Centre International de Recherche sur
l'Environnement et le Développement

International Energy Workshop, Paris, 2008

Tradable permit schemes assessed by a dynamic CGE model applied to Romania

Rodica Loisel
CIRED-CNRS

General Framework

- **Issue** 1. tradable permit market – European Trade Scheme
  2. the case of Romania

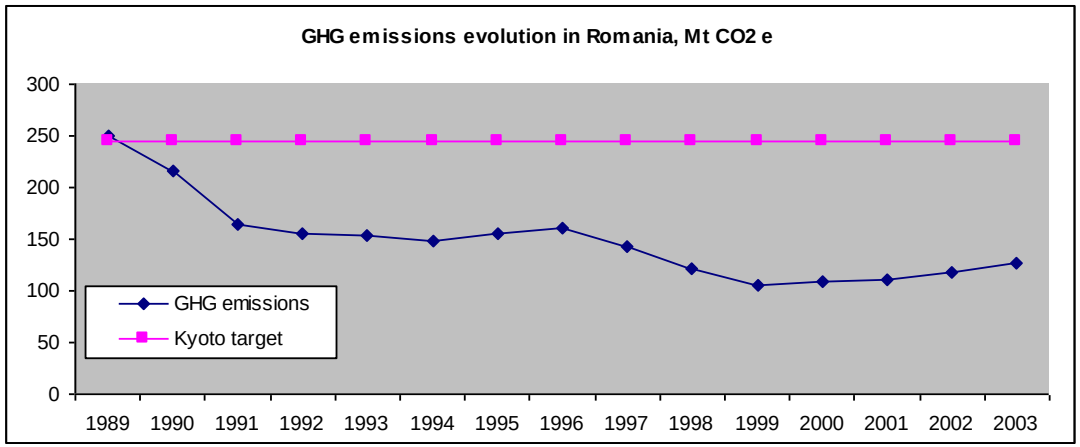
- **Main objectives**: to estimate CO2 abatement cost – only internal efforts
  to create a policy signal - permit seller/buyer, JIP

- **Country specificities**

  Significant hydrocarbon endowment;

  Specific environmental path;

  Dichotomy: political engagement within environmental agreements *vs*.
  national needs for rapid economic growth.



Plan

1. Considerations on quota allocation rules

2. Theoretical specifications of the model

3. Simulations and discussion

    3.1 The historical approach case
    3.2. Results from alternative allocation rules

4. Concluding remarks

1. Considerations on quota allocation rules (1/2)

- **Sectors** - large emitters (power & heat generation industry, energy-intensive industrial sectors)

Simulations - NAP : electricity, oil-derived products, metallurgy, glass, cement, pulp-paper production.

- **ETS Mechanisms** - quotas trade, JI Projects/ CDM

Simulations - CO2 tradable permit market.

- **Hot-air = 0.**
  - KP: it should be supplemental to domestic actions.
  - Romania = 125 Mt CO2 = net permit seller.
  - Ro hot-air = not real environmental improvement but transitional recession.
  - could undermine the permit market structure (Pesic, 2003).

1. Considerations on quota allocation rules (2/2)

- **Binding emissions target**
  - EU 2008-2012 cap = 2.08 billion allowances / year < 10% 2005-2007.
  - Romanian 2003 GHG = 149 Mt CO2e, 75.25 % CO2.
    ETS sectors = 70.97 Mt CO2.
  - Romanian NAP proposition 2008-2012 = 95.7 Mt CO2 annually.
  - EC cap = 75.9 Mt CO2 < 20.7% Romanian proposition.

Simulations - 20.7% reduction / database 2003 = 19.8 Mt CO2.

- **Allocating target modes** - historical, forecast emissions, least-cost approach.
  - 2008-2012: 90% grandfathering, 10% auctions. 2013 = 100% auctions.
  - Romanian NAP = HA + FA.
  - Reference period = 2001-2004. Base year CO2 projections = 2003.
  - Least-cost approach = theoretical technique based on uniform CO2 tax.

Simulations - historical approach (*HA*), least-cost approach (*LCA*),
- all sectors KP (*All*), auctioning (*AUC*),
- permits-auctioning recycling – employers' payroll taxes (*REC*).

