32% respectively in the tradable permits system EN against -0.16% in the fiscal scenario PN.

- The semi-industrialized region SI is the only region where we observe the substitution of the energy goods by labor[15]. The intermediate consumption of energy goods CI_{EN} is reduced by -3.52% while the labor demand increases by +0.3%.
- However, the industrialized region ID is the only region where the production activities increase by (+0.005%) stimulated by a rise of the transportation services (+1.55%).

6.2 Polluting emissions and tradable emission permits

It is important to remind that we defined two categories of emissions for producers : POL_{ETR}^{pr} corresponds to the emissions originating from the use of propellants and POL_{EOT}^{pr} is related to the other uses of energy. We apply the same identifications to the households in order to define these two types of emissions for households (POL_{ETR}^{cn} and POL_{EOT}^{cn}).

[15]Labor is cheaper in the semi-industrialized region SI because the lowest social security premiums are applied in this region.

The following table summarizes the emission variations in the three regions.

FIG. 6 – Regional emissions

	NATIONAL	ID	SI	RR
EMISSIONS	-2.34	1.28	-1.96	-8.63
EMISSIONS - ENERGIE	-2.47	1.44	-2.34	-8.76
Producteur	-2.67	1.56	-2.61	-9.02
Consommateur	0.14	0.03	0.12	0.78
EMISSIONS -TRANSPORT	-1.50	0.27	-0.29	-7.53
Producteur	-2.14	0.47	-0.52	-8.68
Consommateur	-0.12	-0.12	-0.06	-0.35

– We have already mentioned the rise of the total consumption (+0.12%) and energy consumption (+0.05%) in the semi-industrialized region SI. This phenomena brings a rise of the emissions related to the consumers' energy use +0.12%.

Meanwhile, regional production falls by - 0.54 %, with a significative diminution of the transportation activities (-3.18%) (figure 2). The intermediate consumptions of the two types of energy goods CI_{EOT} and CI_{ETR} decrease respectively by -4.71% and -2.02% (figure **??**). The corresponding emissions are, therefore, reduced by -2.61% for POL^{pr}_{EOT} and -0.52% concerning POL^{pr}_{ETR}.

In the semi-industrialized region SI, augmentation of the emissions linked to the households' energy consumption POL^{cn}_{EOT} (+0.12%) is compensated by a more significant decrease of the producers' energy demand. Emissions related to the production activities decrease : POL^{pr}_{EOT} fall by -2.61% and POL^{pr}_{ETR} by -0.52%. The emission level in the SI region is reduced by -1.96%.

– We observe inverse economic phenomena in the industrialized region ID, production activities increase by +0.05% and consumption falls by -0.01% . In the mean time, intermediate consumptions increase in two kinds of energy goods (+0.97% for CI_{ETR} and +0.65% concerning CI_{EOT}) (figure **??**) brings a rise of the emissions coming from the enterprises : +1.56 % concerning POL^{pr}_{EOT} and + 0.47% for POL^{pr}_{ETR}. On the other hand, emissions coming from households' other uses of energy POL^{cn}_{EOT} increase by +0.03%. Households' demand in transportation services brings a -0.12% reduction in the emissions related to this kind of activities POL^{cn}_{ETR}. Finally, due to the increase of other types of emission, the regional emission level increases by + 1.28% despite a fall of POL^{cn}_{ETR} type emission.

– In contrast, in the rural region RR, a simultaneous fall of the consumption (-0.02%) and production (-0.16%) results in a decrease of the emissions (-8.63%). An important reduction of the regional emission level occurs despite an increase in the emissions coming from households' other use of energy POL^{cn}_{EOT}

(+0.78%) due to a rise of the energy goods' consumption (+0.2%).

At the national level, we observe a decrease of -2.34% in G.H.G. emissions. This variation is less significant than the emission fall in the PN scenario (-3.33%) but close to the $PN - CN$ case (-2.25%).

