Türkçe'ye Global iklim değişikliği sorununa Karşı

Anloomunun Türkiye'deki ekonomik etkilerini ölçmek için bir区域的General

Enerji ve ulaşım sektörlerini ayrı ayrı detaylandırdı ve farklı region ve farklı

1 Giriş


Sebnem Sahin

Haziran 3, 2002

Abstract

Bir uygulama genel eşdeğer model önerildi, bu model Türkiye ekonomisinin bir uluslararası çevre programına dayanan çevresel vergiler ve bir emisyon izinler sisteminin etkisi ile quantify the impact of a national environmental program on the Turkish economy, based on environmental taxes and a system of tradable pollution permits. In this model, Turkey is divided into different regions according to the level of industrialization and pollution in order to determine the most appropriate policies. The energy and transport sectors are detailed in order to develop a trading permits system between different regions and different sectors of production. The conclusions of the model are used to suggest a sustainable development policy respecting the international conventions on global warming.

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1 Giriş

In this paper, a computable general equilibrium model (GEM) is built to quantify both the impact of the environmental policies that can be adopted by the Turkish government on the economy and the impact of economic policies on the environmental quality.

Turkey is divided into three regions depending on their economic activities:
- industrialized (Marmara and Aegean region),
- semi-industrialized (Central Anatolia, Black Sea and Mediterranean region),
- rural regions (Eastern and South-Eastern Anatolia).

We first describe the specifications used in different economic agents’ behaviors and secondly summarize the results of environmental policy scenarios. Finally we propose some policy scenarios which will be accomplished in the final version of the paper.

Nested demand CES functions are used in the production and consumption sides. The disaggregation of these composite factors are represented in common figures with different indices on consumer, pr producer, gv government, iv investor). A detailed lexica exists at the end of the paper.

2 Consumption

2.1 Household income

Two types of households which are distinguished by index k (skilled sk and unskilled us) exist in each of the three region. Their disposable incomes $RV_{sk}$ are composed of the labor income and social transfers $TRS_k$. For example, the income of the skilled labor is written as:

$$RV_{sk} = w_{sk} (1 - \tau_{sk}^{IR}) (1 - \tau_{sk}^{e}) LS + TRS_{sk}$$

The disposable income of the skilled household $RV_{sk}$ takes into account their labor earnings, the amount of social cotisations (rate $\tau_{sk}^{e}$) as well as income tax (rate $\tau_{sk}^{IR}$).

Total social cotisations $TRS_{tot}$ is given by the sum of employee ($\tau^e$) and employer cotisations ($\tau^{ep}$).

$$TRS_{tot} = (\tau_{us}^e + \tau_{us}^{ep}) w_{LUS} \sum_j LUS_j + (\tau_{sk}^e + \tau_{sk}^{ep}) w_{LS} \sum_j LS_j$$

The consumer spends all his income $RV_k$ on the purchase of transport and non transport goods. In this long term vision, the consumer does not hold any saving.
2.2 Consumer’s utility

The consumer maximizes his utility by increasing his consumption while the amount of pollution in his region represents a disutility. The maximization program of the representative agent is given as follows:

\[
\begin{align*}
\max_{C_k} & \quad U(C_k) \\
\text{st} & \quad U(C_k) = u_k - \Theta_k POL_{TOT} \\
RV_k & = C_{kts} pc_{kts} + C_{knt} pc_{knt}
\end{align*}
\]

where

\[
u_k = \sum_{kts} \beta_{1kts} \ln(C_{kts} - \overline{C}_{kts}) + \sum_{knt} \beta_{2knt} \ln(C_{knt} - \overline{C}_{knt}) \quad (3)
\]

\(C_k\) stands for the consumption of different goods with \(\overline{C}_k\), the corresponding subsistence levels. The following conditions are verified for budget coefficients \((\beta_{1kts} + \beta_{2knt} = 1)\) with \((0 < \beta_{1kts}, \beta_{2knt} < 1)\), and the consumption levels \((C_{kts} - \overline{C}_{kts} > 0\) and \(C_{knt} - \overline{C}_{knt} > 0)\).

The total pollution \(POL_{TOT}\) (originating from industry, households and transport services) represents a disutility for the households’ utilities, with the corresponding coefficient \(\Theta_k\).

Households’ demands are derived from the first order conditions for non transport goods

\[
C_{knt} = \overline{C}_{knt} + \beta_{2knt} \left( \frac{RV_k - \sum_{knts} pc_{knts} \overline{C}_{knts}}{pc_{knts}} \right) \quad (4)
\]

and for transport services:

\[
C_{kts} = \overline{C}_{kts} + \beta_{1kts} \left( \frac{RV_k - \sum_{knts} pc_{knts} \overline{C}_{knts}}{pc_{knts}} \right) \quad (5)
\]

2.3 Disaggregation of consumption products in terms of their origin

For the consumer and the producer, we represent the disaggregation of transport services and energy demands in the same formulas with different indices.

In the case of non transport goods, the consumer chooses between domestic and imported goods. His cost minimization program is given as follows:
\[ \begin{align*}
\text{Min } & \quad pc_{knt} C_{knt} \\
\text{st } & \quad C_{knt} = A_{nt} \left[ CD_{knt}^{1-\gamma_{nt}} + \beta_{knt} CM_{knt}^{1-\gamma_{nt}} \right]^{\frac{1}{1-\gamma_{nt}}} \\
\end{align*} \]

Demands for domestic \( CD_{knt} \) and imported \( CM_{knt} \) consumption goods are:

\[\begin{align*}
CD_{knt} &= C_{knt} A_{nt}^{\gamma_{nt}-1} \left( \frac{pc_{knt}}{pd_{nt}} \right)^{\gamma_{nt}} \\
CM_{knt} &= C_{knt} A_{nt}^{\gamma_{nt}-1} \left( \frac{\beta_{knt} pc_{knt}}{pm_{knt}} \right)^{\gamma_{nt}}
\end{align*}\]

While the corresponding price relation can be written as:

\[ pc_{knt} C_{knt} = pd_{nt} CD_{knt} + pm_{knt} CM_{knt} \]

### 3 Production

#### 3.1 Non agricultural sectors

The indice \( \xi \) means that this disaggregation will also be used for the demands coming from other actors of the economy (cn consumer, pr producer, gv government and iv investors).

