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Economic Effects of a Constant Energy Tax in Greece

by

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1. Introduction

In response to the emerging evidence that climate change could have a major global impact, in June 1992, Greece, both as an individual country and as a member-state of the EU, signed the UN Framework Convention on Climate Change (UNFCCC), in Rio de Janeiro and committed itself -under the Kyoto Protocol in 1997- to limit the scale of increase in its emissions by 15%[1] (Karagianni and Pempetzoglou, 2001, pp. 96-7).

Taxation of externalities has frequently been advocated as one of the most economically efficient ways to internalize externalities (Baron, 1999, p. 207). More specifically, an energy tax is a charge, whose level depends on the quantity of energy consumed and it is specified in some common unit (Baranzini et al., 2000, p. 397). An energy tax directly influences the market price of goods and services and as a result it affects indirectly the quantities of energy used. Cost-effectiveness is due to the fact that, since the tax rate is the same for each polluter, marginal abatement costs are equalized between polluters and polluters with relatively low abatement costs will make greater abatement efforts; thus, the "global" total cost of reducing emissions is minimized.

The EU first proposed the introduction of a carbon/energy tax in 1992. In general terms, the energy tax would be based 50% on energy content and 50% on the carbon content of fuels and it was intended to burden all energy products with the exception of renewables (Bill, 1999). It would start by

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1. The adoption of the Kyoto Protocol led to the EU *"burden sharing"* agreement, according to which, the EU member-states would implement their respective commitments, forming a European "bubble". Thus, different commitment targets applied to all member-states. According to this, Greece was committed for a 15% increase in its emissions by 2000 compared to 1990 levels.

\$3/barrel and it would increase to \$10/barrel within a 7-year implementation period. However, since not all member-states were convinced for the necessity of a new tax, no agreement was reached. Eventually, each member-state developed its own national climate change strategy and some of them applied energy or carbon taxes individually.

A great number of studies has been conducted to examine the effects of energy taxation on economic variables either at a global, regional or country level. Many of them, were based on international environmental models (e.g. GREEN[2], Global 2100) or on regional or country models, which were developed to examine likewise issues in specific regions (e.g. Susquehanna River Basin CGE model[3]) or countries (e.g. GDMEEM[4]). The accruing results are significantly differentiated across studies, since all of them reveal remarkable differences in terms of hypothesis, methodology and policy scenarios. In general terms, though, it arises that well-designed energy taxes appear to have insignificant effects on macroeconomic variables and competitiveness. The most negatively affected sectors appear to be the energy intensive branches, like pulp and paper, steel and electricity production industry.

In this paper, we examine the macroeconomic and sectoral effects of a constant energy tax, introduced unilaterally in Greece. For this purpose, we developed a model, whose structure is based on the framework of the environmental input-output tables of the Greek economy. Noteworthy is that, this is the first study that examines the economic effects of energy taxation in Greece. The most important characteristic of the present study is that, although most studies make use of input-output tables, the present one is based exclusively on the framework and the data of the environmental input-output tables.

The structure of the paper is as follows. Section 2 describes the basic framework of the environmental input-output tables of the Greek economy and section 3 presents a brief non-technical overview of the model and the interactions between the various economic and environmental variables. Section 4 addresses the energy tax characteristics and Section 5 describes the scenarios adopted. Section 6 sets out the results for the economic variables as

2. Oliveira-Martins, J. et al. (1992).
3. Oladusu, G.A. and Kamat, R.S. (1997).
4. Goto, N. (1995).

well as for international competitiveness and carries out comparisons. The final section concludes.

2. The environmental input-output tables of the Greek economy

This section aims at presenting the basic framework and the functioning of the environmental input-output tables of the Greek economy. These tables constitute a useful and dynamic tool in studying the existing relations between the economy and the environment (Mylonas, 2000, p. 20) and this framework facilitates a straightforward and a more complex analysis of the effects of economic and environmental policies on both the economy and on the pressure on the environment (EUROSTAT, 1999).

The environmental symmetric input-output tables of the Greek economy use a classification of 25 economic branches. The nomenclature of the 25 industries classification of the Greek input-output tables appears on table 1.