Emission permit trade

As we have already emphasized, certain energy sectors increase their production in order to satisfy the increasing energy demand. The increase in the L.P.G. production at the national level (the less polluting propellant) reaches 32% and the investment in that good is doubled. The production of gas, fuel and oil increase in the rural region following a delocalization of the energy production towards that zone. We should also notice that the expansion of the energy sectors that are capable of increasing their productions are the depolluting sectors (those who can substitute energy goods by other factors of production). The highest fall occurs in the use of coal (the most polluting fuel). The demand of coal CI_{CH} decreases therefore by -80.43% in the fuel producing sector, -83.79 % in oil and -95.27% in the L.P.G. sector.

FIG. 7 – Intermediate consumption of coal

Agriculture	0.80
Electricité	0.07
Charbon	-0.21
Gaz	66.22
Fuel	-80.43
Essence	-83.79
Diesel	-35.90
LPG	-95.27
Manufacture	-0.25
A l'etranger- route	-0.02
Domestic-urbain-route	0.67
Domestic-urbain-autre	-6.79
A l'etranger- autre	8.52
Domestic-interurbain-route	2.55
Domestic-interurbain-autre	-14.34

The following table describes the inter-sectorial emission permit trade. We note that the "less polluting" energy sectors increase their production. The demand for emission permit increases simultaneously with the demand increase of the other factors of production. This is the case for oil, fuel and L.P.G. producing sectors; as a consequence, these sectors buy additional permits.

The equilibrium of the permit market is defined by the quantities sold and bought at the national level. The semi-industrialized region SI appears as the zone that supplies permits to the remaining regions. We also mentioned the substitution of the energy goods by labor in that region. The unused emission quota is purchased by the two other regions where the production increase necessitates the use of new emission permits. (It is important to note that the production level increases by +1.55% in the transportation sector TR of the industrialized ID region, by +40% concerning natural gas, by +99% of the fuel and +87% of the oil sector in the rural region RR, (see figure 2).

FIG. 8 – Intersectorial trade of emission permits

	ID	SI	RR	TOTAL
Agriculture	0.12	-4.39	0.20	-4.07
Electricité	5.24	-3.05	-26.99	-24.80
Charbon	2.46	1.51	-33.68	-29.72
Gaz	-9.52	2.04	40.19	32.70
Fuel	-2.48	-32.83	98.59	63.27
Essence	4.60	-48.17	86.50	42.93
Diesel	10.59	-5.32	-58.16	-52.89
LPG	-40.64	184.70	-27.11	116.95
Manufacture	0.52	-4.60	-0.03	-4.11
A l'etranger- route	-1.93	4.47	-12.13	-9.59
Domestic-urbain-route	0.53	-0.40	-1.85	-1.72
Domestic-urbain-autre	3.52	-34.02	8.89	-21.61
A l'etranger- autre	28.23	-14.09	-56.40	-42.26
Domestic-interurbain-route	2.70	-0.67	5.44	7.47
Domestic-interurbain-autre	13.33	-71.47	-14.41	-72.55
TOTAL	17.26	-26.30	9.04	0.00

The welfare impact in terms of variation of equivalent revenue is given by the below table.

FIG. 9 – Equivalent revenue variation (% of GDP)

	EN	
Welfare	**Skilled**	**Unskilled**
ID	-0.13	-0.086
SI	0.746	0.737
RR	0.251	0.411

6.3 Comparison of fiscal policy scenarios (PN and PN-CN) with the tradable emission system EN

As we have already highlighted, the tradable emission permit scenario results EN are close to the PN (tax on producer energy prices) scenario in terms **economic efficiency** and to the $PN - CN$ scenario (tax on producer and consumer energy prices), in terms of **environmental efficiency**.

It is important to note that the increase of in the importations was more significant in the fiscal policies (-0.22% in PN, -1.77% in $PN - CN$ and against -0.009% in the permits scenario EN). This phenomenon can be explained by the fact that contrary to the permit scenario, the fiscal policies concern both national and imported products[16].

The major disadvantage of this configuration is the environmental efficiency. In comparison to the fiscal policies, we observe an important substitution of the domestic energy goods by their imported equivalents in the permit scenario. Because of the insufficiency concerning environmental data, we applied the same emission coefficient to the two types of energy. The scenario results lead us to a situation where imported fuels (as polluting as their domestic equivalents) substitute domestic fuels. In Chapter I, we also mentioned policy efforts concerning the substitution of the domestic coal by the imported coal in Turkey. It will be an important amelioration for our model to test the same policies with different emission coefficients for domestic and imported fuels.