All sectors except agriculture is given by a three factor CES functions. Profit maximization program of the producer is given as follows:

\[\begin{align*}
\text{Max } & \quad p_{Y_{\xi}} Y_{\xi} = p_{KL_{\xi}} KL_{\xi} + p_{EM_{\xi}} EM_{\xi} + p_{TR_{\xi}} TR_{\xi} \\
\text{st } & \quad Y_{\xi} = A_{Y_{\xi}} \left[ \vartheta_{1_{\xi}} KL_{\xi}^{1-\frac{1}{\gamma_{1_{\xi}}}} + \vartheta_{2_{\xi}} EM_{\xi}^{1-\frac{1}{\gamma_{2_{\xi}}}} + (1 - \vartheta_{1_{\xi}} - \vartheta_{2_{\xi}}) TR_{\xi}^{1-\frac{1}{\gamma_{1_{\xi}}}} \right]^{\frac{1}{1-\gamma_{1_{\xi}}}} \\
\forall \xi : & \quad \text{non agricultural sectors}
\end{align*}\]

Where \( KL \) is the capital labor composite input, \( EM \) energy - manufactured good input and \( TR \) stand for transport services.

Demands of these production factors are defined as:
The corresponding price relation of the activity $p_{Y_{\xi}}$ is given by:

$$p_{Y_{\xi}} = p_{EM_{\xi}}EM_{\xi} + p_{KL_{\xi}}KL_{\xi} + p_{TR_{\xi}}TR_{\xi} \quad (9)$$

The composite input structure used in all non agricultural sector is summarized in the below (figure 1).

### 3.1.1 Demand of capital-labor factor

In the second level of production, the composite factor $KL_{\xi}$ with a CES specification. The non agricultural sectors’ cost minimization program is given by:

$$\begin{align*}
\text{Min} & \quad p_{KL_{\xi}}KL_{\xi} \\
\text{st} & \quad KL_{\xi} = A_{KL_{\xi}} \left[ \phi_{3_{\xi}}K_{\xi}^{1-\frac{1}{\alpha_{\xi}}} + (1 - \phi_{3_{\xi}})L_{\xi}^{1-\frac{1}{\beta_{\xi}}} \right]^{\frac{1}{\alpha_{\xi}}} \\
\forall \xi & : \text{non agricultural sectors}
\end{align*}$$
Factor demands are derived from the first order conditions (FOC):

\[ K_\xi = A_{KL_\xi}^{k_3-1} KL_\xi \left( \frac{\vartheta_{3L} p_{KL_\xi}}{p_K} \right)^{k_3} \]  
\[ L_\xi = A_{KL_\xi}^{k_3-1} KL_\xi \left( \frac{1 - \vartheta_{3L} p_{KL_\xi}}{p_{L_\xi}} \right)^{k_3} \]  
\[ (10) \]

The corresponding relation gives the composite capital labor price \( p_{KL_\xi} KL_\xi = p_K K_\xi + p_{L_\xi} L_\xi \) 
\[ (11) \]

### 3.1.2 Demand of skilled and unskilled labor

For the sector \( j \), the labor cost minimization program is determined as the following:

\[ \text{Min } p_{L_j} L_j = p_{LS_j} L_{S_j} + p_{LUS_j} L_{US_j} \]
\[ \text{st} \]
\[ L_j = A_{L_j} \left[ \vartheta_{L_j} L_{S_j}^{1 - \frac{1}{\kappa_j}} + (1 - \vartheta_{L_j}) L_{US_j}^{1 - \frac{1}{\kappa_j}} \right]^{1 - \frac{1}{\kappa_j}} \]

FOC give the demand for qualified \( L_{S_j} \) qualified and non qualified \( L_{US_j} \) labors:

\[ L_{S_j} = A_{L_j}^{\kappa_{L_j} - 1} L_j \left( \frac{\vartheta_{L_j} p_{L_j}}{p_{LS_j}} \right)^{\kappa_{L_j}} \] 
\[ L_{US_j} = A_{L_j}^{\kappa_{L_j} - 1} L_j \left( \frac{1 - \vartheta_{L_j} p_{L_j}}{p_{LUS_j}} \right)^{\kappa_{L_j}} \]  
\[ (12) \]

The prices of qualified \( p_{LS} \) and non qualified \( p_{LUS} \) labor are calculated from the wage rate \( (w_{LS} \text{ and } w_{LUS}) \) by applying the corresponding social cotisation rates \( (\tau_{sk}^e \text{ and } \tau_{us}^e) \) as follows:

\[ p_{LS} = w_{LS} (1 + \tau_{sk}^e) \]  
\[ (13) \]

and

\[ p_{LUS} = w_{LUS} (1 + \tau_{us}^e) \]  

6
3.2 Agricultural sector

After a detailed review of literature we chose a Cobb Douglas production function for the agricultural sector.

3.2.1 Demand of land

The cost minimizing program of the agricultural producer $Sag$ is determined as follows:

$$
\text{Min } p_{Y_{Sag}} Y_{Sag} = p_{LT_{Sag}} LT - p_{EN_{Sag}} EN_{Sag} - p_{TR_{Sag}} TR_{Sag}
\text{st } Y_{Sag} = A_{Sag}(LT)^{\alpha_1}(EN_{Sag})^{\alpha_2}(TR_{Sag})^{\alpha_3} (AG_{Sag})^{(1-\alpha_1-\alpha_2-\alpha_3)}
$$

The Cobb Douglas production function is written with a scale parameter $A_{Sag}$ and the following condition on elasticities $(\alpha_1 - \alpha_2 - \alpha_3) < 1$.

The composite land labor factor $LT_{Sag}$, energy $EN$, transport services $TR$, agricultural products $AG$ are used by the sector $Sag$.

