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Effects of Implementation of Green Tax on Environmental Pollutants' Dispersion on Macroeconomic Variables: Application of Multi-Regional General Equilibrium Model

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ABSTRACT
The present paper aims to determine the effects of various scenarios of green tax burden on pollution dispersion and multiple macro-economic variables such as GDP along with welfare and inflation. In addition, the effects of technical progress on major pollutant industries such as coal, oil and gas were evaluated. For this purpose general multiregional equilibrium method (GTAP-E) was used. The results of the study indicated that under low tax rate scenario, GDP remained unchanged. Increase in the carbon tax rate would not followed by increase in GDP. Energy consumption and social welfare increased but inflation decreased. Furthermore, increase in efficiency along with advance technology caused reduction in dispersion of environmental pollutants along with GDP growth and consequent increase in government tax revenue.

Keywords: Environmental CGE model, carbon tax rate, energy consumption, CO_2 emissions, Multi-Regional General Equilibrium Model GTAP).

INTRODUCTION
According to energy coefficient index which is obtained from dividing growth rate of final consumption by growth rate of gross domestic production, energy coefficient in Iran has always been higher than one which indicates a weak relationship between energy consumption and GDP. In Iran, the issue is about the influence of correcting energy prices and pollution on major economic variables. The interaction between energy sector, environment and economy is one of the main pillars of sustainable development .Climatic change is a function of the world's CO_2 pollutants, applying same carbon tax wherever these pollutants are created is the most effective strategy to control them. Although this approach is optional, because countries are reluctant to agree until understanding the benefits arising from this approach. Emission of greenhouse gases and the increase in these gases in the atmosphere more than its natural amount causes more and more climate warming, destruction in the protective layer of the earth protecting earth against dangerous sun rays, and endangering the entire natural life. Iran's economy is passing through its stagflation period. The economic growth rate is negative (about -2.2% growth obtained from oil revenue and -2 %growth obtained from non- oil revenue in 2013).

Noteworthy, at least in recent decade, the government has been faced with budget deficit and negative non-oil trade balance which has been in fluctuation at least from 2001 to first quarter of 2013 ranging from 12 to 38 billion dollars. The value of all mentioned variables and other variables of Iran's economy exhibits the recession and stagnation in all economic sectors. Our aim was to specify these effects in a general equilibrium condition using a new and trade- related methodology. Energy is considered as an important commodity in many economic activities. Its usage influences the environment via CO_2 emissions and the greenhouse effect. Modeling the linkages between energy-economy-environment-trade is an important objective in applied economic policy analysis. However, the modeling of these linkages in GTAP has been incomplete so far.

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This occurs because energy substitution, as a key factor in this chain of linkages, is absent from the standard model specification. This paper resolves this deficiency by incorporating energy substitution into the standard GTAP model. It begins first by reviewing some of the existing approaches to this problem in contemporary CGE models.The approach is implemented as an extended version of the GTAP model called GTAP-E. In addition, GTAP-E incorporates carbon emissions from the combustion of fossil fuels as well as a mechanism to trade these emissions internationally. The policy relevance regarding GTAP-E in the context of the existing debate about climate change is illustrated by some illustrative simulations for the implementation of the Kyoto Protocol. Lin *et al.* (2018) in a paper entitled "The energy, environmental and economic effects of the carbon tax rate and taxation industry: a CGE-based study in China" nine scenarios reported considering different carbon tax rates and the different taxable industries to analyze the effect of the Carbon Tax System (CTS) on energy, environment and the economy. If carbon taxes are levied on energy-intensive enterprises, the effect on carbon emissions will be also relatively small, even if the carbon tax rate is relatively high.

A higher carbon tax rate will result in higher CO_2 emission reduction and higher marginal CO_2 emission reduction of CTS. In a study, Firouzeh *et al.* (2017) investigated the exertion of green tax on the energy carriers emitting carbon dioxide and the double advantage gained thereof in Iran's economy. The results indicated that setting tax on pollutants is accompanied by positive and, while uprising pollution and welfare, respectively, for all of the scenarios and that such a decrease in pollution andelevating in welfare is boosted by increased tax rates. Mahmoudi (2017) in another study entitled "Oil price reduction impacts the Iranian economy"reported that oil export revenue and the mineral commodity export earnings will drop, while other production sectors' exports will upraise.

