TURKEY FACING THE GLOBAL CLIMATE CHANGE PROBLEM
An economic analysis within a regional General Equilibrium Model with a carbon tax policy and a tradable emission permits system

Preliminary version

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Abstract

An applied general equilibrium model is proposed to 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.

1 Introduction

For the last few years, environmental problems have become a problematic topic for Turkey. As an Annex I country Turkey had to sign the UN Framework Convention on Climate Change (FCCC). Meanwhile during the negotiations, Turkish authorities refused to sign the Convention by arguing that the economic situation in Turkey is not appropriate to satisfy this agreement.

Since 1992, permanent debates take place in Turkey on the feasibility of reducing greenhouse emissions. Recently the Turkish government declared putting the climate change problem in his priority list.

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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 *cn* 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 disponible 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:

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

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

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

$$TRS_{tot} = \left(\tau_{us}^{e}+\tau_{us}^{ep}\right)w_{LUS}\sum_{j}LUS_j + \left(\tau_{sk}^{e}+\tau_{sk}^{ep}\right)w_{LS}\sum_{j}LS_j \tag{2}$$

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:

$$\begin{aligned} & Max \quad U(C_k) \\ & st \\ U(C_k) &= u_k - \Theta_k POL_{TOT} \\ RV_k &= C_{k_{ts}} pc_{k_{ts}} + C_{k_{nt}} pc_{k_{nt}} \end{aligned}$$

where

$$u_k = \sum_{ts} \beta_{1k_{ts}} \ln(C_{k_{ts}} - \overline{C}_{k_{ts}}) + \sum_{nt} \beta_{2k_{nt}} \ln(C_{k_{nt}} - \overline{C}_{k_{nt}}) \tag{3}$$

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 $\left(\beta_{1k_{ts}} + \beta_{2k_{nt}} = 1\right)$ with $\left(0 < \beta_{1k_{ts}}, \beta_{2k_{nt}} < 1\right)$, and the consumption levels ($C_{k_{ts}} - \overline{C}_{k_{ts}} > 0$ and $C_{k_{nt}} - \overline{C}_{k_{nt}} > 0$).

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

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

$$C_{k_{nt}} = \overline{C}_{k_{nt}} + \beta_{2k_{nt}} \frac{\left(RV_k - \sum_{nt} pc_{k_{nt}} \overline{C}_{k_{nt}}\right)}{pc_{k_{nt}}} \tag{4}$$

and for transport services:

$$C_{k_{ts}} = \overline{C}_{k_{ts}} + \beta_{1k_{ts}} \frac{\left(RV_k - \sum_{ts} pc_{k_{ts}} \overline{C}_{k_{ts}}\right)}{pc_{k_{ts}}} \tag{5}$$

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:

$$
\begin{aligned}
& Min \; pc_{k_{nt}} C_{k_{nt}} \\
& st \\
C_{k_{nt}} &= A_{nt} \left[CD_{k_{nt}}^{1-\frac{1}{\gamma_{nt}}} + \beta_{3k_{nt}} CM_{k_{nt}}^{1-\frac{1}{\gamma_{nt}}} \right]^{\frac{1}{1-\frac{1}{\gamma_{nt}}}}
\end{aligned}
$$

Demands for domestic $CD_{k_{nt}}$ and imported $CM_{k_{nt}}$ consumption goods are:

$$
\begin{aligned}
CD_{k_{nt}} &= C_{k_{nt}} A_{nt}^{\gamma_{nt}-1} \left(\frac{pc_{k_{nt}}}{pd_{nt}} \right)^{\gamma_{nt}} \\
CM_{k_{nt}} &= C_{k_{nt}} A_{nt}^{\gamma_{nt}-1} \left(\frac{\beta_{3k_{nt}} pc_{k_{nt}}}{pm_{k_{nt}}} \right)^{\gamma_{nt}}
\end{aligned} \tag{6}
$$

While the corresponding price relation can be written as:

$$
pc_{k_{nt}} C_{k_{nt}} = pd_{nt} CD_{k_{nt}} + pm_{k_{nt}} CM_{k_{nt}} \tag{7}
$$

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:

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

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

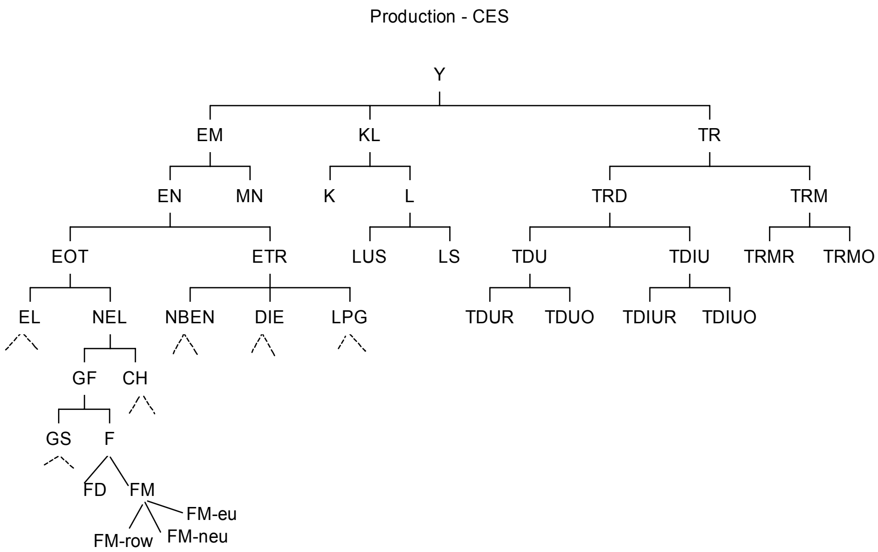
Demands of these production factors are defined as:

$$
\begin{aligned}
KL_\xi &= Y_\xi A_\xi^{\kappa_{1_\xi}-1}\left(\frac{\vartheta_{1_\xi} p_{Y_\xi}}{p_{KL_\xi}}\right)^{\kappa_{1_\xi}} \\
EM_\xi &= Y_\xi A_\xi^{\kappa_{1_\xi}-1}\left(\frac{\vartheta_{2_\xi} p_{Y_\xi}}{p_{EM_\xi}}\right)^{\kappa_{1_\xi}} \\
TR_\xi &= Y_\xi A_\xi^{\kappa_{1_\xi}-1}\left(\frac{\left(1-\vartheta_{1_\xi}-\vartheta_{2_\xi}\right) p_{Y_\xi}}{p_{TR_\xi}}\right)^{\kappa_{1_\xi}}
\end{aligned} \tag{8}
$$

The corresponding price relation of the activity p_{Y_ξ} is given by:

$$
p_{Y_\xi} Y_\xi = p_{EM_\xi} EM_\xi + p_{KL_\xi} KL_\xi + p_{TR_\xi} TR_\xi \tag{9}
$$

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_ξ with a CES specification. The *non agricultural* sectors' cost minimization program is given by:

$$
\begin{aligned}
Min \quad p_{KL_\xi} KL_\xi &= p_K K + p_{L_\xi} L_\xi \\
& \quad st \\
KL_\xi &= A_{KL_\xi}\left[\vartheta_{3_\xi} K_\xi^{1-\frac{1}{\kappa_{3_\xi}}} + \left(1-\vartheta_{3_\xi}\right) L_\xi^{1-\frac{1}{\kappa_{3_\xi}}}\right]^{\frac{1}{1-\frac{1}{\kappa_{3_\xi}}}} \\
\forall \xi &: \text{ non agricultural sectors}
\end{aligned}
$$

Factor demands are derived from the first order conditions (FOC):

$$
\begin{aligned}
K_\xi &= A_{KL_\xi}^{\kappa 3-1} KL_\xi \left(\frac{\vartheta_{3_\xi} p_{KL_\xi}}{p_K} \right)^{\kappa 3_\xi} \\
L_\xi &= A_{KL_\xi}^{\kappa 3-1} KL_\xi \left(\frac{\left(1-\vartheta_{3_\xi}\right) p_{KL_\xi}}{p_{L_\xi}} \right)^{\kappa 3_\xi}
\end{aligned} \tag{10}
$$

The corresponding relation gives the composite capital labor price p_{KL_ξ}:

$$
p_{KL_\xi} KL_\xi = p_K K_\xi + p_{L_\xi} L_\xi \tag{11}
$$

3.1.2 Demand of skilled and unskilled labor

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

$$
\begin{aligned}
Min\ p_{L_j} L_j &= p_{LS} LS_j + p_{LUS} LUS_j \\
& \quad st \\
L_j &= A_{L_j} \left[\vartheta_{4_j} LS_j^{1-\frac{1}{\kappa_{4_j}}} + \left(1-\vartheta_{4_j}\right) LUS_j^{1-\frac{1}{\kappa_{4_j}}} \right]^{\frac{1}{1-\frac{1}{\kappa_{4_j}}}}
\end{aligned}
$$