It is also interesting to test a tradable emission system that will work between national and foreign producers (similar to the fiscal policy case). The results concerning this type of policy will be briefly presented in the thesis (french version).

In comparison to the energy tax policies, the tradable emission scenario EN appears as the only policy where a welfare amelioration occurs (+0.05%). We note the most important welfare loss (-2.14%) in the $PN - CN$ scenario. This can be explained by the fact that we put into practice fiscal measures concerning directly the consumer prices. While the fiscal policy scenario PN or the permit scenario EN concern first producer prices, therefore, influence indirectly consumer prices.

FIG. 10 – Comparison of the scenarios

Scénario	**PN**	**PN-CN**	**EN**
Production	-0.12	-0.49	-0.15
Emissions	-3.34	-2.25	-2.34

[16] In the fiscal scenarios, energy tax t_{en} is applied to domestic pd and imported pm_g energy prices.

In the mean time, in terms of environmental efficiency, the most important emission reduction occurs in the PN scenario (-3.34% compared to -2.34% in the emission policy EN).

With reference to the discussions about Kyoto protocol, we express the following point of view that a slight decrease of the G.H.G. emissions even a stabilization at the 1990 level, in the 2005 - 2008 period, can be considered as a sufficient performance for Turkey. Since the 1% difference that occurs between the fiscal (-3.34%) and tradable emission permit scenarios (-2.34%) is not very significant. Hence, the energy tax policy and the tradable emission policy display similar results in terms of G.D.P. reduction and emission decrease.

However, we should take into account the political acceptability and administrative cost aspects of the tradable emission system. We include a methodological discussion in our analysis in order to elaborate these two important points for various emission policies (upstream, downstream and hybrid).

In the economic literature, the tradable emission scenario EN, defined between energy producer sectors appears to be the most politically acceptable and the most feasable (low administration cost) policy.

The administrative costs concerning tradable emission permit system are beyond the scope of the current study, it requires some additional data concerning institutions. It is important to remember that Turkish authorities have already put into practice export subsidy measures in the 1980's. The opposition to the environmental policies often uses this argument and defends the importance of economic competitiveness in the exporting sectors. Therefore, it is important to analyze in detail the impact of environmental fiscal measures on different sectors.

The TURCO model gives us the first results concerning the implementation of a tradable emission permits system on the Turkish economy. In the tradable emission system like in the fiscal environmental measures, the export performance falls slightly. A detailed sectorial analysis is necessary for a realistic evaluation of the scenarios. As an example, production activities concerning the chemical and textile sectors are both classified in the manufacturing category MN. However, the two branches use different production processes therefore pollute in different ways. The suggested measures should also take into account these technological divergences.

Until a new version of the model where these technical details can be integrated, we limit our discussion to a methodological discussion concerning the different possible configurations of a tradable emission permit system between energy producing and energy consuming sectors.

7 Evaluation of tested environmental policies

Our objective was to test different environmental measures for Turkey. Concerning both the fiscal and tradable emission permits, we observed that the variations on the economic indicators were inferior to those obtained with similar models constructed for European economies more specifically MEGAPESTES, Beaumais, Schubert (1994).

The main explanation comes from the fact that the most polluting sectors represents only a minor part of the Turkish economy and their are concentrated mainly on Istanbul and the surrounding area.

We hence tested the vision that the GHG emissions problem should be reduced to a regional problem and the energy taxation should be implemented on "a regional level. This kind of "partial" policies did not give significant result. Given the fact that the goods and services market is defined at the national level, increasing the prices of energy goods in one region, means encouraging the purchase of the same good from other regions. As a consequence, we chose to test "national" of environmental policies in our analysis.

Concerning the small magnitude of our results in comparison to those obtained in European models, we note that the imposition of a (+20%) tax on energy prices ; the PN scenario gives closer results, to Roe and Yeldan (1994) simulation results corresponding to a 25% increase on VAT rates.