The trade balance in Iran will be affected negatively and strongly along with the reduced oil and other service productionIn the production sectors' market, the demand for labor, natural resources, and investment decreased dramatically, and the demand for land increased. Using equivalent variation (EV), changes in Iran's welfare is highly negative. Finally, deflation, reduction in value and quantity of GDP and changes in consumption combination from the public to private sector are the other economic impacts of a reduction in oil price on Iran's economic status (Ziaee 2013). The aim of the present study was construction and application of a multi-regional computable general equilibrium (MRCGE) model, namely Iran ORANI-G, and employing it in simulation and analysis of economic shocks and policy scenarios. So that, the database of model was made in TABLO language in GEMPACK software. Regarding simulation of drought, the results showed that GDP, GRP in all provinces, regional employment in most of provinces, aggregate employment and export were decreased, while, import and Consumer Price Index (CPI) were increased. At aggregated sector level, the results were implied on lessening of value added variable in all of aggregated sectors and expansion of employment in agricultural sector.

Liu *et al.* (2015) in another study entitled "Economic and environmental implications of raising China's emission standard for thermal power plants: An environmentally extended CGE analysis" thermal power plants were considered as the main source of atmospheric pollutants in China due to their massive emissions of sulfur dioxide (SO_2) and nitric oxide (NO_X). Their results exhibited that imposing the new emission standard may lead to a reduction in SO_2 and NO_X emissions by 22.8% and 11.4%, respectively per year, with the absolute amounts which were reduced by 5597 and 1482 thousand tons. This is the result of the improvement of the emission removal technologies and the sharp decrease in the coal consumption. On the other hand, the new emission standard may cause about 0.2% loss of GDP in the target year. In terms of changes in prices of goods and services and final demand structure, the new emission standard can make a contribution to curbing inflation, with the consumption demand reduced. Although many studies have been carried out about the dispersion of bioenvironmental pollutants in various countries, Mousavi *et al*. (2018) studied the effect of higher fuel price on pollutants emission in Iran reporting variables such as per capita CO_2 emission, fuel price, per capita production, and per capita energy consumption. In this study, the relationship was examined by auto-regressive distributed lag (ARDL) model and it was found that CO_2 emission is related to actual price of fuel indirectly and to per capita production as well as per capita energy consumption directly.

Furthermore, according to their findings, 1% higher price of fuel would decrease CO_2 emission by 0.14%, while 1% higher per capita production would increase it by 0.59%. Given the effectiveness of subsidy reform policy and theelevated price of fuel on the alleviation of greenhouse gas emissions by road transport sector, they advised gradually upraising fuel price until it reaches to FOB price in the Persian Gulf.

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MODEL AND DATA

CGE model

CGE model is widely used in policy analysis (Paroussos *et al.* 2015; Lin & Jia 2017; Lu *et al.* 2017; Zhao *et al.* 2018). The construction of all CGE models is based on traditional Walrus paradigm, which means that the model can be described as a system of simultaneous equations deduced from all actors' maximizing behaviors. CGE model simulates the behavior of social agents such as resident enterprises, government, and foreigners (Bohringer *et al.* 2017; He & Lin 2017). The CGE framework model in this paper is adapted from the study by Hosoe *et al.* (2010). We add some parts to this framework such as sectorial classification, production function, energy factor, energy-policy block, dynamic recursion, two households. It is consisted of five blocks such as: 1-production, 2-income-expenditure, 3-trade, 4-energy-policy, and 5-macroscopic-closure & market-clearing blocks. The general framework of the CGE model is illustrated in Fig. 1. There is a wide range of CGE models that have explained the effect of economic variables' shocks on an economy such as the model developed by Esmailpouri *et al.* (2017). CGE models have been widely used in analyses of policy effects such as taxes, subsidies and so on. Depending on the research purposes, various CGE models have been presented including single-region, multi-region global or country, comparative static, dynamic models and etc. (Dong *et al.* 2015). Igos *et al.* (2015) applied a practical combination of a CGE and a Partial Equilibrium (PE) model by linking the outcomes obtained from coupling with a hybrid input-output process to assess the environmental consequences of two energy policy scenarios in Luxembourg during 2010 and 2025. Liu & Lu (2015) applied a dynamic CGE model–CASIPM-GE model to investigate the effects of a carbon tax and different tax revenue recycling schemes on China's economy (Liu & Lu 2015).