FOC give the demand for qualified LS_j qualified and non qualified LUS_j labors:

$$
\begin{aligned}
LS_j &= A_{L_j}^{\kappa_{4_j}-1} L_j \left(\frac{\vartheta_{4_j} p_{L_j}}{p_{LS}} \right)^{\kappa_{4_j}} \\
LUS_j &= A_{L_j}^{\kappa_{4_j}-1} L_j \left(\frac{\left(1-\vartheta_{4_j}\right) p_{L_j}}{p_{LUS}} \right)^{\kappa_{4_j}}
\end{aligned} \tag{12}
$$

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

$$
p_{LS} = w_{LS} \left(1+\tau_{sk}^{ep}\right) \tag{13}
$$

and

$$
p_{LUS} = w_{LUS} \left(1+\tau_{us}^{ep}\right)
$$

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:

$$
\begin{aligned}
Min \quad p_{Y_{Sag}} Y_{Sag} &= p_{LT_{Sag}} LT - p_{EN_{Sag}} EN_{Sag} - p_{TR_{Sag}} TR_{Sag} \\
& st \\
Y_{Sag} &= A_{Sag} (LT)^{\alpha_1} (EN_{Sag})^{\alpha_2} (TR_{Sag})^{\alpha_3} \left(AG_{Sag}\right)^{(1-\alpha_1-\alpha_2-\alpha_3)}
\end{aligned}
$$

The Cobb Douglas production function is written with a scale parameter A_{Sag} and the following condition on elasticities $(\alpha_{1g} - \alpha_{2g} - \alpha_{3g}) < 1$.

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:

$$
\begin{aligned}
LT_{Sag} &= \alpha_{1g} \frac{p_{Y_{Sag}}}{p_{LT_{Sag}}} Y_{Sag} \qquad (14) \\
EN_{Sag} &= \alpha_{2g} \frac{p_{Y_{Sag}}}{p_{EN_{Sag}}} Y_{Sag} \\
TR_{Sag} &= \alpha_{3g} \frac{p_{Y_{Sag}}}{p_{TR_{Sag}}} Y_{Sag} \\
AG_{Sag} &= \left(1 - \alpha_{1g} - \alpha_{2g} - \alpha_{3g}\right) \frac{p_{Y_{Sag}}}{p_{AG_{Sag}}} Y_{Sag}
\end{aligned}
$$

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

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

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

$$
\begin{aligned}
L_{Sag} &= A_{LT}^{\kappa_{10}-1} \left(\frac{\vartheta_{10} p_{LT_{Sag}}}{p_{L_{Sag}}} \right)^{\kappa_{10}} LT_{Sag} \qquad (15) \\
TE &= A_{LT}^{\kappa_{10}-1} \left(\frac{(1-\vartheta_{10}) \, p_{LT_{Sag}}}{p_T} \right)^{\kappa_{10}} LT_{Sag}
\end{aligned}
$$

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:

$$\begin{aligned} TR_{\Im} &= \left[\varphi_{4_{\Im}} TRD_{\Im}^{1-\frac{1}{\phi 4_{\Im}}} + \left(1-\varphi_{4_{\Im}}\right) TRM_{\Im}^{1-\frac{1}{\phi 4_{\Im}}} \right]^{\frac{1}{1-\frac{1}{\phi 4_{\Im}}}} \qquad (16) \\ & \Im \quad \text{all actors } cn,\ pr,\ iv,\ gv \end{aligned}$$

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

$$TRM_{\Im} = A_{TM_{\Im}} \left[\varphi_{6_{\Im}} TRMR_{\Im}^{1-\frac{1}{\phi 6_{\Im}}} + \left(1-\varphi_{6_{\Im}}\right) TRMO_{\Im}^{1-\frac{1}{\phi 6_{\Im}}} \right]^{\frac{1}{1-\frac{1}{\phi 6_{\Im}}}} \qquad (17)$$

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

$$TRD_{\Im} = A_{DU_{\Im}} \left[\varphi_{5_{\Im}} TDU_{\Im}^{1-\frac{1}{\phi 5_{\Im}}} + \left(1-\varphi_{5_{\Im}}\right) TDIU_{\Im}^{1-\frac{1}{\phi 5_{\Im}}} \right]^{\frac{1}{1-\frac{1}{\phi 5_{\Im}}}} \qquad (18)$$