2. Theoretical specifications of the model (1/4)

- neoclassical approach (Nordhaus, 1992; Lee *et al*., 1994; Beaumais, 1995; McKibbin, Wilcoxen, 1995; Burniaux, Troung, 2002, etc)
- small open economy, price taker behaviour
- KLEM key: K, L, E, M = fully mobile across sectors
- Sectoral disaggregation – NAP nomenclature

1. SEL	(ETS)	8. SPA	(ETS)
2. SCA		9. SCH	
3. SGS		10. STR	
4. SPE	(ETS)	11. SAG	
5. SMS	(ETS)	12. SCO	
6. SCM	(ETS)	13. SCS	
7. SGL	(ETS)	14. SOA	

– intertemporal dynamic based on exogenous growth - Ramsey-Cass-Koopmans
– active population growth = demograph. decline + agriculturally-disguised unemployment

– modified golden rule (Euler equation): $1+r=(1+\rho)(1+n)$

- K accumulation: $K_{t+1}=\left[I_t+(1-\delta)K_t\right]/(1+n)$

- Endogenized growth rate (Lau *et al*., 2002): $\frac{I_T}{I_{T-1}}=\frac{C_T}{C_{T-1}}$

- GAMS/MCP software (Brooke *et al*., 1998).
- Calibration – 2003 Database - Romanian National Accounts (NIS, 2006)

2. Theoretical specifications of the model (2/4)
The Consumer

- Intertemporal dynamics (Ramsey, 1928)
- forward-looking specifications, perfect expectations
- infinitely living representative household
- maximization int**e**rtemporal utility s./c. intertemporal budget constraint

$$\underset{C_t, l_t}{Max} U = \frac{1}{1-\theta} \sum_t \frac{1}{(1+\rho)^t} u(C_t, l_t)^{1-\theta}$$

$$s/c \sum_t \frac{(1+n)^{t-1}(p_k K_t + w_t l_t + TRSr_t)}{\prod_{s=1,t}(1+r_s)} = \sum_t \frac{(1+n)^{t-1}(pc_t C_t + ep_t + TRSp_t)}{\prod_{s=1,t}(1+r_s)}$$

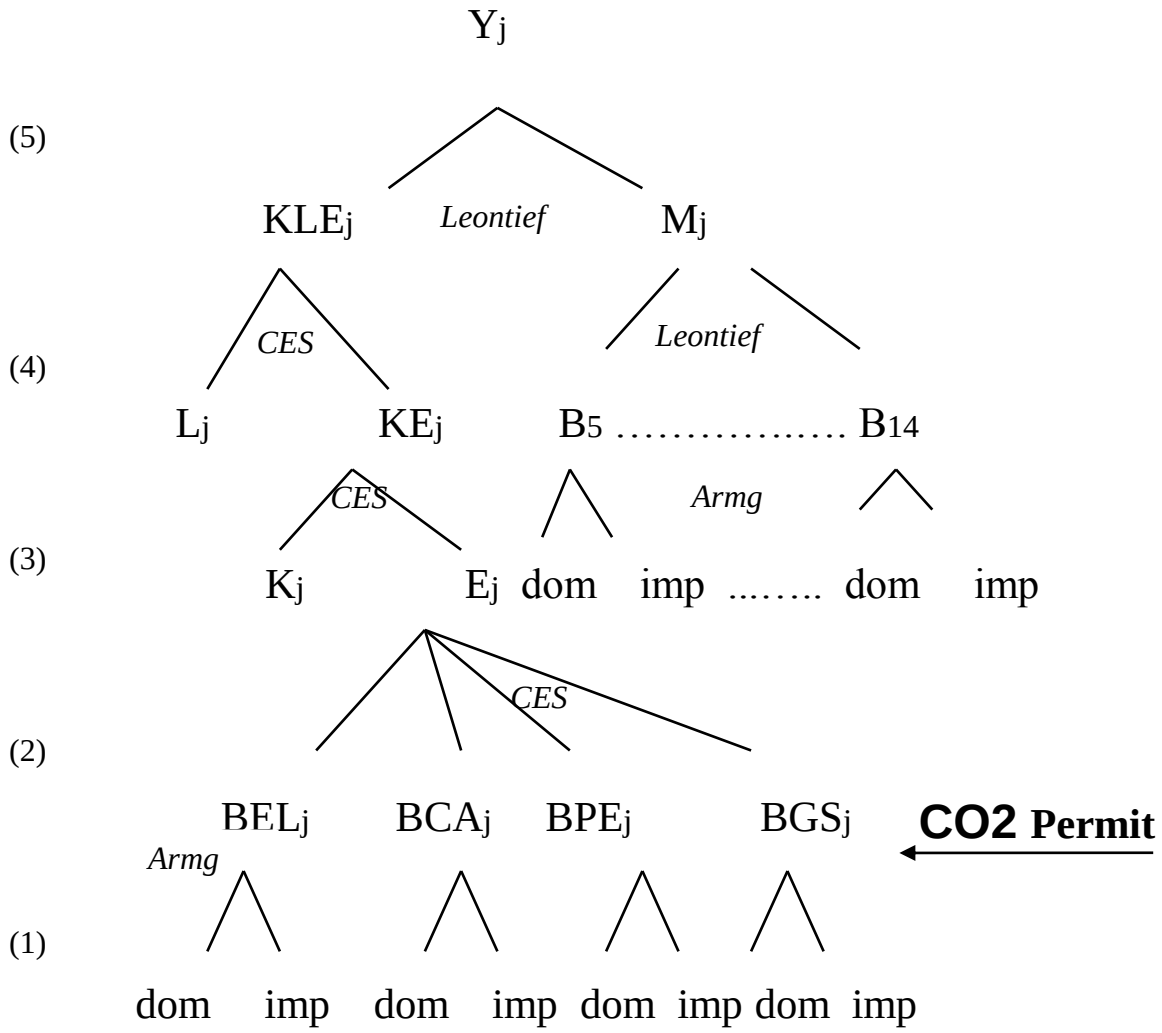
- Intr**a**temporal utility – consumption-leisure trade-off (*CES* function)
  – net of environmental quality