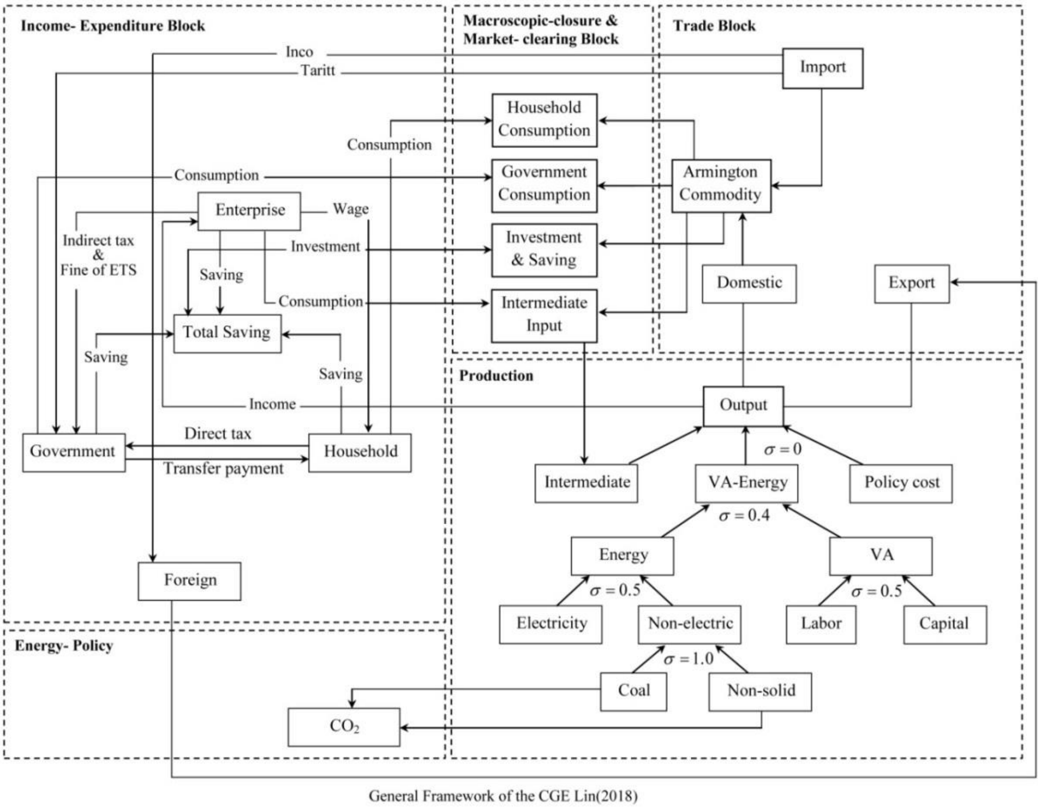

Fig. 1. Framework based on the research done by CGE Lin (2018).

Elaboration of Model Blocks:

The general equilibrium model has been codified within the format of the following blocks in the present study.

1-1 Production block

CGE model divides production function into parts. In Fig. 1, they are more similar to a reverse tree. The head branch of the tree is the technology used for explaining final construction of the product or service. Each branch

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of this tree is a sub-process with its own special production function or technology. These branches are called nest production functions, because larger processes are nested in production of the final product. On low level, those nest functions explain that there are possibilities for substituting labor, capital, and a basket of energy inputs; therefore, an additional nest describes the possibilities for replacing various types of energy in an energy basket, such as coal, oil, or gas. The advantage of adding nests is that it allows the modeler to explain input subsets in production process as complementary instead of substitution. Leontief VAE is a software package which includes value added (VA) and energy of constant elasticity of substitution function (CES). Non-electric energy complex including coal fuel and non-solid fuel (oil and gas) follow CES function. Since, Iranian industry does not separate oil and gas industries, and coal is the main type of energy consumption in Iran, so in this study, oil and gas were not separated from each other.