In "Natural Resource Accounts and Environmental Input-Output Tables for Greece 1988-1998" presented the pilot environmental input-output table* for the Greek economy for the year 1994. The general framework of the input-output table consists of seven column parts. Part 1 of the table refers to the symmetric matrix of the total intermediate inputs-outputs of the input-output table. For the symmetric part of the intermediate intra-branch relations for the 25x25 branches of the Greek economy, transactions recorded into columns and rows 1.01 to 1.25 refer to the level of the total transactions related with domestic production and imports. Part 2 refers to the vectors of final uses and part 3 to the vector of gross domestic value of production. Final demand consists of the market final consumption of household vector, the non-market final consumption vector, the gross fixed capital formation, the changes in stocks and the exports vector. Part 4 refers to lignite stocks and the fifth part presents seven types of atmospheric emissions –namely, CO_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2– into the branches classification of 1.01 to 1.25 and into households (the metric unit is 1000 tones). The sixth part concerns the impact of greenhouse and

* Mylonas, N.A., Vlachos, P., Krasadaki, A., Molfeta, K., Economakou, M., Stromplos, N. and Frangoulopoulos, N. (2000), *"Natural Resource Accounts and Environmental Input-Output Tables for Greece 1988-1998"*, *"Pilot Namea Table for the Greek Economy For the Year 1994"*, Athens: Institute of Computer and Communications Systems (ICCS) of National Technical University of Athens (NTUA), pp. 79-80.

acidification phenomena in the environment, provided that the relevant data are available for the particular emissions and, finally, the seventh part presents the total of pollutants (in 1000 tones).

Table 1

Nomenclature of the 25 industries classification of the Greek input-output tables

Serial Number	NOMENCLATURE OF THE 25 INDUSTRIES
1.01	Agriculture, hunting and related service activities, products of forestry: logging related services
1.02	Fish and other fishing products
1.03	Mining of coal and lignite: extraction of peat, extraction of crude oil and natural gas, mining of nuclear materials
1.04	Manufacture of metal ores, other mining and quarrying products
1.05	Manufacture of food products and beverages, tobacco products
1.06	Manufacture of textiles, manufacture of clothes process and dyeing of fur, manufacture of tanning and dressing of leather
1.07	Wood and wood products
1.08	Pulp, paper and paper products, publishing printing and reproduction of recorded media
1.09	Manufacture of coke: refined petroleum products and nuclear fuel
1.10	Manufacture of chemicals and chemical products, manufacture of rubber and plastic products
1.11	Manufacture of other non-metalic mineral products
1.12	Basic metals and fabricated metal products
1.13	Fabricated metal products except machinery and equipment
1.14	Machinery and equipment, office machinery and computers, electrical machinery and apparatus, radio, television and telecommunications equipment and apparatus, medical precision and optical instruments, watches and clocks, motor vehicles trailers and semi-trailers, other transport equipment, furniture, recycling
1.15	Electricity, gas, steam and hot water, collection, purification and distribution of water
1.16	Construction work
1.17	Whole sale and retail sale of motor vehicles, whole sale and retail sale except vehicles, retail sale
1.18	Hotel and restaurant services
1.19	Transports, water transport services, air transport services, insurance and

	pension funding services, post and telecommunications
1.20	Financial intermediation services, insurance and pension funding services, services auxiliary to financial intermediation
1.21	Real estate services, renting services of machinery and equipment, computer and related services, research and development services, other business services
1.22	Public administration and defense services, sewage and refuse disposal services sanitation
1.23	Education, health and social work services
1.24	Membership organization services
1.25	Recreational, cultural and sporting services, other services, domestic services

Source: Mylonas, N.A., Vlachos, P., Krasadaki, A., Molfeta, K., Economakou, M., Stromplos, N., and Frangoulopoulos, N. (2000), *Natural Resource Accounts and Environmental Input-Output Tables for Greece 1988-1998*, Athens: Institute of Computer and Communications Systems (ICCS) of National Technical University of Athens (NTUA), pp. 70-73.