- Welfare indicator – hicksian measure of equivalent income variation

$$EV = e(Pc_1, w_1, r_1, U_1) - e(Pc_0, w_0, r_0, U_1)$$

2. Theoretical specifications of the model (3/4)

The nested production function



2. Theoretical specifications of the model (4/4)

Tradable permit market formalisation

* *Zero-sum game* rule: $\sum_j \sum_i (CO2_{i,j} - \overline{CO2_{i,j}}) = 0$

* Scarcity rent - producer integrates into his final profits or not:

$$P_{per} \sum_i \overline{CO2_{i,j}}$$

Hypo: the producer modifies the energy price with the net balance of permit trade s./c. at equilibrium the firm's profit is null.

* Sectoral permit balance + / - (buyer/ seller).

$$P_{pen} \sum_i (CO2_{i,j} - \overline{CO2_{i,j}})$$

* National context.
* No preexistant energy fiscality.
* Auctioning and recycling: budget neutrality.

3.1. Simulations and discussion. Historical approach case (1/5)
Permit market

Volume = 2.27 Mpermits. Price = 5.75 €

Table 1. Sectoral results from the permit market implementation (%, reference = 0)

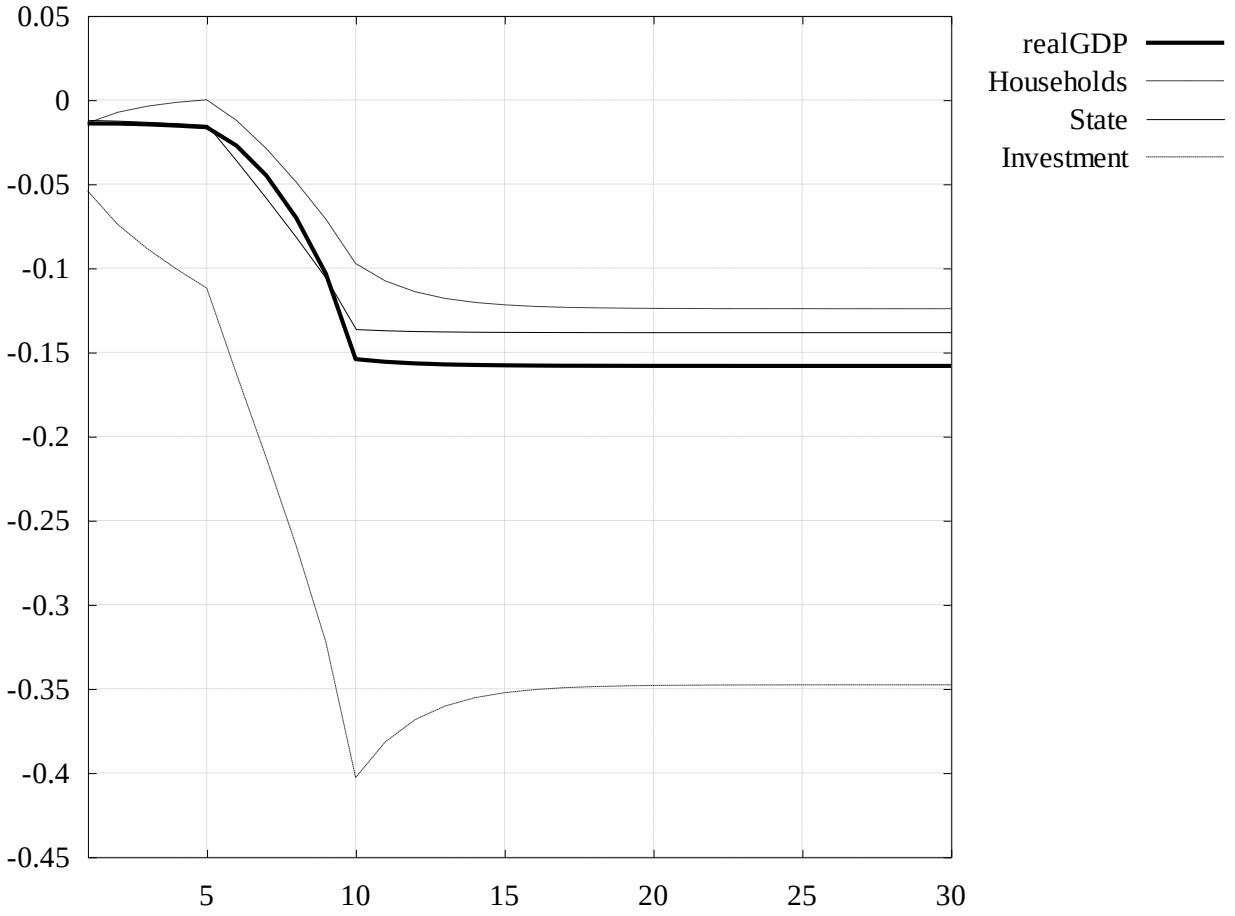