Factor demands of the agricultural sector are given as follows:

$$
LT_{Sag} = \alpha_1 \frac{p_{Y_{Sag}}}{p_{LT_{Sag}}} Y_{Sag}
\text{ (14)}
$$

$$
EN_{Sag} = \alpha_2 \frac{p_{Y_{Sag}}}{p_{EN_{Sag}}} Y_{Sag}
$$

$$
TR_{Sag} = \alpha_3 \frac{p_{Y_{Sag}}}{p_{TR_{Sag}}} Y_{Sag}
$$

$$
AG_{Sag} = (1 - \alpha_1 - \alpha_2 - \alpha_3) \frac{p_{Y_{Sag}}}{p_{AG_{Sag}}} Y_{Sag}
$$

The composite land and labor factor $LT_{Sag}$ is decomposed by a CES function:

$$
\text{Min } p_{LT_{Sag}} LT_{Sag} = p_{L_{Sag}} L_{Sag} + p_T TE
\text{st } LT_{Sag} = A_{LT} \left[ \vartheta_{10} L_{Sag}^{-\frac{1}{\kappa_{10}}} + (1 - \vartheta_{10}) TE^{-\frac{1}{\kappa_{10}}} \right]^{1 - \frac{1}{\kappa_{10}}}
$$

The corresponding demands of labor $L_{Sag}$ and land $TE$ are calculated as:

$$
L_{Sag} = A_{LT}^{\kappa_{10} - 1} \left( \frac{\vartheta_{10} p_{LT_{Sag}}}{p_{L_{Sag}}} \right)^{\kappa_{10}} LT_{Sag}
\text{ (15)}
$$

$$
TE = A_{LT}^{\kappa_{10} - 1} \left( \frac{1 - \vartheta_{10}}{p_T} \right)^{\kappa_{10}} LT_{Sag}
$$
3.3 Transport demands of different actors

We put the emphasis on the transport activities because by reference to technical measurements, these seem to be the most polluting activities. We classify the "road transport" as the most polluting activity because of the same reasons. This consideration is justified by the lack of any international standards in Turkey (as ISO 9000) in motor vehicles’ production and by the existence of a very old stock of trucks used in the country.

We proceed our analysis by the decomposition of transport activities (identical decomposition for the consumer $cn$ and the producer $pr$). The corresponding demands are calculated from the cost minimization programs.

Transport services are first classified as national $TRD$ and international $TRM$:

$$TRD_3 = \left[ \varphi_{4a} \cdot TRD_{3}^{1 - \frac{1}{\varphi_{4a}}} + (1 - \varphi_{4a}) \cdot TRM_{3}^{1 - \frac{1}{\varphi_{4a}}} \right]^{-\frac{1}{\varphi_{4a}}}$$  \hspace{1cm} (16)

for all actors $cn$, $pr$, $iv$, $gv$.

At the next level, agents choose between roads $TRMR$ and other ways of transport $TRMO$ (ships, airways, railways) for the international transport services:

$$TRM_3 = ATRM_3 \left[ \varphi_{6a} \cdot TRMR_{3}^{1 - \frac{1}{\varphi_{6a}}} + (1 - \varphi_{6a}) \cdot TRMO_{3}^{1 - \frac{1}{\varphi_{6a}}} \right]^{-\frac{1}{\varphi_{6a}}}$$  \hspace{1cm} (17)

While domestic urban $TDU$ and interurban $TDIU$ transport services are also distinguished:

$$TRD_3 = A_{DU3} \left[ \varphi_{5a} \cdot TDU_{3}^{1 - \frac{1}{\varphi_{5a}}} + (1 - \varphi_{5a}) \cdot TDIU_{3}^{1 - \frac{1}{\varphi_{5a}}} \right]^{-\frac{1}{\varphi_{5a}}}$$  \hspace{1cm} (18)

Finally for urban and interurban travels, there exists a choice between roads and other ways. This relation is given as follows for the urban transport as

$$TDU_3 = A_{UR3} \left[ \varphi_{8a} \cdot TDU_{UR3}^{1 - \frac{1}{\varphi_{8a}}} + (1 - \varphi_{8a}) \cdot TDUR_{3}^{1 - \frac{1}{\varphi_{8a}}} \right]^{-\frac{1}{\varphi_{8a}}}$$  \hspace{1cm} (19)

and for interurban activities:

$$TDIU_3 = A_{IU3} \left[ \varphi_{7a} \cdot TDIU_{3}^{1 - \frac{1}{\varphi_{7a}}} + (1 - \varphi_{7a}) \cdot TDIUO_{3}^{1 - \frac{1}{\varphi_{7a}}} \right]^{-\frac{1}{\varphi_{7a}}}$$  \hspace{1cm} (20)

The corresponding demands are calculated from the first order conditions as above.
3.4 Decomposition of energy demand

Like in the transport services case, the disaggregation of transport services is identical for the consumer and the producer. The first distinction appears between the energy used on transport needs $ETR$ and in other needs $EOT$. The cost minimizing program is given as follows:

$$
\begin{align*}
\text{Min} & \quad p_{EN3}EN_3 = p_{ETR3}ETR_3 + p_{EOT3}EOT_3 \\
\text{st} & \quad EN_3 = A_{EN3} \left[ \vartheta_{43} ETR_3^{1-\frac{1}{\kappa_4}} + (1 - \vartheta_{43}) EOT_3^{1-\frac{1}{\kappa_4}} \right]^{\frac{1}{1-\frac{1}{\kappa_4}}}
\end{align*}
$$

Each type of demand is disintegrated into simple demands in fuels as above.

3.4.1 Energy demand for transport activities

Aggregate energy demand for transport activities $ETR_3$ is composed of simple energy demands as follows:

$$
ETR_3 = A_{ET3} \left[ \vartheta_{53} DIE_3^{1-\frac{1}{\kappa_5}} + \vartheta_{63} NBEN_3^{1-\frac{1}{\kappa_5}} + (1 - \vartheta_{53} - \vartheta_{63}) LPG_3^{1-\frac{1}{\kappa_5}} \right]^{\frac{1}{1-\frac{1}{\kappa_5}}}
$$

(21)

Diesel $DIE$, oil $NBEN$ and liquefied gas $LPG$ are the most demanded fuels and they correspond to various emission coefficients. In a decreasing order, the cleaner fuel is liquefied petroleum followed by oil and diesel.