1-2 Income-expenditure block

Four social factors are government, company, family (residents of villages and residents of cities) and foreign company. CGE model involves the concept of balance and relationship between these four factors. Transitional payments regarding consumer spending and savings all depend on the level of income. Each of these is an increasing function of income. Among these, only tax revenue is a function of gross income. For the government, financial income is received through directand indirect taxes and also tariffs, and all income is used for payments in transfer, consumption and saving sectors. Domestic firms earn sale income obtained from consumption by government, households, other companies, and foreigners in order to support their own costs including indirect tax, households' income, and savings.

1-3 Trade block

Three principles of market reduction are: state budget balance, foreign trade balance, and investment-savings balance. This applies to any economic system, and for the ratio of national savings of an economic system, in the case of passing the simple sustainability test, must be more than the reduction in cost savings in natural and artificial capitals. For investment-saving balance, CGE model assumes that total saving has been turned into investment, and in market equilibrium price, market equilibrium of Armington combined commodities indicates that all Armington commodities are used for household consumption and government consumption, moderate consumption and saving, without use of surplus; and the reason for market equilibrium price is that there is no unemployment in the market.

1-4 Energy-policy block

Carbon tax at the same rate indicating $48 per ton of CO_2 will reduce pollutants as equal to 40% by 2020 all over the world Increasing tax rates also causes a reduction in pollutants because these stages have been resulted from minimizing carbon costs (Burfisher 1994). In some countries, by applying carbon tax only, the reduction in pollutants is slightly less than one-third of the second state (same global tax), due to the significant carbon leakage as a production shift for countries without tax. Through adjusting the full importand export border taxes, carbon leakage will be stopped. Currently, at least 20 countries in the world have imposed carbon tax. These countries are widely divided into two categories: the first group, such as Denmark and the Netherlands, having comprehensive carbon tax system formerly, have begun the implementation of carbon tax system earlier than others and have made better political efforts. The second category includes countries that have reduced carbon tax in the framework of reducing common global emission, but the level of their implementation is not enough.

Technologies are concerned with 1-5 Macroscopic-closure & Market-clearing block. Three principles of market closure are considered in this model: government budget balance, foreign trade balance, and investment-saving balance. The first two balances are introduced in section 2.1.2. As for investment-saving balance, CGE model assumes that all of the savings are transformed into investment, which means that total investment is equal to total savings. Two principles are considered in the market clearing.

The Linkage of ETA to MACRO

Researchers from a global CGE model, recursive-dynamic; open -source, CIM-EARTH using the GTAPV.7.0 database. This model places energy in the value-added hut and introduces substitutability between sources of energy in the production of goods and services.

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(i) $$EN_j = kQ_j\left(\frac{C_j}{PEN_j}\right)^{\sigma}$$

where k is some constant is the own-price elasticity of demand for composite energy.
Let j EN, j C, and j PEN be the 'reference level' for these variables, i.e. the level as determined in the MACRO module. The linkage of ETA to MACRO is then defined by the following equation:

(ii) $$EN_j = \overline{EN}_j\left(\frac{PEN_j}{\overline{PEN}_j}\frac{\overline{C}_j}{C_j}\right)^{-\sigma}$$

which follows from the previous relation, and

(iii) $$PEN_j = \left(\frac{P^E(1+t_j^E)+\mu_j^E}{\overline{P_j^E}}\right)^{-a_j}\left(\frac{P^N(1+t_j^N)+\mu_j^N}{\overline{P_j^N}}\right)^{1-a_j}$$

where:
t Ej, t Nj, are ad-valorem tax rates on electric and non-electric energy demand in sector j.
μEj, μNj , are distribution margins on electric and non-electric energy (cost indices).
PjE, PjN , are the reference prices (user costs) of electric and non-electric energy.
The last equation is based on the assumption that the structure of the electric and non-electric energy compositions are Cobb-Douglas.
If the energy cost is only a small proportion of the overall sector cost, i.e.:

$$\frac{PEN_j.EN_j}{C_j} = \frac{PEN(\partial C_j/\partial PEN_j)}{C_j} << 1$$

then equation (b) can beestimated by:

(iv) $$EN_j = \overline{EN}_j\left(\frac{PEN_j}{\overline{PEN}_t}\right)^{-\sigma}$$

(v) $$PEN_j = \overline{PEN}_j\left(\frac{EN_j}{\overline{EN}_t}\right)^{-\frac{1}{\sigma}}$$

Equation (v) can be used to represent the inverse demand function for composite energy in ETA which will come out to be close to that modeled in MACRO. This is added to the list of equations for ETA (shown as equation 22 in equations).

List of Important Equations in ETA

The structure of production in the MACRO module of the CETM model categorizes the labor and capital together, and these factors are separated from the energy branch (see Fig. 1). This means that energy-capital and energy-labor will have the same substitution elasticity and this implies a severe restriction (see the discussion on the issue of capital - energy substitutability or complementarity in section 2.2 below). On the other hand, the internal structure of the inter-fuel substitution in the MACRO module makes a useful distinction between electric and non-electric energy inputs. Although the econometric evidence is scarce regarding the substitution between electric and non-electric energy inputs, this distinction is useful at least from a theoretical viewpoint. Since the choice of the electricity-generation technologies may have an important effect on the environment (such as the emission of CO_2), hence the focus on consumption level of electric energy may help to focus the attention on the choice of these technologies. Different forms of non-electric energy such as oil, gas, coal (direct use), synthetic fuels,

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renewable fuels or the non-electric backstop technologies, are treated as perfect substitutes in the ETA module (see equation 6). Perhaps this assumption is rather restrictive especially from the end-user's point of view. Natural gas, for example, is known to command a premium over coal due to its ease of handling. It may also come into conflict with other assumptions made in the model such as the fact that the market share is limited (see equation 7) for natural gas. Limited market share often implies some difficulty of substitution rather than a limitation in supply. Finally, if these non-electric energy forms are substitutable perfectly, then their marginal costs (prices) must also be set equal to each other. These are strong assumptions.

MATERIALS AND METHODS

Research data

After a review of CO_2 emission theories and the related studies, the relevant variables in Iran, factors affecting CO_2 emission were included in econometrics model. One important parameter in CO_2 emission is the government revenues which are in different forms. According to similar studies, the following model employedthe general multiregional equilibrium method (GTAP-E) to evaluate the effect of pollutants' emission and carbon dioxide changes, GDP along with welfare and inflation rates within the format of tax scenarios followed by an investigation of technical progresses made in 2017 in Iran in such sectors as coal, petroleum, gas and oil products

RESULTS AND DISCUSSION

To evaluate the effect of the changes in the macroeconomic variables on the environment quality and pollution index according to the Iran's economy with the objective of developing methods for reducing bioenvironmental pollution, the inference stage was carried out using scenario analysis of the variables. Thus, this section presents various scenarios of the model designed and simulated for Iran's economy. The simulation results indicate the effects of executing various policies and change of variables on bioenvironmental quality index. To construct aggregation, GTAP software was employed. There are preset aggregations in this program and the databases existent therein were applied by specifying the intended regions and sectors in Iran as well as other spots of the world to be subjected to further research. Such sectors included coal, petroleum, gas and oil products as the sources emitting carbon dioxide as well as the other non-energy sectors. In this program, there are predetermined aggregations that will be used along with the databases existent therein for the specification of the regions and sectors which were intended for the study of two regions in Iran and the other spots around the world. The intended sectors are coal, oil, gas, petroleum products as emitters of carbon dioxide and the other non-energy sectors. According to the results of the input-output in Table 1 presenting the data calculated for Iran's status in 2014, it can be concluded that the power plants, amongst all the economic sectors, produce the highest rate of pollutants such that 187 kg pollutants are produced per every million Rials annually in terms of final demand in power plant sector and that the highest pollution rate belonging to CO_2. In agriculture sector, 13 kg pollutants are produced per every million Rials of final demand and CO_2 accounts for the highest rate of pollution. In industry sector43 kg pollutants are also produced annually per every million Rials of final demand and CO_2 is the major cause of pollution. But, the trends are ascending for CO_2 in agricultural and mine sectors substantially as a result of gas-oil consumption. Additionally, it can be found from the Table 1 that the fossil fuels cause the highest pollution, while renewable energies have been found with lowest pollution rates.