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

$$TDU_{\Im} = A_{UR_{\Im}} \left[\varphi_{8_{\Im}} TDU_{R_{\Im}}^{1-\frac{1}{\phi 8_{\Im}}} + \left(1-\varphi_{8_{\Im}}\right) TDU_{O_{\Im}}^{1-\frac{1}{\phi 8_{\Im}}} \right]^{\frac{1}{1-\frac{1}{\phi 8_{\Im}}}} \qquad (19)$$

and for interurban activities:

$$TDIU_{\Im} = A_{IU_{\Im}} \left[\varphi_{7_{\Im}} TDIUR_{\Im}^{1-\frac{1}{\phi 7_{\Im}}} + \left(1-\varphi_{7_{\Im}}\right) TDIUO_{\Im}^{1-\frac{1}{\phi 7_{\Im}}} \right]^{\frac{1}{1-\frac{1}{\phi 7_{\Im}}}} \qquad (20)$$

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:

$$
\begin{aligned}
& Min \quad p_{EN_{\Im}} EN_{\Im} = p_{ETR_{\Im}} ETR_{\Im} + p_{EOT_{\Im}} EOT_{\Im} \\
& st \\
EN_{\Im} \quad = \quad & A_{EN_{\Im}} \left[\vartheta_{4_{\Im}} ETR_{\Im}^{1-\frac{1}{\kappa_{4_{\Im}}}} + (1-\vartheta_{4_{\Im}}) \, EOT_{\Im}^{1-\frac{1}{\kappa_{4_{\Im}}}} \right]^{\frac{1}{1-\frac{1}{\kappa_{4_{\Im}}}}}
\end{aligned}
$$

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 $ETR_{\Im}$ is composed of simple energy demands as follows:

$$
ETR_{\Im} = A_{ET_{\Im}} \left[\vartheta_{5_{\Im}} DIE_{\Im}^{1-\frac{1}{\kappa_{5_{\Im}}}} + \vartheta_{6_{\Im}} NBEN_{\Im}^{1-\frac{1}{\kappa_{5_{\Im}}}} + (1-\vartheta_{5_{\Im}} - \vartheta_{6_{\Im}}) \, LPG_{\Im}^{1-\frac{1}{\kappa_{5_{\Im}}}} \right]^{\frac{1}{1-\frac{1}{\kappa_{5_{\Im}}}}} \tag{21}
$$

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 $EOT_{\Im}$ 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:

$$
\begin{aligned}
& Min \quad p_{EOT_{\Im}} EOT_{\Im} = p_{EL_{\Im}} EL_{\Im} + p_{NEL_{\Im}} NEL_{\Im} \\
& st \\
EOT_{\Im} \quad = \quad & A_{ET_{\Im}} \left[\vartheta_{7_{\Im}} EL_{\Im}^{1-\frac{1}{\kappa_{7_{\Im}}}} + (1-\vartheta_{7_{\Im}}) \, NEL_{\Im}^{1-\frac{1}{\kappa_{7_{\Im}}}} \right]^{\frac{1}{1-\frac{1}{\kappa_{7_{\Im}}}}}
\end{aligned}
$$

FOC give the corresponding simple energy demands for electricity $EL_{\Im}$ and non electric energy $NEL_{\Im}$:

$$
\begin{aligned}
EL_{\Im} &= EOT_{\Im}\left(\frac{\vartheta_{7_{\Im}} p_{EOT_{\Im}}}{p_{EL_{\Im}}}\right)^{\kappa_{7_{\Im}}} \\
NEL_{\Im} &= EOT_{\Im}\left(\frac{\left(1-\vartheta_{7_{\Im}}\right) p_{EOT_{\Im}}}{p_{NEL_{\Im}}}\right)^{\kappa_{7_{\Im}}}
\end{aligned} \tag{22}
$$

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:

$$
\begin{aligned}
& Min \quad p_{NEL_j} NEL_j = p_{CH_j} CH_j + p_{GF_j} GF_j \\
& st \\
NEL_j &= A_{NE_j}\left[\vartheta_{8_j} CH_j^{1-\frac{1}{\kappa_{8_j}}} + \left(1-\vartheta_{8_j}\right) GF_j^{1-\frac{1}{\kappa_{8_j}}}\right]^{\frac{1}{1-\frac{1}{\kappa_{8_j}}}}
\end{aligned} \tag{23}
$$