We also compared our policy simulation results by Karadag and Westaway (2000), where the objective was to quantify the impact of a significant increase in the VAT rates (they are multiplied by a coefficient that varies between 8 and 200%). Similar small changes are observed in the simulation results (percentage variation between 0.1 and 1%). The main explanation comes from an inelastic of the demand to price changes (concerning both the intermediate consumption and the private consumption goods).

Fig. 11 – Comparison of environmental measures

Scénario	**PN**	**PN-CN**	**EN**	**ET**
Production	-0.12	-0.49	-0.15	-0.06
Consommation privée	-0.14	-1.98	0.03	0.11
Importations	-0.22	-1.77	-0.09	0.05
Emissions	-3.34	-2.25	-2.34	-1.48

As we have already emphasized in the first chapter, in terms of total energy consumption, Turkey's energy demand corresponds only to the half of the OECD average. However, the energy intensity of each unit of production is superior to the OECD countries'. This is the reason why the IEA experts talk about "the waste of energy" in the Turkish economy. We note the same phenomenon in our policy results since small variations in the production level corresponds to significant changes in the emission level.

By referring to our discussion on the Kyoto Protocol, maintaining the emission level at the 1990 level or 1 to 3% decrease with respect to this level, should be considered as a good performance for Turkey. From that point of view, we consider that the environmental performances of our policy simulations are satisfactory. However our aim consists in putting the emphasis on the regional impacts of environmental policies.

In terms of the regional differences of the policy results : we are concerned by two important points. First, the labor force substitutes to the "highly polluting" energy factors in some regions. We observe a delocalization of the energy activities and a migration of the labor force towards the rural region. As a consequence, a labor supply increase accompanies the raise of the production activities in the rural region[17] (the most significant increase is about +14% of labor supply in the rural region). Considering the traditional "low population density" characteristic of the region, this increase corresponds only to the migration of a marginal part of the total population.

In the rural region, the magnitude of the production level increase seems also as important at the first sight, however it should be noted that the initial contribution of the region corresponds to less than 10% of the national production. Even with the most significant increase in the production activities (+16% increase with respect to the initial production level of the rural region), this production level stays largely inferior to the industrialized region's economic performance. It should be also noted that these policy results correspond to the "high priority" development objectives determined by the Turkish governments.

From a sustainable development perspective, both measures seem to be satisfactory since a small fall of the national production level accompanies a satisfactory reduction of the GHG emissions.

However, energy taxation policies appear to be the most efficient tools because the fiscal measure concerns both the domestic and imported energy good prices. As the tradable emission permit system is designed only between domestic energy producing sectors, the corresponding policy results lead to an increase in the demand for imported energy goods. Considering the already existing problems about the deficit of the balance of trade and the weakness of the Turkish Lira with respect to the other currencies, this policy would not be sustainable.

[17] We should remind that the labor supply is exogenously distributed between regions. The cost of labor differences between regions originate from the applications of different social security premiums according to regions. The highest labor cost corresponds to the rural region and the cheapest to the semi-industrialized region. Our assumption about the superiority of the labor cost is justified by the adoption of a law in 1998 abolishing the social premium rates applied in the rural region.

We therefore arrive to the conclusion that the environmental measures should be applied simultaneously to domestic and imported price of energy goods. The conformity of such measures to the OMC principles could constitute another research theme.

We can conclude our policy discussion analysis by underlining the idea that the imposition of environmental measures in Turkey would not lead to a drastic deterioration of the economic performance. However, by defining a sustainable development policy in line with the UNFCCC principals would give the country the access to the international funds in environment. Turkey would prove its sensitivity to the environmental problems and would adapt itself to the internationally accepted conventions on environment. In the mean time, Turkish authorities should negotiate the definition of such environmental objectives with the international authorities like it was the case for other "fast developing" economies (Mexico, South Korea...) in order to reconcile Turkey's economic development priorities with international global warming policies.

8 Appendix

Walras rule

In the TURCO model, Walras rule is written for the capital market and determines the price of capital. We already assumed that the households consume all their revenue hence the national saving does not exist. Observing the Turkish government's debt policies during the 1980-90s, we made the hypothesis that the foreign savings finance the investment.

This hypothesis brings the problem of determining the sustainable foreign debt level for Turkey in a dynamic perspective.