Table 1. Multiplier coefficients of direct and indirect pollutant emissions resulting from fuel consumption in economic sectors per kilogram for 2014.

Economic sectors		Mine	Industry	Water, electricity and natural gas supply	Buildings	Transportation and warehousing and communication	Services
SPM	0.017	0.015	0.253	0.030	0.006	0.39	0.02
SO_2	0.05	0.09	0.30	0.53	0.02	0.53	0.09
SO_3	0.000	0.001	0.004	0.003	0.001	0	0
CO	0.131	0.252	7.844	0.495	0.161	10.53	0.64
CO_2	13	43	122	170	11	174.43	39.98
CH_4	0	0	0.01	0.01	0.01	0.06	0
NOX	0.05	0.10	0.77	0.57	0.03	1.14	0.11
Total	13.248	43.458	131.181	171.638	11.228	187.08	40.84

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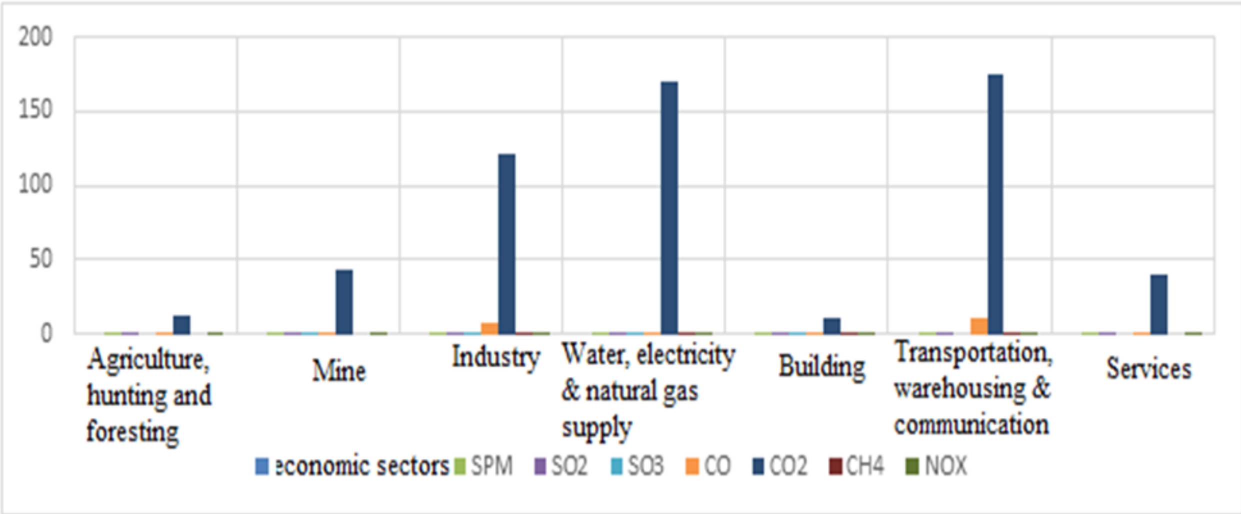

Fig. 2. Multiplier coefficients of direct and indirect pollutant emissions resulting from fuel consumption in economic sectors per kilogram for 2014.

Table 2. The scenario of imposing tax on carbon.