Horizontally now, in the lower part of the intermediate uses matrix, row 1.26 refers to the total level of intermediate and final uses. Furthermore, row 2 includes the relevant information on pollutants for the household sector and row 3 depicts the information of total imports according to intermediate branch and by category of final use. Row 4.1 refers to the total value of taxes burdening each branch of the economy, row 4.2 involves the total value of subsidies received by each branch and row 4.3 indicates the total value of VAT charging each branch. Row 5 describes the gross domestic value of production. In the rows 6.1 to 6.4 of the table are shown the accounts for the quantities of energy flows for intermediate and final uses, whereas row 7 presents the total energy input. After the 7th row of the table, rows 8.1 to 8.7 are presented referring to the information of total pollutants as presented in the column of part 7. Besides, row 9 presents the total pollutants of part 5, while row B describes the balancing in the magnitude of withdrawable stocks, which are transferred in the beginning of the next year. Finally, in the lower part of the table, various additional relevant information is presented, provided they are available with the net changes of energy reserves, the supply of ship fuelling abroad, the waste treatment and disposal and the emissions of other air pollutants related with the greenhouse effect.

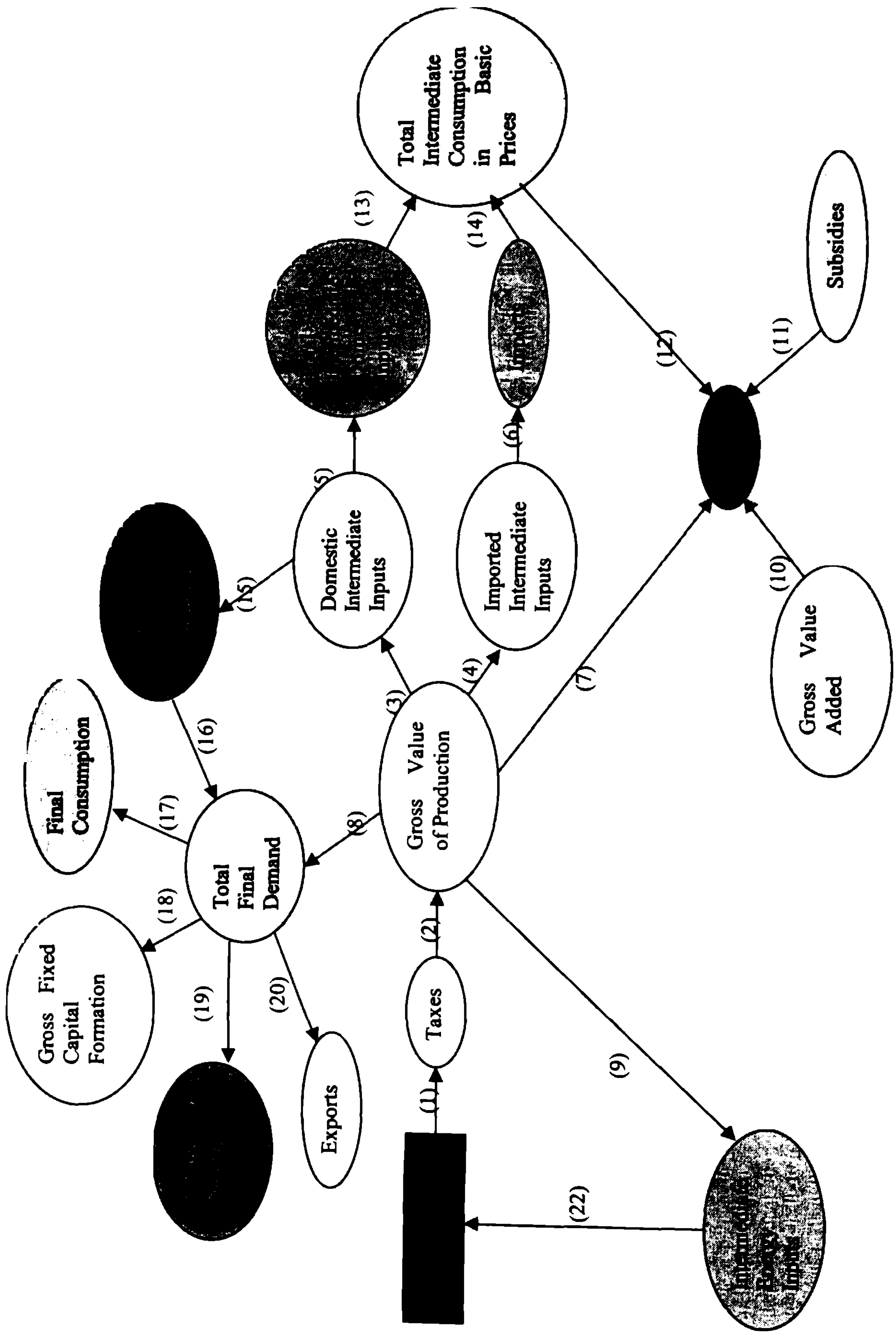

Figure 1: *The Structure of the Input-Output Model of the Greek Economy.*

3. The structure of the model

In Figure 1, the structure of the input-output model of the Greek economy is presented. Initially, an energy tax is imposed according to the intermediate consumption of the energy products in every branch of the economy (arc 22). The energy tax imposition will increase the total tax revenues of the economy (arc 1) and assuming that the level of subsidies, VAT and gross value added remains constant, we lead up to the new level of the gross value of production (arc 2). Due to the modification in the gross value of production, the matrices of the intermediate domestic (arc 3) and imported inputs (arc 4) will change (through the matrices of technological coefficients matrices, that associate the matrices of the total level of intermediate domestic and imported inputs, respectively, with the gross value of production and they are assumed to be constant). The changes in the intermediate domestic and imported inputs matrices will affect the total level of intermediate domestic inputs (arc 5) and imports (arc 6) and, furthermore, the total level of intermediate consumption in basic prices (arcs 13 and 14). The new level of the total intermediate consumption (arc 15) is determined according to the new intermediate domestic inputs matrix. Given the new levels of the total intermediate consumption and the gross value of production, the new level of the total final demand is defined (arcs 16 and 8). Additionally, by keeping fixed the technological coefficients matrix –the one that sets the relation between