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

$$
\begin{aligned}
& Min \quad p_{GF_j} GF_j = p_{GS_j} GAS_j + p_{F_j} FUEL_j \\
& st \\
GF_j &= A_{GF_j}\left[\vartheta_{9_j} GAS_j^{1-\frac{1}{\kappa_{9_j}}} + \left(1-\vartheta_{9_j}\right) FUEL_j^{1-\frac{1}{\kappa_{9_j}}}\right]^{\frac{1}{1-\frac{1}{\kappa_{9_j}}}}
\end{aligned} \tag{24}
$$

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:

$$
\begin{aligned}
& Min \quad p_{CH_j} CH_j = pd_{CH} CH_{D_j} + pm_{CH_j} CH_{M_j} \\
& st \\
CH_j &= A_{CH_j}\left[\vartheta_{10} CH_{D_j}^{1-\frac{1}{\kappa_{10_j}}} + \left(1-\vartheta_{10}\right) CH_{M_j}^{1-\frac{1}{\kappa_{10_j}}}\right]^{\frac{1}{1-\frac{1}{\kappa_{10_j}}}}
\end{aligned} \tag{25}
$$

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:

$$M_{nt} = \sum_{nt} \left(pm_{cn_{nt}} CM_{nt} + pm_{gv_{nt}} GM_{nt} + pm_{pr_{nt}} CIM_{nt} + pm_{iv_{nt}} INM_{nt} \right) \tag{26}$$

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 τ_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:

$$Min \quad pm_{EL_j} EL_{M_j} = \sum_g pm^g_{EL_j} EL^g_{M_j}$$

$$st$$

$$EL_{M_j} = A_{g_j} \left[\alpha_{E_{jg}} EL_{M_j}^{EU-O(1-\frac{1}{\mu_j})} + \alpha_{E_{jg}} EL_{M_j}^{NEU-O(1-\frac{1}{\mu_j})} + \left(1 - \alpha_{E_{jg}} - \alpha_{E_{jg}}\right) EL_{M_j}^{ROW(1-\frac{1}{\mu_j})} \right]^{\frac{1}{1-\frac{1}{\mu}}}$$

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

$$EL^g_{M_j} = YA_g^{\mu_j - 1} \left(\frac{\alpha_{E_{jg}} pm_{EL_j}}{pm^g_{EL_j}} \right)^{\mu_j} \tag{27}$$

The related price relation is given by:

$$pm_{EL_j} EL_{M_j} = pm^{EU}_{EL_j} EL^{EU}_{M_j} + pm^{NEU}_{EL_j} EL^{NEU}_{M_j} + pm^{ROW}_{EL_j} EL^{ROW}_{M_j} \tag{28}$$

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 $\overline{pw}_{nt}$. This relation is given by:

$$EX_{nt} = \psi_{nt} \left[\frac{pd_{nt}}{tc\,\overline{pw}_{nt}} \right]^{\varsigma_{nt}} \tag{29}$$

Where ψ_{nt} is a positive constant, ς_{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} :

$$GR = TVA_{tot} + DD_{tot} + IR + TEN \tag{30}$$

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^g_{nt}. 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}.

$$TVA_{nt} = \left(\tau^{tvad}_{cn_{nt}} + \tau^{tvam}_{cn_{nt}}\right) q_{nt} + \left(\tau^{tvad}_{pr_{nt}} + \tau^{tvam}_{pr_{nt}}\right) q_{nt} + \left(\tau^{tvad}_{gv_{nt}} + \tau^{tvam}_{gv_{nt}}\right) q_{nt} + \left(\tau^{tvad}_{iv_{nt}} + \tau^{tvam}_{iv_{nt}}\right) q_{nt} \tag{31}$$

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:

$$DD_{nt}^{pr} = \sum_{g} \tau_{nt,g}^{dd} CIM_{nt}^{g} \tag{32}$$

The total import tariff revenue DDT coming from different actors' accounts are aggregated as follows:

$$DDT_{nt} = DD_{nt}^{cn} + DD_{nt}^{pr} + DD_{nt}^{gv} + DD_{nt}^{iv} \tag{33}$$

The national aggregation is given by DD_{TOT}:

$$DD_{TOT} = \sum_{nt} DDT_{nt} \tag{34}$$

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 $\tau_{sk,us}^{IR}$ to different households depend on the region and on the quality of labor . Total income tax receipts IR is given by:

$$IR = \tau_{sk}^{IR} w_{sk} LS + \tau_{us}^{IR} w_{us} LUS \tag{35}$$

6.2.4 Carbon tax

In an environmental perspective, a carbon tax τ_{nt}^{EN} is instaured on the use of energy goods depending on their emission coefficients. The domestic price of fuels becomes then:

$$pd_{nt} = \left(1 + \tau_{nt}^{EN}\right)\left(1 + \tau_{nt}^{tvad}\right) q_{nt} \tag{36}$$