3.4.2 Energy demand for other needs

Energy demand for other activities $EOT_3$ is also disaggregated following the previous structure of composite factors. At the first step, electricity $EL$ and non electric energy $NEL$ demands are combined by a CES function. Where the cost minimization program is given by:

$$
\begin{align*}
\text{Min} & \quad p_{EOT3}EOT_3 = p_{EL3}EL_3 + p_{NEL3}NEL_3 \\
\text{st} & \quad EOT_3 = A_{ET3} \left[ \vartheta_{73} EL_3^{1-\frac{1}{\kappa_7}} + (1 - \vartheta_{73}) NEL_3^{1-\frac{1}{\kappa_7}} \right]^{\frac{1}{1-\frac{1}{\kappa_7}}}
\end{align*}
$$

FOC give the corresponding simple energy demands for electricity $EL_3$ and non electric energy $NEL_3$:
\[
EL_3 = EOT_3 \left( \frac{\varphi_7 p_{EOT_3}}{p_{EL_3}} \right)^{\kappa_{EOT}} \tag{22}
\]
\[
NEL_3 = EOT_3 \left( \frac{(1-\varphi_7) p_{EOT_3}}{p_{NEL_3}} \right)^{\kappa_{EOT}}
\]

At the second level, non electric energy demand \( NEL \) is represented by a CES function between coal \( CH \) and a composite gas fuel \( GF \). Hence for the producing sector \( j \) we write:

\[
\begin{align*}
\text{Min} & \quad p_{NEL_j} NEL_j = p_{CH_j} CH_j + p_{GF_j} GF_j \\
\text{st} & \quad NEL_j = A_{NEL_j} \left[ \varphi_{8_j} CH_j^{1 - \frac{1}{\kappa_8}} + (1 - \varphi_{8_j}) GF_j^{1 - \frac{1}{\kappa_8}} \right]^{\frac{1}{1 - \frac{1}{\kappa_8}}}
\end{align*}
\tag{23}
\]

Similarly we proceed by minimizing the cost of the use of the composite gas fuel as follows:

\[
\begin{align*}
\text{Min} & \quad p_{GF_j} GF_j = p_{GS_j} GAS_j + p_{F_j} FUEL_j \\
\text{st} & \quad GF_j = A_{GF_j} \left[ \varphi_{9_j} GAS_j^{1 - \frac{1}{\kappa_9}} + (1 - \varphi_{9_j}) FUEL_j^{1 - \frac{1}{\kappa_9}} \right]^{\frac{1}{1 - \frac{1}{\kappa_9}}}
\end{align*}
\tag{24}
\]

### 3.4.3 Origin of imported energy goods

Imported energy products are imperfectly substitutable to the domestic goods. The consumer chooses for example between the domestic \( CH_{D_j} \) and imported coal \( CH_{M_j} \) depending on their prices. Therefore we write the consumer’s program as:

\[
\begin{align*}
\text{Min} & \quad p_{CH_j} CH_j = p_{CH_{D_j}} CH_{D_j} + p_{CH_{M_j}} CH_{M_j} \\
\text{st} & \quad CH_j = A_{CH_j} \left[ \varphi_{10_j} CH_{D_j}^{1 - \frac{1}{\kappa_{10_j}}} + (1 - \varphi_{10_j}) CH_{M_j}^{1 - \frac{1}{\kappa_{10_j}}} \right]^{\frac{1}{1 - \frac{1}{\kappa_{10_j}}}}
\end{align*}
\tag{25}
\]

We proceed in the same way to calculate the part of imported and domestic goods for electricity \( EL \), fuel \( FUEL \) and natural gas \( GAS \) demands.
4 Imports

The value of non transport goods $M_{nt}$ is the sum of imported consumption goods $CM_{nt}$, imported production goods $CIM_{nt}$, imported goods used by government $GM_{nt}$ and private investors $INM_{nt}$. This relation is given by:

$$M_{nt} = \sum_{nt} (pm_{cn_{nt}}CM_{nt} + pm_{gv_{nt}}GM_{nt} + pm_{pr_{nt}}CIM_{nt} + pm_{iv_{nt}}INM_{nt})$$

(26)

4.1 Geographical distribution of imported goods

The choice of the origin of imported goods depends on the existing relative prices in each group of partner countries $g$. For all kind of actor ($cn$, $pr$, $iv$, $gv$), the corresponding import price is derived from the world price base, by adding the import tariffs $dd_g$ and the value added tax on imported products $\tau_{g}^{tvam}$ depending on the bloc $g$.

As an example, the choice of the origin of the imported electricity depends on the cost minimizing program of the producer:

$$\begin{align*}
\text{Min} & \quad pm_{EL_j}EL_{M_j} = \sum_{g} pm_{EL_j}^g EL_{M_j}^g \\
\text{st} & \quad EL_{M_j} = A_g \left[ \alpha_{E_{g_j}} EL_{M_j}^{EU-O(1-\frac{1}{\mu_j})} + \alpha_{E_{g_j}} EL_{M_j}^{NEU-O(1-\frac{1}{\mu_j})} + (1 - \alpha_{E_{g_j}} - \alpha_{E_{g_j}}) EL_{M_j}^{ROW(1-\frac{1}{\mu_j})} \right]^{1-\frac{1}{\mu_j}} \\
& \quad EL_{M_j}^g = YA_{g_j}^{\mu_j-1} \left( \frac{\alpha_{E_{g_j}} pm_{EL_j}}{pm_{EL_j}^g} \right)^{\mu_j} 
\end{align*}$$

(27)

Therefore we have the demand of the imported electricity coming from the bloc of country $g$ as:

$$EL_{M_j}^g = YA_{g_j}^{\mu_j-1} \left( \frac{\alpha_{E_{g_j}} pm_{EL_j}}{pm_{EL_j}^g} \right)^{\mu_j}$$

(27)

The related price relation is given by:

$$pm_{EL_j}EL_{M_j} = pm_{EL_j}^{EU} EL_{M_j}^{EU} + pm_{EL_j}^{NEU} EL_{M_j}^{NEU} + pm_{EL_j}^{ROW} EL_{M_j}^{ROW}$$

(28)

5 Exports

For each non transport good, the exportable amount is obtained by the ratio between the domestic $pd_{nt}$ and world price of this good $\bar{pm}_{nt}$. This relation is given by:
\[ EX_{nt} = \psi_{nt} \left[ \frac{pd_{nt}}{tc pm_{nt}} \right] ^{\varsigma_{nt}} \]  

(29)

Where \( \psi_{nt} \) is a positive constant, \( \varsigma_{nt} \) a negative elasticity, \( tc \) a fixed exchange rate between domestic prices and exogenous world price.