the components of the final demand (final consumption, gross fixed capital formation, changes in stocks and exports) and the total final demand– we conclude to the new levels of the final consumption (arc 17), gross fixed capital formation (arc 18), changes in stocks (arc 19) and exports (arc 18). Assuming that the relation between the intermediate energy uses of every branch and the gross value of production remains constant, the new level of intermediate energy uses of every energy input and for every branch is defined (arc 9). The energy tax will again be estimated according to the new level of energy uses (arc 22) and the procedure continues as above.

For the empirical analysis, some special software has been developed in the programme language Borland C++. The programme has been based on the specific equations and restrictions of the model and it has been developed in two different versions, according to the scenarios adopted.

4. Energy tax characteristics

The energy tax is imposed on fuels and the other energy sources according to their energy or thermal content and it is expressed as a constant absolute amount of money specified in some common unit – in our case in TeraJoules (TJ). More specifically, under both scenarios, the energy tax is set at the level of 1000 drs/TJ and it remains constant ever after. The implementation period is extended until the achievement of economic equilibrium. The energy tax burdens the intermediate uses of energy products in every sector of the economy, while the final consumption is exempted. The specific level of the energy tax (1000 drs/TJ) has been chosen, since it is very close to the level of the proposed by the EU energy tax, in 1992. At that time, the amount of 1000 drs was almost equivalent to $3.

5. Policy scenarios

In our analysis, we are interested in determining the effects of energy taxation on main macroeconomic and sectoral variables of the Greek economy, when we apply a constant energy tax. However, it would be interesting to determine and compare the effects of energy taxation, when it is imposed on all energy products without exception, as well as when some specific energy products are exempted from the energy tax imposition. Overall, two scenarios are examined:

- *Scenario 1:* The first scenario involves the implementation of an energy tax set at the level of 1000 drs/TJ applied at an annual basis. The energy tax is common in all branches of the economy and it applies to all energy products. The tax is assumed to remain constant at its initial level during all the following years until the achievement of equilibrium in the economy.

- *Scenario 2:* The second scenario involves the implementation of an energy tax set at the level of 1000 drs/TJ applied at an annual basis. The energy tax is common in all branches of the economy and it applies to all energy products, except for the environmental-friendly energy products, namely natural gas and gas. The tax is assumed to remain constant at its initial level during all the following years until the achievement of equilibrium in the economy.