Sect	Output	Labor	Invest.	Energy	EnergPr	Export	Import	PrCost	CO_2	Permits*	Perm€**
SEL	6.48	7.62	7.42	6.17	0.78	-1.13	9.47	0.50	-20.69	**7.45**	**42.8**
SCA	-22.11	-21.98	-22.17	-22.22	0.04	-0.52	-21.76	-0.11	-21.76	**0**	**0**
SPE	-0.13	0.23	-0.02	-0.29	0.20	-0.66	0.71	0.03	-0.37	**813.2**	**4672.4**
SGS	-1.26	-1.52	-1.87	-1.01	-0.46	-0.34	-1.15	-0.29	-1.60	**0**	**0**
SMS	-0.86	1.24	0.84	-2.08	1.65	-0.82	-0.01	0.19	-5.67	**1450.1**	**8331.6**
SGL	-0.22	-0.92	-1.06	2.65	-2.03	-0.20	-0.01	-0.44	-66.48	**-251.8**	**-1446.7**
SCM	-0.17	-1.46	-1.56	3.24	-2.61	-0.04	-0.13	-0.59	-65.77	**-1892.8**	**-10875.1**
SPA	-0.51	-0.35	-0.60	-0.40	-0.08	-0.44	0.00	-0.19	-53.06	**-126.2**	**-725.1**
SCH	-0.52	0.08	-0.08	-0.96	0.42	-0.52	-0.10	-0.11	-0.64	**0**	**0**
STR	-0.34	-0.16	-0.38	-0.73	0.14	-0.52	0.71	-0.12	-0.46	**0**	**0**
SAG	-0.27	-0.11	-0.27	-0.71	0.17	-0.54	1.08	-0.09	0.13	**0**	**0**
SCO	-0.14	0.05	-0.19	-0.92	0.31	-0.46	1.11	-0.18	-0.10	**0**	**0**
SCS	-0.08	0.09	-0.15	-0.71	0.22	-0.49	0.75	-0.15	-0.56	**0**	**0**
SOA	-0.49	-0.29	-0.48	-1.33	0.33	-0.45	0.42	-0.19	-1.28	**0**	**0**