6 Government

6.1 Government expenses

Government expenses \( G \) are realized in all type of goods except for agricultural ones. In order to encourage the economic growth of less developed regions, the government follows different investment policies in each region.

6.2 Government revenue

Government revenues \( GR \) consist of import tariffs \( DD_{tot} \), income tax \( IR \), carbon tax \( TEN \) and value added tax \( TVA_{tot} \):

\[ GR = TVA_{tot} + DD_{tot} + IR + TEN \]  

(30)

6.2.1 VAT (Value added tax)

Different value added tax rates are applied to the base price \( q_i \), give domestic consumption prices \( pd_i \) and import prices \( pm_{nt}^{g} \). These rates differ depending on their application on the consumption or intermediate goods.

This detailed analysis aims to reflect the Turkish government’s policy of refund some part of the collected VAT receipts to the households, on a monthly basis.

Different receipts coming from different agents give the total amount of VAT \( TVA_{nt} \).

\[ TVA_{nt} = (\tau_{cn_{nt}} + \tau_{cn_{nt}}^{team}) q_{nt} + (\tau_{pr_{nt}} + \tau_{pr_{nt}}^{team}) q_{nt} + (\tau_{gv_{nt}} + \tau_{gv_{nt}}^{team}) q_{nt} + (\tau_{iv_{nt}} + \tau_{iv_{nt}}^{team}) q_{nt} \]  

(31)

6.2.2 Import tariffs

The import tariff receipts for different actors coming from different blocs \( g \) are calculated in similar ways for the consumer \( cn \), producer \( pr \), government \( gv \) and investors \( iv \).

As an example the import tariff revenues on imported intermediate goods are calculated by:
The total import tariff revenue $DDT$ coming from different actors’ accounts are aggregated as follows:

$$DDT_{nt} = DDC_{nt} + DDp_{nt} + DDS_{nt} + DDi_{nt}$$

(33)

The national aggregation is given by $DDT_{TOT}$:

$$DDT_{TOT} = \sum_{nt} DDT_{nt}$$

(34)

### 6.2.3 Income tax

Two different wage rates exist depending on the quality of labor, hence households earn different income per unit of labor supplied. The rate income tax applied $\tau_{IRsk,us}$ to different households depend on the region and on the quality of labor. Total income tax receipts $IR$ is given by:

$$IR = \tau_{IRsk} w_{sk} LS + \tau_{IRus} w_{us} LUS$$

(35)

### 6.2.4 Carbon tax

In an environmental perspective, a carbon tax $\tau_{ENnt}$ is instaured on the use of energy goods depending on their emission coefficients. The domestic price of fuels becomes then:

$$pd_{nt} = \left(1 + \tau_{ENnt} \right) \left(1 + \tau_{tvad} \right) q_{nt}$$

(36)

### 6.3 Public debt

As the government expenses $G$ are greater than the government revenues $GR$, given the absence of national saving, the public budget deficit is covered by a foreign debt $DP$. Hence the balance is given by:

$$DP = GR - G$$

(37)
7 Investment

The relation between the investment and the aggregate capital demand coming from different sectors is given by:

\[ IN = \delta \sum_j K_j \]  

(38)

Where \( r \) is the interest rate and \( \delta \) (depreciation rate) is given exogenously. \( p_I \), the aggregate investment price is determined by the capital price \( p_K \) by the following condition:

\[ p_K = (r + \delta) p_I \]  

(39)

The total investment \( I \) is divided into as transport \( IN_{TR} \) and \( IN_{NTR} \) nontransport investments. The minimization of the total investment cost is given as follows:

\[
\begin{align*}
\text{Min } & p_I I = p_{iv_{TR}} IN_{TR} + p_{iv_{NTR}} IN_{NTR} \\
\text{st } & I = A_{IN} \left[ \Upsilon_1 IN_{TR}^{\frac{1}{\Upsilon_0}} + (1 - \Upsilon_1) IN_{NTR}^{\frac{1}{\Upsilon_0}} \right]^{\frac{1}{\Upsilon_0}} - \frac{\Upsilon}{\Upsilon_0}
\end{align*}
\]  

(40)

In the next level, total investment is disaggregated into two as maintenance investments and infrastructural investment.

For example for investment in manufactured domestic goods, the expression is given as follows:

\[ IN = \theta_I IN_{ENT_{MND}} + (1 - \theta_I) IN_{INF_{MND}} \]  

(41)

The coefficient \( \theta_I \) is determined exogenously. The overall investment is decomposed as the production structure presented above (figure 1).

8 Pollution

8.1 From households

The pollution \( POL_{HH} \) coming from the consumption of energy by the two types of households living in different regions is given by their energy consumption times the emission coefficients \( \varpi_e \) for different types of energy:
Then the total pollution coming from households $POL_{HH}$ is the sum of all regional pollution:

$$POL_{HH} = \sum_k POL_{HH_k}$$  \hspace{1cm} (43)

8.2 From industry

$POL_{IND}$ pollution coming from the energy consumption during the production of the domestic good depends on the initial pollution stock $POL_{INDo}$ and the energy dependency of the domestic production sector given by the domestic demand to energy demand ratio $\frac{Y_j}{EN_j}$:

$$POL_{NDj} = POL_{INDoj} \left( \frac{Y_j}{EN_j} \right) \epsilon_{NDj}$$  \hspace{1cm} (44)

Where $\epsilon_{IND}$ is the elasticity of the domestic demand to the energy use in the industry.