6. Results

The results reveal slight or, in some cases, no differences between the two scenarios. At the aggregate level, macroeconomic variables display increases, whereas, at the sectoral level, certain variables in certain branches display reductions.

More specifically, at the aggregate level, as table 2 indicates, economic variables display increases of the same size in both scenarios. The gross value of production increases by 0.58% and stabilization is achieved in 13 years. The increase in the gross value of production reflects the increase in the level of prices and, in other words, the cost of production (Mariolis et al., 1997). The greatest increases involve in the total tax revenues (14.87%) and the changes in stocks (14.89%). Competitiveness is measured by the difference between exports and imports and it is positively affected; specifically, exports raise by 2.46% and imports by only 1.31%. Thus, the balance of trade improves. The energy use is increasing by 2.39%, while the gross fixed capital formation faces the smallest increase (0.08%). For most economic variables, the stabilization period ranges between 2-28 years.

Table 2

Final results at the aggregate level

VARIABLES	SCENARIO 1	SCENARIO 2
Gross value of production	0.58%	0.58%
Taxes	14.87%	14.87%
Total intermediate domestic inputs	0.83%	0.83%
Total intermediate consumption	0.83%	0.83%
Imports	1.31%	1.31%
Exports	2.46%	2.46%
Final consumption	0.26%	0.26%
Total final demand	0.49%	0.49%
Gross fixed capital formation	0.08%	0.08%
Changes in stocks	14.89%	14.89%
Intermediate energy inputs	2.39%	2.39%

At the sectoral level, as table 3 indicates, in the case of the gross value of production, the membership organization services branch (branch 24) reveals a slight decrease of 0.02%, while branch 2-fish and other fishing products is not affected at all. The most heavily affected branch is branch 12-basic metals and fabricated metal products (11.17%). As far as the imports are concerned, the most negatively affected branch is branch 12-basic metals and fabricated metal products, whose imports increase by 11.26% and 11.25% in scenario 1 and 2, respectively. Branch 24-membership organization services is not affected at all, while branch 2-fish and other fishing products shows a decrease of 0.07% in both scenarios. Other negatively affected branches are branch 11-manufacture of other non-metalic mineral products (3.31% and 3.30%, respectively), 21-real estate, renting and business services (2.07%) and 10-manufacture of chemical and plastic products (1.97%). The less negatively affected branches are branch 16-construction work (0.01%), 15-electricity, gas and distribution of water (0.1%) and 19-transport services and telecommunications (0.16%). Exports greatest increases involve in branch 12-basic metals and fabricated metal products (24.74%) and 11-manufacture of other non-metalic mineral products (7.35%). Branch 20-financial services is not affected at all, while the most negatively affected branches are 4-mining of metal ores and quarrying products (6.63%) and 3-mining of coal and lignite (6.56%). Total final demand increases involve in branches 12-basic metals and fabricated metal products (24.74%) and 11-manufacture of other non-metalic mineral products (7.35%); the greatest reductions appear in branches 4-mining of metal ores and quarrying products (6.63%) and 3-mining of coal and lignite (6.57%). Branches 12-basic metals and fabricated metal products (11.17%) and 11-manufacture of other non-metalic mineral products (3.39%) show the greatest increases as far as the energy use is concerned, while branches 16-construction work (0.02%) and 21-real estate, renting and business services (0.03%) show the greatest decreases.

7. Conclusion

In this paper, we develop a model, in order to determine the economic effects accruing from the unilateral imposition of an energy tax in Greece. The model structure is based exclusively on the framework and the functioning of the environmental input-output tables of the Greek economy. We consider 1994 as the base year of the study and we apply an energy tax that remains constant at the level of 1000 drs/TJ. The implementation period lasts until the economy stabilizes. In our research, we adopt two scenarios: in the first one, the tax burdens all energy products in all branches with no exception, whereas in the second the environmental-friendly energy products "natural gas" and "gas" are exempted.