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:

$$DP = GR - G \tag{37}$$

7 Investment

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

$$IN = \delta \sum_j K_j \tag{38}$$

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

$$p_K = (r + \delta)\, p_I \tag{39}$$

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

$$\begin{aligned} Min \quad p_I I &= p_{iv_{TR}} IN_{TR} + p_{iv_{NTR}} IN_{NTR} \\ & st \\ I &= A_{IN} \left[\Upsilon_1 IN_{TR}^{1-\frac{1}{\partial_{10}}} + (1-\Upsilon_1)\, IN_{NTR}^{1-\frac{1}{\partial_{10}}} \right]^{\frac{1}{1-\frac{1}{\partial_{10}}}} \end{aligned} \tag{40}$$

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:

$$IN = \theta_I IN_{ENT_{MN_D}} + (1-\theta_I)\, IN_{INF_{MN_D}} \tag{41}$$

The coefficient θ_I is determined exogenously. The overall investment is decomposed as the production structure presented above (figure1).

8 Pollution

8.1 From households

The pollution POL_{HH_k} 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 ϖ_e for different types of energy:

$$POL_{HHk} = EL_k\varpi_{EL} + NEL_k\varpi_{NEL} + GAS_k\varpi_{GAS} + FUEL_k\varpi_{FUEL} + CH_k\varpi_{CH} \tag{42}$$

Then the total pollution coming from households POL_{HH} is the sum of all regional pollution:

$$POL_{HH} = \sum_k POL_{HH_k} \tag{43}$$

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_{IND0} and the energy dependency of the domestic production sector given by the domestic demand to energy demand ratio $\frac{Y_j}{EN_j}$.

$$POL_{NDj} = POL0_{NDj}\left(\frac{Y_j}{EN_j}\right)^{\in_{NDj}} \tag{44}$$

Where $\in_{IND}$ 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:

$$POL_{IND} = \sum_j POL_{ND_j} \tag{45}$$

8.3 Total pollution

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

$$POL_{TOT} = POL_{HH} + POL_{IND} \tag{46}$$

9 Equilibrium conditions

9.1 Labor market

Endowments in qualified and non qualified types of travail ($\overline{QLS}$ and $\overline{QLUS}$) are fixed exogenously as follows for each region:

Region/Labor	QLS	$QLUS$
Industrialized	60%	40%
Semi-industrialized	50%	50%
Rural	40%	60%

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

$$\overline{QLS} = \sum_j LS_j^D \tag{47}$$

For the unskilled labor the equilibrium is:

$$\overline{QLUS} = \sum_j LUS_j^D \tag{48}$$

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:

$$BC = \sum_{nt,g} pex_{nt}^g EX_{nt}^g - \sum_{nt,g} M_{nt}^g \tag{49}$$

9.3 Government budget

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

$$DP = GR - G \tag{50}$$

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

$$TRS = \tau_{sk}^e w_{sk} LS + \tau_{us}^e w_{us} LUS \tag{51}$$

9.4 Equilibrium on the goods and services market

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

$$Y_{nt} + M_{nt} = \sum_k C_{nt_k} + \sum_j CI_{nt_j} + G_{nt} + IN_{nt} + X_{nt} \tag{52}$$

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:

$$p_K \sum_j K_j = p_I IN + DP + BC \tag{53}$$

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

$$p_I r K = DP + BC \tag{54}$$

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 effected (-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:

$$Max\ p_{Y_{MNz}} Y_{MNz} - p_{KL_{MNz}} KL_{MNz} - p_{EM_{MNz}} EM_{MN_z} - p_{TR_{MNz}} TR_{MN_z} \quad (55)$$
$$-\Omega_{MNz} \left(POL_{MNz} - POL0_{MNz} \right) \quad (56)$$

Total emissions are limited and determined differently for each sector in each region. $POL0_{zj}$ is the initial allowance for industrial pollution. POL_{INDz} stands for the actual pollution measured at the regional level. POL^{*}_{IND} is the target value of pollution for all sectors and all regions:

$$\sum_{z,j} POL0_{zj} = POL^{*}_{IND} \quad (57)$$

Initial allowances are distributed in such a manner that the overall emission limit is respected POL^{*}_{IND}.