Total amount of industrial production $POL_{IND}$ is given the sum of the industrial emissions coming from different regions which can be expressed as the following:

$$POL_{IND} = \sum_j POL_{NDj}$$  \hspace{1cm} (45)

8.3 Total pollution

Hence the total pollution formula is given by the sum of the pollution coming from the households and the industry:

$$POL_{TOT} = POL_{HH} + POL_{IND}$$  \hspace{1cm} (46)

9 Equilibrium conditions

9.1 Labor market

Endowments in qualified and non qualified types of travail ($QLS$ and $QLUS$) are fixed exogenously as follows for each region:
<table>
<thead>
<tr>
<th>Region/Labor</th>
<th>QLS</th>
<th>QLUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrialized</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Semi-industrialized</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Rural</td>
<td>40%</td>
<td>60%</td>
</tr>
</tbody>
</table>

The equilibrium in the labor markets determines the equilibrium prices $p_L$ for the skilled labor:

$$QLS = \sum_j LS^D_j$$ (47)

For the unskilled labor the equilibrium is:

$$QLUS = \sum_j LUS^D_j$$ (48)

The labor market is cleared by the unskilled wage $w_{us}$.

### 9.2 Trade balance

The trade balance $BC$ is given by the difference between exports and imports:

$$BC = \sum_{nt,g} p_{nt,g} x_{nt}^g e X_{nt}^g - \sum_{nt,g} M_{nt}^g$$ (49)

### 9.3 Government budget

The disequilibrium between government revenues $GR$ and expenses $G$ is covered by external public debt $DP$:

$$DP = GR - G$$ (50)

Social transfers $TRS$ appear as an independent account, equal to the sum of employers’ and employees’ cotisations for the two different types of labor.

$$TRS = \tau_{sk}^w w_{sk} LS + \tau_{us}^w w_{us} LUS$$ (51)

### 9.4 Equilibrium on the goods and services market

Equilibrium of the goods’ and services market is given by the following relation:

$$Y_{nt} + M_{nt} = \sum_k C_{nk}^c + \sum_j CI_{ntj} + G_{nt} + IN_{nt} + X_{nt}$$ (52)

Where $Y$ is the supply of domestic good, $C_k$ private consumption, $CI_j$ demands of intermediate goods, $X_{nt}$ exports, $M_{nt}$ imports (in volume), $G$ government expenses and $IN$ private investment.
10 Walras rule

The walras rule is written for the capital market equilibrium. Using the aggregate balance at the national economy’s level and the "zero profit" production condition we get:

\[ p_K \sum_j K_j = p_I IN + DP + BC \]  \hspace{1cm} (53)

Thanks to the capital investment relations as \( p_K = (r + \delta) p_I \), and \( I = \delta K \) we reach the equilibrium:

\[ p_I r K = DP + BC \]  \hspace{1cm} (54)

This way of proceeding means fixing the interest rate \( r \) as the capital market clearing variable. Given the deficit of the trade balance, this equation implies that the capital market will be supported by the foreign capital funds. This results corresponds to the policy orientation applied in Turkey since the 1980’s. Starting an import substituting, export oriented trade policy, the Turkish government tried to attract the foreign investors by a reform in baking and financial sectors. The underlying question remains as usual the determination of a sustainable debt level.

11 Environmental tax policy scenarios

11.1 Energy tax

This tax is introduced in an environmental objective. This tax is calculated "ex ante" in such a way that its receipts reach 1% of the GDP. This tax rate corresponds to 10 dollars / barrel.

The price increase following the introduction of this tax decreases the overall consumption (-1%). This phenomena is more important for energy goods (-1.8%). Enterprises choose to substitute the intermediate goods by the other factors of production. The overall demand of labor is increased by (0.1%) in average.

We observe a positive impact on the emissions (an average decrease of -4%). The positive impact is obtained despite the economic objective.

11.2 An energy tax compensated by a decrease of VAT

In this scenario, we redistribute the receipts of this energy tax by decreasing the rate of VAT, in order to get a "win win" situation.

A decrease of (-7%) of the VAT, the consumption increases by (+0.6%) and the total pollution decreases by (-2.5%).
The energy tax increases the production cost by (2%) in average. The increase in domestic prices leads to an increase in import substitutes of these products. The decrease in the demand of the intermediate goods by the enterprises is in average (-2.5%). Meanwhile the consumer demand of the same goods is less affected (-0.5%). This phenomena can be explained by the rigidity of consumption elasticities.

11.3 Tradable permits system

For example for the MN sector, we introduce the tradable permits in the program of the enterprise as follows:

\[
\begin{align*}
\text{Max } & \, p_{YMz}Y_{MNz} - p_{KLz}KL_{MNz} - p_{EMz}EM_{MNz} - p_{TRz}TR_{MNz} \\
& - \Omega_{MNz} (POL_{MNz} - POL_{0MNz}) \\
\end{align*}
\]

Total emissions are limited and determined differently for each sector in each region. \(POL_{0zj}\) is the initial allowance for industrial pollution. \(POL_{1INDz}\) stands for the actual pollution measured at the regional level. \(POL_{1IND}\) is the target value of pollution for all sectors and all regions:

\[
\sum_{z,j} POL_{0zj} = POL_{1INDz}^{*}
\]

Initial allowances are distributed in such a manner that the overall emission limit is respected \(POL_{1IND}\).

In a case of free distribution of emission permits, the price frontier becomes:

\[
\begin{align*}
p_{zj}Y_{zj} = p_{KLz}KL_{zj} + p_{EMz}EM_{zj} + p_{TRz}TR_{zj} + \Omega_{zj} (POL_{1INDzj} - POL_{0zj})
\end{align*}
\]

For each sector \(j\), we define \(S\) as the traded (sold or bought) amount of permits:

\[
S_j = \Omega_z (POL_{zj} - POL_{0zj})
\]

\(\Omega_z\) is the permit price that the producer faces. It depends on the total amounts of his emissions and the overall fixed target of pollution.