The emission standard on Iran's Macro Economy Unit: %.			
Items	**Change**		**Contribution to GDP**
Macroeconomic variables		From the expenditure side	
GDP	3.38	Consumption	−0.1
CPI	-0.03	Saving	13.18
Regional Household	10.58	Income deflator	-1.29
Investment	-4.43	Emission quota	6.02
Export			
Import	0.7		0.01
The real rate of exchange	0.4	Capital	0.0
Term of trade	−0.1	Tech change From	0.0
Factor market		income side	
money value of energy usage at agents prices	0.03	Labor	0.01
The elasticity of cost-utility	0.88	Capital	21.73
Price of capital	−0.2	Indirect tax	−0.2

The amounts of import (0.7) and export (-4.43) are indicators of the idea that, unfortunately, the country's foreign trade status is not so much auspicious. The governance of uncertainty space amongst the economic activists inside the country and the continuation of embargos along with the great economic stagnations worldwide have caused Iran's international commercial exchanges to be faced with a decrease in value for four consecutive years. Carbon dioxide emission rate has been increased by 10.73% with the possible increase in the trade rate (trade openness degree). Government investment causes an increase in the GDP (3.38) at first and influences the environmental quality as well as pollution indexsecondly. Thus, the government investment influences the pollution index and environmental quality via GDP's intermediary role. Considering the observed increase in inflation, the investors, motivated by acquiring higher rates of profit, tend to make more investments and larger production brings about a reduction in inflation hence in investment in the later periods. However, the increase in trade leads to the improvement of the environmental quality in the country. Since trade can elevate production and income, the favorable effect of trade on production is accompanied by pollution emission reduction, as well asthe substantial part of pollution emission following the augmentation of trade stems from the change in the composition of the produced goods rather than from the increase in production level and the type of production technology applied. Almost most of the reduction in pollution emission after elevation trade can be attributed to the change in the composition of the produced goods rather than to the increase in the production technology. The production level incorporates the technical effects, as well. Environmental quality improvement originating from the degree of

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trade openness can be due to the reason that the goods and their production process cause the production of a large amount of pollutants imported from China. Therefore, the pollution is increased in the exporting countrywhile decreased in Iran, because the importing country, due to thereduced production of the goods lead to larger deal of pollution in the course of their production as well as due to the reduced export trend of other polluting heavy products such as cement, glass, ceramic, iron and steel in the course of their production lead to releasing a large deal of pollutants

Table 3. Percentage of Change in Potential GDP (PGDP).

pgdp	**w**	**Pre w**	**Post w**	**Ch/%Ch w**
Technical progress	-1.15	1	0.99	-0.01
Tax shock	0.03	1	1	0
Simultaneous shock	10.25	528424.94	582583.69	54158.75

As shown in Table 3, the highest value of economic growth through imposing a simultaneous technical progress and tax shock is equal to 10.25 by implementing various scenarios in the energy sectors. This is reflective of the idea that the increase in the production does not lead to larger deal of pollution necessarily. The necessity for omitting the technologic barriers can be related to the expansion of new energies as compared to the use of non-renewable energies in developing countries. Due to its special geographical conditions, Iran possesses capacities for employing the hydroelectric, hydropower, wind, solar, geothermaland biomass power energies. In case of making proper investments and achieving new technologies, optimal opportunities can be provided. By imposing green tax on the air pollutant sectors, the GDP index undergoes a decrease. According to the fact that Iran's economy is dependent on oil, the goods and services production are reduced through establishment of a green tax system on the energy carriers, hence, the GDP is reduced by 0.03. So, the government should accept thisfact that the CO_2 emission is reduced by imposing green tax on the pollutants. However, due to the high preliminary costs and final prices of producing energy-consuming goods causing larger pollution, insufficient investment brings about an intensive reduction in production and GDP followed by suffering lower government incomes. Therefore, the oil exporting countries should have specific programs and strategies and make greater investments on higher levels of production and consumption based on renewable energiesIt can be argued that taxation is a control tool influencing such monopoly control as well as on investment and savings.

Carbon dioxide emission is reduced with the imposition of green tax along with allocation of efficiency levels due to the use of modern production technologies. The scenario of imposing tax on carbon along with the technical progress of 15% tax on carbon.