The empirical evidence reveals that the exemption of the specific energy products does not differentiate significantly the results arising from the two scenarios, either at the aggregate or sectoral level. We should, thus, be indifferent between the exemption or inclusion of the environmental-friendly energy uses. In addition, the stabilization period is the same in both scenarios.

At the aggregate level, economic variables show an increase ranging from 0.08% (gross fixed capital investment) to 14.89% (changes in stocks). The balance of trade and furthermore competitiveness seems to improve, since the aggregate increase of exports (2.46%) surpasses the aggregate increase in imports (1.31%).

At the sectoral level, the greatest variations are faced by branches 12-basic metals and fabricated metal products and 11-manufacture of other non-metalic mineral products. On the other hand, branches 2-fish and other fishing products and 21-real estate, renting and business services seem to be the less affected ones. As far as the balance of trade and competitiveness are concerned, some branches show improvement, while others reveal deterioration. Energy uses increase or remain stable in most cases.

In conclusion, the proposed energy tax seems to have positive effects at the economy level. Indeed, most macroeconomic variables, like gross value of production and total intermediate consumption show improvements and it seems that positive effects far surpass negative ones.

Table 3a: *Final results at the sectoral level (scenario 1)*

Gross value of production	0.32%	0%	1.11%	1.23%	1.04%	1.09%	0.93%	1.15%	1.78%	1.98%	3.39%	11.17%	0.98%	0.45%	0.17%	0.02%	0.16%	0.78%	0.15%	0.65%	0.03%	0.19%	0.09%	-0.02%	0.35%
Taxes	11.93%	0.05%	70.83%	16.30%	8.90%	50.40%	29.64%	28.61%	5.90%	32.37%	33.10%	187.95%	47%	33.12%	1.56%	2.47%	10.53%	27.25%	2.49%	13.44%	12.80%	13.59%	8.60%	1.91%	31.41%
Total intermediate domestic inputs	0.33%	0.02%	1.10%	1.24%	1.05%	1.08%	0.93%	1.15%	1.77%	1.97%	3.39%	11.18%	0.98%	0.45%	0.18%	0.01%	0.16%	0.78%	0.15%	0.65%	0.03%	0.19%	0.07%	0%	0.36%
Total intermediate consumption	0.85%	0.60%	1.33%	4.37%	0.82%	0.89%	0.40%	0.77%	0.80%	0.84%	0.78%	1.80%	1.92%	1.21%	2.08%	0.13%	0.83%	0.23%	0.32%	0.76%	0.52%	0.28%	0.33%	0.31%	0.25%
Imports	0.32%	-0.07%	0.92%	1.13%	1.04%	1.09%	0.90%	1.14%	1.77%	1.97%	3.31%	11.26%	1.91%	0.45%	0.10%	0.01%	0.25%	0.72%	0.16%	0.67%	2.07%	0.20%	1.03%	0%	0.36%
Exports	-1.48%	-0.26%	-6.56%	-6.63%	1.16%	1.14%	5.30%	1.74%	2.52%	3.39%	7.35%	24.74%	-3.07%	1.38%			-0.11%	0.79%	0.03%	0%	-0.27%				0.44%
Final consumption	-1.48%	-0.25%			1.16%	1.14%	5.31%	1.74%	2.52%	3.40%	7.35%	-24.74%	-3.07%	1.38%	-3%	0.01%	-0.11%	0.80%	0.03%	-0.01%	-0.28%	0.19%	0.08%	-0.28%	0.42%
Total final demand	-1.48%	-0.25%	-6.57%	-6.63%	1.18%	1.14%	5.30%	1.74%	2.52%	3.38%	7.35%	24.74%	-3.07%	1.38%	-3%	0.01%	-0.11%	0.80%	0.03%	-0.01%	-0.28%	0.19%	0.08%	0.28%	0.42%
Gross fixed capital formation	-1.48%						5.29%						-3.07%	1.38%		0.01%	-0.11%				-0.28%				0.42%
Changes in stocks	1.48%	0.21%	6.56%	-6.62%	-1.16%	1.14%	5.30%	1.77%	-2.52%	3.40%	7.38%	24.74%	-3.08%	1.39%			0.12%								
Intermediate energy inputs	0.32%	0.00%	1.11%	1.23%	1.04%	1.09%	0.93%	1.15%	1.78%	1.98%	3.39%	11.17%	0.98%	0.45%	0.17%	0.02%	0.16%	0.78%	0.15%	0.65%	0.03%	0.19%	0.09%	0%	0.35%