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

$$p_{zj} Y_{zj} \quad (58)$$
$$= p_{KL_{zj}} KL_{zj} + p_{EM_{zj}} EM_{zj} + p_{TR_{zj}} TR_{zj} + \Omega_{zj} \left(POL_{INDzj} - POL0_{INDzj} \right) \quad (59)$$

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

$$S_j = \Omega_z \left(POL_{zj} - POL_{0zj} \right) \quad (60)$$

Ω_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:

$$p_{Y_j} Y_j = p_{KL} KL_j + p_{EM} EM_j + p_{TR} TR_j + S_j \quad (61)$$

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 competitivity 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

$$z : \text{regions in Turkey}^{1} \left\{ \begin{array}{c} I : \text{industrialized} \\ SI : \text{semi industrialized} \\ R : \text{rural} \end{array} \right\}$$

$$g : \text{country blocs} \left\{ \begin{array}{c} OECD-EU : \text{eurpoean OCDE countries} \\ OECD-NEU : \text{ non european OCDE countries} \\ ROW : \text{Rest of the world} \end{array} \right\}$$

$$\Im : \text{actors of the economy} \left\{ \begin{array}{c} cn : \text{consumer} \\ pr : \text{producer} \\ gv : \text{government} \\ iv : \text{private investment} \end{array} \right\}$$

For

$$\begin{array}{ccc} cn_k & \in & \Im \\ pr_j & \in & \Im \end{array}$$

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

$$Pr_j : \text{producer} \left\{ \begin{array}{c} SAG : \text{ Agriculture} \\ SMN : \text{Manufacture} \\ SLPG : \text{ Liquefied Petroleum} \\ SDIE : \text{ Diesel} \\ SNBEN : \text{ Oil} \\ SCH : \text{ Coal} \\ SGS : \text{ Natural Gas} \\ STDUR : \text{ Urban domestic road transport} \\ STDUO : \text{Urban domestic transport-other than road} \\ STDIUR : \text{Inter-urban road transport} \\ STDIUO : \text{Urban domestic transport-other than road} \\ STRMR : \text{International transport by road} \\ STRMO : \text{International transport other than road} \end{array} \right\}$$

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

13.2.2 Indexes des biens

$$i \text{ :simple goods} \left\{ \begin{array}{c} CAG: \text{ Agriculture} \\ CMN: \text{Manufacture} \\ CLPG: \text{ Liquefied Petroleum} \\ CDIE: \text{ Diesel} \\ CNBEN: \text{ Oil} \\ CCH: \text{ Coal} \\ CGS: \text{ Gas} \\ CTDUR: \text{ Urban domestic road transport} \\ CTDUO: \text{Urban domestic transport-other} \\ CTDIUR: \text{Inter-urban road transport} \\ CTDIUO: \text{Urban domestic transport-other} \\ CTRMR: \text{International transport by road} \\ CTRMO: \text{International transport other} \end{array} \right\}$$

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 $ts \subset i$

$$ic : \text{composite goods} \left\{ \begin{array}{c} CEM: \text{ Energy - manufacture composite good} \\ CEN: \text{ Energy} \\ CETR: \text{ Energy used in transport} \\ CEOT: \text{ Energy used for other needs} \\ CGF: \text{ Gas-fuel} \\ CNEL: \text{ Non electricity energy} \\ CTR: \text{Transport} \\ CNTR: \text{Non transport} \\ CTRD: \text{Domestic transport} \\ CTRM: \text{International transport} \\ CTDU: \text{Urban domestic transport} \\ CTDIU: \text{Inter urban domestic transport} \end{array} \right\}$$

13.2.3 Endogenous variables

Households $C_{k_{nt}}$: Consumption of household k in non transport goods
$C_{k_{ts}}$: Consumption of household k in transport goods
$CM_{k_{nt}}$: Consumption of household k in imported goods
$CD_{k_{nt}}$: Consumption of household k in domestic goods
$CI_{j_{ts}}$: Demand of sector j in transport goods
$CI_{j_{nt}}$: Demand of sector j in non transport goods
RV_k : Income of household type k
TRS_k : Transfers to household type k

Industry KL_ξ : Demand of capital - labor by sectors ξ
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
$IN_{ENT_{na}}$: Maintenance investment in non agricultural goods na
$IN_{INF_{na}}$: 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
$pd_{k_{nt}}$: Price paid by the household k for the domestic good nt
$pm_{k_{nt}}$: Price paid by the household k for the imported good nt
$pm^g_{k_{nt}}$: Price paid by the household k for the imported good nt coming from the partner countries g