Hence we can write the "zero profit condition" as follows:

\[
p_{Yj}Y_j = p_{KL}KL_j + p_{EM}EM_j + p_{TR}TR_j + S_j
\]
12 Further Scenarios

The results of tradable permits’ scenarios and other detailed analysis on taxation policy will be explained in the final version of the paper.

As firms are incited to choose low polluting types of energy in order to pay less tax, we fix higher emission tax for the industrialized regions. This scenario will first let us to see the impact on the regional distribution of the industrial activities. Will a higher increase in energy prices in industrialized regions give the other regions an advantage to catch up? Secondly, we expect that the emission tax will have a more important influence on the energy intensive sectors who will loose in competitiveness thus will be replaced by less polluting activities.

In the taxation policy scenario, the model calculates the amount of tax that is necessary in order to reach the emission level required by the FCCC. The collected amount of pollution tax will be recycled into the economy by a reduction of revenue tax or social cotisations.

The trading emission permits scenario is simulated between industrialized and less industrialized regions. The emission restrictions will be more severe in the industrialized ones. Consequently the cost of production will be higher for these producers. The model will calculate the overall effect of this policy on the economy and will determine to what extend an environmental measure can influence the economic structure of the country.

This scenario is tested in two versions, first assuming the existence of a national environmental agency: the exchange of tradable permits is possible between regions. Secondly, in the presence of regional environmental agencies: the trade of permits will be possible between different regions and different sectors.
13 Lexica

13.1 Note

In order to simplify the variable notations, all indices are sometimes used as powers.

In each region, we adopt the same specifications for different regions. This is the reason why we neglect the "region" indice $z$ at the first stage. The regional notation is used in the "scenario" part.

13.2 Indices

$z$: regions in Turkey\(^{1}\) \{ $I$: industrialized, $SI$: semi industrialized, $R$: rural \}

$g$: country blocs \{ $OECD - EU$: europecan OCDE countries, $OECD - NEU$: non european OCDE countries, $ROW$: Rest of the world \}

$\exists$: actors of the economy \{ $cn$: consumer, $pr$: producer, $gv$: government, $iv$: private investment \}

For

$cn_k \in \exists$

$pr_j \in \exists$

$cn_k$: consumer \{ $sk$: skilled, $us$: unskilled \}


\(^{1}\)We call "industrialized" regions those who are specialized in manufacturing, "semi-industrialized" are those who export raw materials.
### 13.2.1 Sector indices

- $j$: all sectors
- $\xi$: non agricultural sectors
- $Sag$: agricultural sector
- $ag \subset j$ with $\xi \subset j$ and $j \in pr$

### 13.2.2 Indexes des biens

#### $i$: simple goods

- $CAG$: Agriculture
- $CMN$: Manufacture
- $CLPG$: Liquefied Petroleum
- $CDIE$: Diesel
- $CNBEN$: Oil
- $CCH$: Coal
- $CGS$: Gas
- $CTDUR$: Urban domestic road transport
- $CTDUO$: Urban domestic transport-other
- $CTDIUR$: Inter-urban road transport
- $CTDIUO$: Urban domestic transport-other
- $CTRMR$: International transport by road
- $CTRMO$: International transport other

#### $ts$: transport goods
- $nt$: non transport goods
- $nta$: non transport - non agricultural goods
- $na$: non agricultural good
- $ag$: agricultural good
- $nta \subset nt \subset i$ and $ts \subset i$

#### $ic$: composite goods

- $CEM$: Energy - manufacture composite good
- $CEN$: Energy
- $CETR$: Energy used in transport
- $CEOT$: Energy used for other needs
- $CGF$: Gas-fuel
- $CNEL$: Non electricity energy
- $CTR$: Transport
- $CNTR$: Non transport
- $CTRD$: Domestic transport
- $CTRM$: International transport
- $CTDU$: Urban domestic transport
- $CTDIU$: Inter urban domestic transport
### 13.2.3 Endogenous variables

#### Households
- \( C_{kn} \): Consumption of household \( k \) in non transport goods
- \( C_{kt} \): Consumption of household \( k \) in transport goods
- \( CM_{kn} \): Consumption of household \( k \) in imported goods
- \( CD_{kn} \): Consumption of household \( k \) in domestic goods
- \( CI_{jn} \): Demand of sector \( j \) in transport goods
- \( CI_{jn} \): Demand of sector \( j \) in non transport goods
- \( RV_k \): Income of household type \( k \)
- \( TRS_k \): Transfers to household type \( k \)

#### Industry
- \( KL_\xi \): Demand of capital - labor by sectors \( \xi \)
- \( CIM_j, CID_j \): Imported, domestic intermediate consumption goods
- \( LS_j \): Demand of skilled labor
- \( LUS_j \): Demand of unskilled labor
- \( K_j \): Capital demand of sector \( j \)
- \( LT_{ Sag} \): Labor - land demand

#### Other accounts
- \( GM, GD \): Government expenses in imported and domestic goods
- \( INM, IND \): Investment in imported and domestic
- \( EX_{nt} \):Exports
- \( I_{ENT, na} \): Maintenance investment in non agricultural goods \( na \)
- \( I_{INF, na} \): Infrastructural investment in non agricultural goods \( na \)
- \( GR \): Government revenue
- \( G \): Government expenses
- \( G_{ENT, na} \): Government expenses for maintenance in goods \( na \)
- \( G_{INF, na} \): Infrastructural government expenses in goods \( na \)
- \( BP \): Balance of payments
- \( DP \): Foreign public debt
- \( BC \): Trade balance