**Sectoral permit supply (-) / demand (+) on the market (10^3).*
***Sectoral loss (+) or gains (-) from the permit trade (million EUR).*

3.1. Simulations and discussion. Historical approach case (2/5)

Macroeconomic effects

Graph 1. Evolution of the GDP by components (%, reference = 0)



3.1. Simulations and discussion. Historical approach case (3/5)
Effects on households

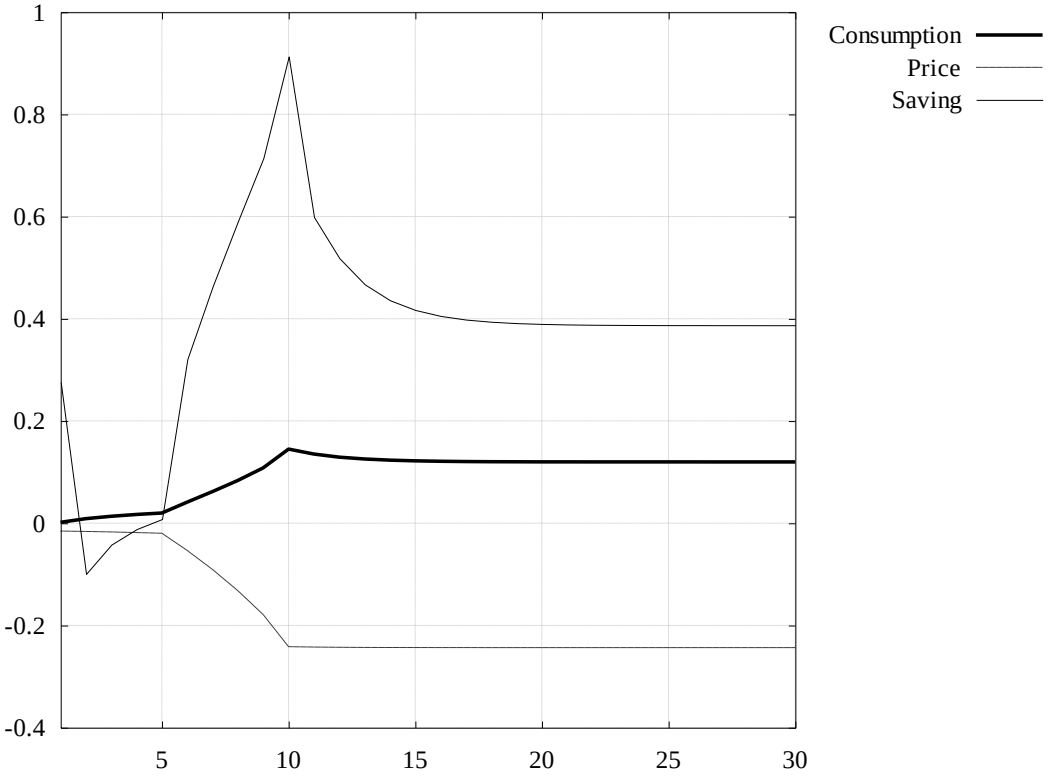
EV = -0.78%

(1) intertemporal utility (r_t).