13.2.5 Intermediate goods' prices

p_{j_i} : Price of intermediate good i used by sector j (given by a CES aggregation between pd_j and pm_j)
$pd_{j_{nt}}$: Price of domestic intermediate good nt used by sector j
$pm_{j_{nt}}$: Price of imported intermediate good nt used by sector j
$pm^g_{j_{nt}}$: 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 ($pY_j = p_i$)
p_{iv_i} : Price of the investment good i
$pm_{iv_{nt}}$: Price of the imported investment good iv
$pm^g_{iv_{nt}}$: Price of the imported investment good iv coming from g
p_I : Aggregate price of investment
p_K : Capital price
p_{L_j} : Aggregate price of demanded by the sector j
p_{LUS} : Unskilled labor price
p_{LS} : Skilled labor price

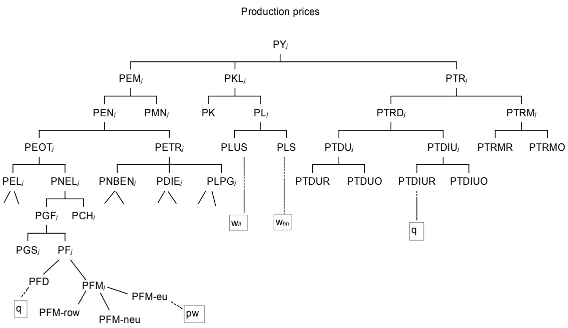


Figure 1:

13.2.7 Parameters

Θ_k : Disutility of pollution coefficient
τ_s^{IR} : Revenue tax rate
τ_s^{e} : Employee cotisation rate (depending on the type of labor s)
τ_s^{ep} : Employee cotisation rate (depending on the type of labor s)
tc : Exchange rate (fixed)
δ : 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

	TVAD	Domestic prices
$CD_{k_{nt}}$	$\tau^{tvad}_{cn_{nt}}$	$pd_j^{nt} = \left(1+\tau^{tvad}_{cn,nt}\right) q_{nt}$
$CID_{j_{nt}}$	$\tau^{tvad}_{pr_{nt}}$	$pd_j = \left(1+\tau^{tvad}_{pr,nt}\right) q_{nt}$
IND_{nta}	$\tau^{tvad}_{iv_{nta}}$	$pd_{iv} = \left(1+\tau^{tvad}_{iv,nta}\right) q_{nta}$

Import prices coming from bloc g

Account	Price	DD	TVAM	Final import price
CM_k^{nt}	$\overline{pw}_{nt}$	$\tau^{dd}_{cn,g_{nt}}$	$\tau^{tvam_{cn}}_{g_{nt}}$	$pm^g_{k_{nt}} = \overline{pw}\left(1+\tau^{dd}_{cn,g_{nt}}\right)\left(1+\tau^{tvam_{cn}}_{g_{nt}}\right)$
CIM_j^{nt}	$\overline{pw}_{nt}$	$\tau^{dd}_{pr,g_{nt}}$	$\tau^{tvam_{pr}}_{g_{nt}}$	$pm^g_{j_{nt}} = \overline{pw}\left(1+\tau^{dd}_{pr,g_{nt}}\right)\left(1+\tau^{tvam_{pr}}_{j_{nt}}\right)$
INM_{nta}	$\overline{pw}_{nta}$	$\tau^{dd}_{iv,g_{nt}}$	$\tau^{tvam_{iv}}_{g_{nt}}$	$pm^g_{iv_{nta}} = \overline{pw}\left(1+\tau^{dd}_{iv,g_{nt}}\right)\left(1+\tau^{tvam_{iv}}_{g_{nta}}\right)$

Import price

Account	Final price
CM_k^{nt}	$pm_{k_{nt}}$
CIM_j^{nt}	$pm_{j_{nt}}$
INM_{nta}	$pm_{iv_{nta}}$

Aggregate prices

Account	Price
CN_{k_i}	pc_{k_i}
CI_{j_i}	p_{j_i}
I	p_I
EX_{nt}	$\overline{pw}_{nt}$
IN_{nta}	$p_{IN_{nta}}$

13.2.9 Exogenous variables

$\overline{QLS}$: Supply of skilled labor
$\overline{QLUS}$: Supply of unskilled labor
$\overline{C}_{k_{nt}}$: Subsistence level of consumption in non transport goods
$\overline{C}_{k_{ts}}$: Subsistence level of consumption in transport services
$\overline{pw}_{nt}$: World price of non transport good nt
w_{LUS} : Unskilled labor wage rate (market clearance)
w_{LS} : Skilled labor wage rate

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