Table 3b: *Final results at the sectoral level (scenario 2)*

Gross value of production	0.32%	0%	1.11%	1.23%	1.04%	1.09%	0.93%	1.15%	1.78%	1.98%	3.39%	11.17%	0.98%	0.45%	0.17%	0.02%	0.16%	0.78%	0.15%	0.65%	0.02%	0.19%	0.09%	-0.02%	0.35%
Taxes	11.93%	0.05%	70.83%	16.30%	8.90%	50.40%	29.60%	28.60%	5.90%	32.37%	33.10%	187.93%	47%	33.12%	1.56%	2.47%	10.53%	27.25%	2.49%	13.44%	12.80%	13.59%	8.60%	1.90%	31.40%
Total intermediate domestic inputs	0.33%	0.02%	1.10%	1.24%	1.05%	1.08%	0.93%	1.15%	1.77%	1.97%	3.39%	11.17%	0.98%	0.45%	0.18%	0.01%	0.16%	0.78%	0.15%	0.65%	0.03%	0.19%	0.07%	0%	0.36%
Total intermediate consumption	0.85%	0.60%	1.33%	4.36%	0.82%	0.89%	0.40%	0.77%	0.80%	0.84%	0.78%	1.80%	1.92%	1.21%	2.08%	0.13%	0.83%	0.23%	0.32%	0.78%	0.52%	0.28%	0.33%	0.31%	0.25%
Imports	0.32%	-0.07%	0.92%	1.13%	1.04%	1.09%	0.90%	1.14%	1.77%	1.97%	3.30%	11.25%	1.90%	0.45%	0.10%	0.01%	0.25%	0.72%	0.16%	0.67%	2.07%	0.20%	1.03%	0%	0.36%
Exports	-1.48%	-0.26%	-6.56%	-6.63%	1.16%	1.14%	5.30%	1.74%	2.52%	3.40%	7.35%	24.74%	-3.07%	1.38%			-0.11%	0.79%	0.03%	0%	-0.27%				0.44%
Final consumption	-1.48%	-0.25%			1.16%	1.14%	5.30%	1.74%	2.51%	3.40%	7.35%	-24.70%	-3.07%	1.38%	-3%	0.01%	-0.11%	0.80%	0.03%	-0.01%	-0.28%	0.19%	0.08%	-0.28%	0.42%
Total final demand	-1.48%	-0.25%	-6.57%	-6.63%	1.16%	1.14%	5.30%	1.74%	2.52%	3.40%	7.35%	24.74%	-3.07%	1.38%	-3%	0.01%	-0.11%	0.80%	0.03%	-0.01%	-0.28%	0.19%	0.08%	-0.28%	0.42%
Gross fixed capital formation	-1.48%						5.29%						-3.07%	1.38%		0.01%	-0.11%				-0.28%				0.42%
Changes in stocks	1.48%	0.21%	6.56%	-6.62%	-1.16%	1.14%	5.30%	1.77%	-2.51%	3.40%	7.38%	24.74%	-3.08%	1.39%			0.12%								
Intermediate energy inputs	0.32%	0.00%	1.11%	1.23%	1.04%	1.09%	0.93%	1.15%	1.78%	1.98%	3.39%	11.17%	0.98%	0.45%	0.17%	0.02%	0.16%	0.78%	0.15%	0.65%	0.03%	0.19%	0.09%	0%	0.35%

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Abstract

Energy taxes have long been advocated as one of the most cost-effective instruments to mitigate global warming. In this paper, we develop an input-output model to examine the macroeconomic and sectoral effects of energy taxation in Greece. The design of the model is based exclusively on the structure of the environmental input-output tables of the Greek economy. The energy tax is set at the level of 1000drs/TJ and remains constant ever since. Two scenarios are examined: according to the first, the tax burdens equally all energy products, whereas in the second environmental-friendly energy products, such as natural gas and gas, are exempted. The results reveal increases in the value of most economic variables as well as the cost of production.