↑ r_t – depreciated intertemp.income

(2) ↑C_t - mg effect on house energy

- households ≠ env. constraint
- energy bill = 9% Tot expenditure
- ↓ C electricity = 3.3% Tot expend.
- CPI = -0.24% : ↑C_t
- *services* = 39% Tot expenditure



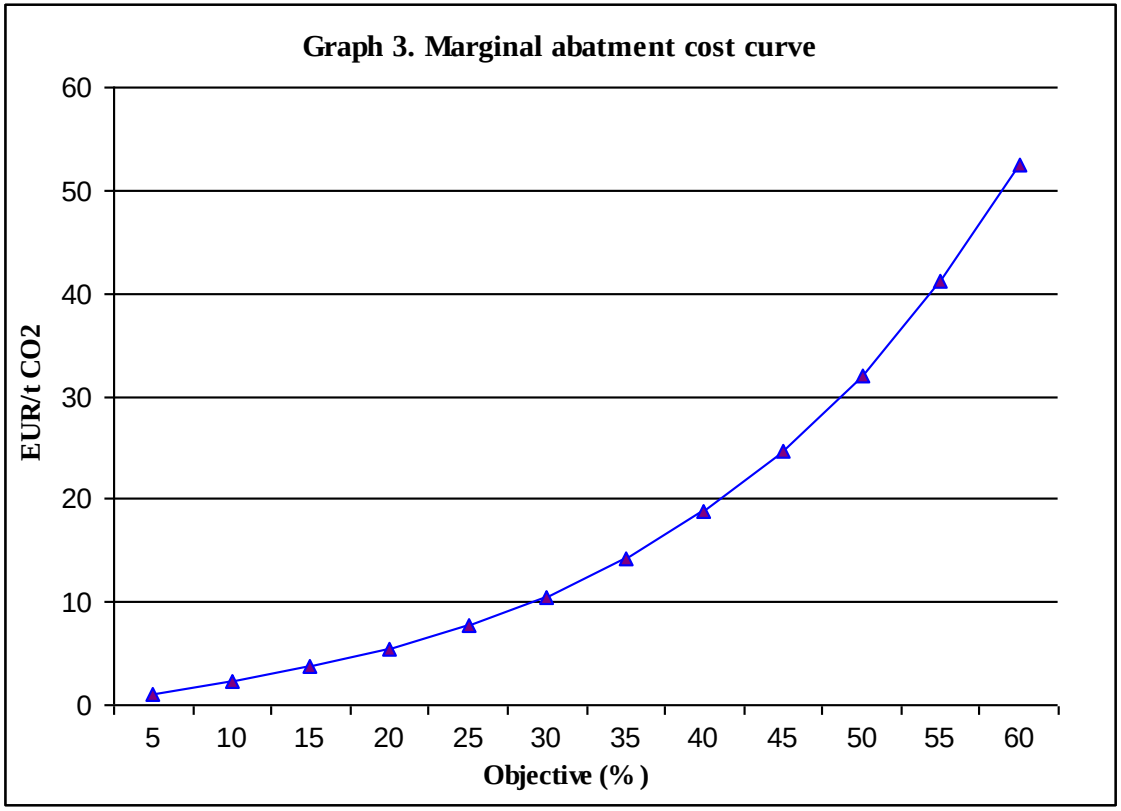
3.1. Simulations and discussion. Historical approach case (4/5)
Effects on households

Good	Price	Volume	Value demand
SEL	0.49	-0.68	-0.20
SCA	-0.27	0.15	-0.12
SPE	-0.28	0.15	-0.12
SGS	-0.57	0.48	-0.09
SMS	-0.52	0.42	-0.10
SGL	-0.54	0.45	-0.09
SCM	-0.60	0.51	-0.09
SPA	-0.45	0.35	-0.10
SCH	-0.52	0.43	-0.10
STR	-0.14	0.00	-0.13
SAG	-0.12	-0.02	-0.14
SCO	-0.18	0.05	-0.13
SCS	-0.17	0.03	-0.13
SOA	-0.41	0.31	-0.11

3.1. Simulations and discussion. Historical approach case (5/5)
Abatment cost curve

Low MAC - cap = 79.3% of the reference emission for ETS sectors.

1) low energy prices
2) high E substitution possibilities: coal by hydraulic and nuclear resources.