#### Other variables
- \( POL_{TOT} \): Total pollution
- \( r \): Interest rate

#### Common notations to economy’s actors \( cn, pr, gv, iv \)
- \( EM \): Energy - manufactured good demand
- \( TR \): Aggregate demand of transport goods
- \( TRM \): International transport services
- \( TRD \): Domestic transport services
- \( TDU \): Urban domestic transport services
- \( TDIU \): Inter - urban domestic transport services
- \( TRMR, TRMO \): International transport services by road or other
\( TDUR, TDUO \) : Urban domestic transport services by road or other
\( TDUIR, TDUIO \) : Inter urban domestic transport by road or other
\( MN \) : Manufactured good demand
\( EN \) : Aggregate energy good demand
\( ETR \) : Energy demand for transports
\( EOT \) : Energy demand for other needs
\( NEL \) : Non electric energy demand
\( GF \) : Demand of composite good gas fuel
\( EL \) : Demand of electricity
\( CH \) : Demand of coal
\( GS \) : Demand of gas
\( FUEL \) : Demand of fuel
\( DIE \) : Demand of diesel
\( NBEN \) : Demand of oil
\( LPG \) : Demand of LPG

13.2.4 Price of consumption goods

\( pc_k^i \) : Price paid by the household \( k \) for the good \( i \)
\( pd_{knt}^i \) : Price paid by the household \( k \) for the domestic good \( nt \)
\( pm_{knt}^i \) : Price paid by the household \( k \) for the imported good \( nt \)
\( pm_g^i \) : Price paid by the household \( k \) for the imported good \( nt \) coming from the partner countries \( g \)

13.2.5 Intermediate goods’ prices

\( p_{ji} \) : Price of intermediate good \( i \) used by sector \( j \) (given by a CES aggregation between \( pd_{j} \) and \( pm_{j} \))
\( pd_{jnt} \) : Price of domestic intermediate good \( nt \) used by sector \( j \)
\( pm_{jnt}^i \) : Price of imported intermediate good \( nt \) used by sector \( j \)
\( pm_g^j \) : Price of imported intermediate good \( nt \) used by \( j \) coming from \( g \)

13.2.6 Other prices

\( pY_j \) : Production price of sector \( j \)
\( p_i \) : Price of production of the good \( i \) by the sector \( j \) \((pY_j = p_i)\)
\( pm_{iv} \) : Price of the investment good \( iv \)
\( pm_g^i \) : Price of the imported investment good \( iv \) coming from \( g \)
\( p_i \) : Aggregate price of investment
\( pK \) : Capital price
\( pL_j \) : Aggregate price of demanded by the sector \( j \)
\( pLUS \) : Unskilled labor price
\( pLS \) : Skilled labor price
13.2.7 Parameters

$\Theta_k$: Disutility of pollution coefficient

$\tau^{IR}_k$: Revenue tax rate

$\tau^{e}_s$: Employee cotisation rate (depending on the type of labor $s$)

$\tau^{ep}_s$: Employee cotisation rate (depending on the type of labor $s$)

$tc$: Exchange rate (fixed)

$\delta$: Coefficient of capital depreciation

13.2.8 Determination of different prices

Different prices utilized in the model appear at the following tables. $q$ is the base price, $pw$ world price, $pd$ domestic price and $pm$ import price for different actors as the consumer, producer, investor and government ($k \in cn, j \in pr, iv, gv$)

### Domestic prices

<table>
<thead>
<tr>
<th>Account</th>
<th>Price</th>
<th>DD</th>
<th>TVAD</th>
<th>Domestic prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CD_{nt}$</td>
<td>$\tau_{cn,nt}$</td>
<td>$pd_{nt} = (1 + \tau^{cn,nt}) q_{nt}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$CID_{nt}$</td>
<td>$\tau_{pr,nt}$</td>
<td>$pd_{j} = (1 + \tau^{pr,nt}) q_{nt}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IND_{nta}$</td>
<td>$\tau_{iv,nta}$</td>
<td>$pd_{iv} = (1 + \tau^{iv,nta}) q_{nta}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Import prices coming from bloc $g$

<table>
<thead>
<tr>
<th>Account</th>
<th>Price</th>
<th>DD</th>
<th>TVAM</th>
<th>Final import price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CM_{nta}$</td>
<td>$pw_{nta}$</td>
<td>$\tau_{cn,nta}$</td>
<td>$\tau^{cm}_{nta}$</td>
<td>$pm_{nta} = pw (1 + \tau^{cn,nta}) (1 + \tau^{cm}_{nta})$</td>
</tr>
<tr>
<td>$CIM_{nta}$</td>
<td>$pw_{nta}$</td>
<td>$\tau_{pr,nta}$</td>
<td>$\tau^{cm}_{nta}$</td>
<td>$pm_{nta} = pw (1 + \tau^{pr,nta}) (1 + \tau^{cm}_{nta})$</td>
</tr>
<tr>
<td>$INM_{nta}$</td>
<td>$pw_{nta}$</td>
<td>$\tau_{iv,nta}$</td>
<td>$\tau^{cm}_{nta}$</td>
<td>$pm_{nta} = pw (1 + \tau^{iv,nta}) (1 + \tau^{cm}_{nta})$</td>
</tr>
</tbody>
</table>
Import price

<table>
<thead>
<tr>
<th>Account</th>
<th>Final price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CM_k$</td>
<td>$pm_{km}$</td>
</tr>
<tr>
<td>$CIM_j$</td>
<td>$pm_{jm}$</td>
</tr>
<tr>
<td>$INM_{nta}$</td>
<td>$pm_{imnta}$</td>
</tr>
</tbody>
</table>

Aggregate prices

<table>
<thead>
<tr>
<th>Account</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CN_k$</td>
<td>$pc_{k}$</td>
</tr>
<tr>
<td>$CT_j$</td>
<td>$pj$</td>
</tr>
<tr>
<td>$I$</td>
<td>$pi$</td>
</tr>
<tr>
<td>$EX_{nt}$</td>
<td>$pW_{nt}$</td>
</tr>
<tr>
<td>$IN_{nta}$</td>
<td>$pW_{nta}$</td>
</tr>
</tbody>
</table>

13.2.9 Exogenous variables

- $QLS$: Supply of skilled labor
- $QLUS$: Supply of unskilled labor
- $C_{kmt}$: Subsistence level of consumption in non transport goods
- $C_{lt}$: Subsistence level of consumption in transport services
- $pm_{nt}$: World price of non transport good $nt$
- $w_{LUS}$: Unskilled labor wage rate (market clearance)
- $w_{LS}$: Skilled labor wage rate
14 References