We verify hereby the Walras rule. The demand and supply equilibrium is written (in value) for every goods and services :

$$\begin{aligned} & \sum_i p_i Q_i + \sum_i IM_i \\ = & \sum_{k,i} C_{k_i} pc_{k_i} + \sum_{j,i} CI_{j_i} p_{j_i} + p_{iv_i} I_i + \overline{GD}_i + \sum_i X_i \end{aligned} \tag{21}$$

where p_i corresponds to the product price, p_{iv_i} to the investment price (we apply the corresponding V.A.T. to the base price q_i), Q_i the level of production, C_{k_i} consumption in good i of the consumer k.

Zero profit conditions are written between the producer's revenue and expenses. The production cost is given by the aggregation of capital K and labor L costs combined with the intermediate consumption expenses :

$$\sum_j p_{Y_j} Y_j = p_K \sum_j K_j + p_{L_j} \sum_j L_j + \sum_{j,i} CI_{j_i} p_{j_i} \tag{22}$$

We eliminate the intermediate consumption CI on the both sides and we replace the private consumption C_{k_i} by its expression concerning households' revenue :

$$\sum_{k,i} C_{k_i} pc_{k_i} = \sum_k RV_k - \sum_k TRS_k$$

After introducing the expression of balance of trade BC by its equation (**??**). We detail the labor cost $p_L L$ in order to separate social security premiums (employee, employer) τ_k^e, τ_k^{ep} and income taxes τ_k^{IR}.

$$\begin{aligned} & p_K \sum_j K_j + \sum_{k,j} w_k \left(1 + \tau_k^{ep}\right) L_{k_j} \\ = & \sum_{k,j} w_k \left(1 - \tau_k^{IR}\right) \left(1 - \tau_k^e\right) L_{k_j} + \sum_k TRS_k + I + \sum_i p_i \overline{G}_i \end{aligned}$$

We aggregate different social security premiums and taxes : import tariff revenue DD, V.A.T. revenues TVA and tax on energy TEN are derived from corresponding rates and the respective prices p_i, p_G, p_I, $pc_{k_{nt}}$.

The specification of the government budget was :

$$\begin{array}{ccc} DP & = & \overline{GD} - GR \\ \left[\text{budget deficit}\right] & = & \left[\text{gvt. expenses}\right] - \left[\text{gvt. revenues}\right] \end{array}$$

Social transfers TRS are eliminated with aggregate social security revenues COT. Finally we get the following relation :

$$p_K \sum_j K_j = I + DP + BC$$

where p_K corresponds to the capital price, $\sum_j K_j$ aggregate capital demand of the sectors j, I aggregate investment (in value), DP foreign debt and BC balance of trade.

The previous relations between the prices of capital p_K and investment p_I, aggregate investment I and capital demand K, lead us to the capital market equilibrium :

$$p_I r K = DP + BC \tag{23}$$

where p_I stands for the investment price, r interest rate, DP foreign debt and BC balance of trade.

The Walras rule is written for the capital market and the market closure determines the capital price p_K . In that configuration, we assume that foreign saving (DP) finances the capital demand of the Turkish economy.

Calibration

This stage necessitated along period of examination and the verification of the existing data. In order to complete the lack of data, we had to refer to the similar cases of other countries and even to consult the experts in the subject. We verified and manipulated the economic and environmental data coming from different sources.

Most of the regional indicators come from the S.I.S statistics. However an harmonization process was necessary. Most of the global economic indicators (consumption, production, export performances, ...) exist in the regional level. However, this is not the case for the region I-O table. We have disaggregated the national I-O table into three regional I-O tables, proportionally to the sectors' contribution to the national production.

It should also be noted that the Industrialized region is dominant in all economic activities including agriculture (since it is composed of the most fertile regions that are the Aegean region and the Marmara region). Hence the variations of this region are most of the time determinant on national results.

In that sense, the migration of the labor between region gives to the model a different perspective and influence the rural region's activities in a positive way.

Details on the calibration process and the energy elasticities estimated for Turkey (Birol, Sahin (1998)) can be found in the appendix of the thesis (they are not reported in this document).

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