3.2. Alternative allocation rules *HA, All, LCA, AUC*.

Sectoral results on the permit market

	Permits (10^3)				Permits 10^3 €			
Sect	*HA*	All	LCA	AUC	*HA*	All	LCA	AUC
SEL	7.45	-1171.9	26.2	41442.3	42.81	-5628.8	149.8	152633.8
SCA	0	-40.8	0	0	0	-196.0	0	0
SPE	813.21	572.1	164.9	3856.5	4672.4	2747.6	941.4	14203.7
SGS	0	-482.8	0	0.00	0	-2318.8	0	0
SMS	1450.08	1038.3	383.3	8739.6	8331.6	4987.2	2188.9	32188.4
SGL	-251.8	-252.6	-65.6	232.9	-1446.7	-1213.2	-374.3	857.9
SCM	-1892.8	-1898.5	-469.1	1784.1	-10875	-9118.5	-2678.8	6571
SPA	-126.20	-125.9	-39.8	223.8	-725.1	-604.5	-227.04	824.1
SCH	0	436.5	0	0	0	2096.4	0	0
STR	0	1250.5	0	0	0	6006.1	0	0
SAG	0	75.9	0	0	0	364.8	0	0
SCO	0	67.3	0	0	0	323.1	0	0
SCS	0	230.3	0	0	0	1105.9	0	0
SOA	0	301.7	0	0	0	1448.9	0	0
Total	2271	3401	574	56279	13046.8	16332.4	3280.1	207278.9
Permit Price €	5.75	4.8	5.71	3.68				

Ranking: *LCA* – SCM, SEL, SGS, SGL, SPA, SCA, SCO, SAG, SCS, SOA, SCH, SPE, SMS, STR.

HA – SCM, SGL, SPA, SEL, SPE, SMS.

3.2. Results from alternative allocation rules *HA, AUC, All, LCA, REC*

Variable	*HA*	*All*	*LCA*	*AUC*	*REC*
Real GDP	**-0.16**	**-0.07**	**-0.14**	**-0.89**	**0.19**
Aggregated output	0.08	0.10	0.08	-1.82	-0.79
Permit price (euro/ tCO_2)	**5.75**	**4.80**	**5.71**	**3.68**	**3.63**
Industrial CO_2 emissions	-15.20	-15.24	-15.18	-15.98	-16.11
Total CO_2 emissions	-14.45	-14.47	-14.43	-15.31	-15.43
Energy inputs	1.92	2.03	1.85	-6.55	-6.81
Total energy demand	2.16	2.24	2.11	-5.45	-5.59
Energy intensity	2.21	2.31	2.12	-5.30	-7.14
Energy dependency	-4.22	-4.19	-4.17	1.29	0.23
Equivalent Variation	**-0.78**	**-0.76**	**-0.60**	**-3.59**	**0.54**
Households consumption	0.12	0.12	0.11	0.45	0.69
Consumer Price Index	-0.24	-0.24	-0.23	-0.96	0.11
Individual Income	-0.12	-0.12	-0.12	-0.51	0.80
Employment	0.02	0.02	0.02	-0.06	0.16
Wage	-0.13	-0.12	-0.12	-0.92	1.06
Public Income	-0.08	-0.08	-0.08	0.41	0.87
Imports	0.11	0.11	0.11	0.44	0.09
Exports	-0.51	-0.47	-0.47	-1.96	-0.91
Exchange rate	-0.63	-0.60	-0.60	-2.46	-0.48
Interest rate	0.50	0.48	0.44	1.93	-0.06
Invested Saving (total)	-0.35	-0.33	-0.30	-2.58	0.51
Households Invested Saving	-0.39	-0.37	-0.33	-1.45	-0.74
Investment	-0.05	-0.05	-0.04	-1.47	0.47
Investment price	-0.29	-0.28	-0.26	-1.12	0.04

4. Concluding remarks

1) **Modest MAC** - high energy intensity, structural/ technological changes, factor mobility + substitution.

2) **International trade** - could lower the MAC further.
Other flexible mechanisms: JIP, technological transfers EU.

3) **Flexibility** PK > ETS (Ppermit *All* < *HA)*
"+" European Directive:

- eligible sectors: all trade participants (-refineries) = lowest abatement costs in the economy.
- transaction costs: fewer financial and institutional resources than an overall trade scheme.

4) ***HA* policy** - more energy efficiency savings driven by increased capital goods.
- enhances the emission reduction across the rest of the economy too.

5) **Auctioning** creates a strong price-signal
- negative impact on labour, energy dependency, external competitiveness.
- slightly improved effects if permit incomes are recycled in the economy.

6) **No significant negative costs** (welfare, growth).
Strong double dividend (*REC*) in the form of improved environmental quality together with negative social costs indicates the great potential Romania has for improving energy efficiency.