The increased value of carbon taxes on agriculture sector does not change the carbon footprint of this sector, but reduces carbon production about 11 % ($ 11 million). The production of carbon in the oil sector has also dropped about 6%. The carbon tax rate has no effect on the economy and energy consumption under the current status of affairs. Price of pm in various sectors, such as agricultural commodity prices, was increased by 8%. Coal prices were increased by 10%. The shift in carbon production in the agricultural sector is not due to the fact that production in thissector is not carbon-based, and therefore the carbon tax will not influence this sector. According to the changes in the prices of the goods and services and the final demand structure, the imposition of tax on carbon can contribute to the inflation So that, the consumption demand was reduced and the consumer price index that somehow indicates inflation was increased in all of the scenarios. Considering the reduction in the workforce under the current circumstances, the use of advanced technologies leads to an increase in the economic production in industrial sectors. The welfare scales used herein are EV equivalent changes. It is a monetary scale that uses the amounts of money spent before and after a shock, instead of the costs incurred before and after shock, to compare the consumer's optimality levels. EV welfare effect compares the income changes needed by the consumers to reach a new level of optimality in the prior prices. Positive EV welfare results indicate welfare gains and negative results thereof reflect welfare losses (Berfisher 1995). Positive EV welfare index found herein signifies the increase in the welfare condition in Iran. According to Table 6, the imposition of tax rate in various

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scenarios and its effects on the amount of social welfare of the whole society demonstrate that the social welfare is increased seminally and then is decreased by 457.93 through the imposition of a 20 % tax rate.

Table 4. Carbon dioxide emission rates with the imposition of green tax and allocated efficiency.

	Agr	Coal	Oil	Gas	Food	TWWL	petro	metal	mvo	Oil_pcts	Electricity	serv
CO_2	--	-10.73	-5.95	-30.56	--	--	--	--	--	-0.68	--	--
	--	-5.12	-24.01	-29.39	--	--	--	--	--	10.1	--	--
Gco2pm	2.83	10.98	11.81	109.17	0.78	1.53	8.05	6.96	4.94	5.44	3.63	14.66
Gco2pd	4.28	-17.44	10.06	-38.32	7.58	14.75	15.36	13.48	15.8	12.77	14.54	11.74
Gco2gm	11.55	10.09	12.76	9.97	9.08	5.16	10.11	8.13	6.17	5.23	4.85	13.21
co2pd	0.26	38.45	0.54	91.68	0.46	0.49	1.59	0.16	0.2	--	4.05	0.53

Table 5. Carbon dioxide emission rates.

Tax Type Scenario	coal	oil	gas	oil_pcts
5 % green tax	-10.73	-5.95	-30.56	-0.68
Green tax+ production technology	-5.12	-24.01	-29.39	10.1
Production technology	5.44	-13.27	2.27	10.88
15% green tax	-18.65	-10.28	-52.66	-1.54

Table 6. Carbon tax scenario plus technical progress.

	1 Agr	2 Coal	3 Oil	Gas	Food	TWWL	petro	metal	mvo	Oil _ pcts	Electricity	serv	
Pg	-0.31	12.81	0.26	3.13	-1.78	-2.6	-0.8	-1.65	-1.92	-1.87	-3.34	1.2	0.22
Pm	0.82	9.53	10.37	9.91	-5.96	-0.66	1.86	0.26	-0.18	-2.66	-3.57	-2.08	-1.93
pm_ir	-0.08	-0.07	-0.04	0	-0.07	-0.07	-0.07	-0.07	-0.07	-0.04	-0.06	-0.07	
Pwu	-0.08	-0.07	-0.02	0.14	-0.09	-0.08	-0.08	-0.08	-0.08	-0.07	-0.09	-0.07	
Ps	-0.66	1.86	0.26	-0.18	-2.66	-3.57	-2.08	-1.93	-2.61	-3.91	-3.57	1.29	-4.63
Qgm	11.55	10.09	12.76	9.97	9.08	5.16	10.11	8.13	6.17	5.23	4.85	13.21	
Qow	0.04	-0.02	0.07	-0.08	0.04	0.01	0.01	0.03	0.04	0.1	0.1	0.04	
Qo	3.42	0.47	0.63	-19.96	6.88	13.15	8.8	8.69	17.78	11.64	11.73	8.78	21.07
Vdem		8.93	6.67	7.41	7.74	7.43							
Vxwcom	-0.07	-0.1	-0.13	0.88	-0.08	-0.07	-0.07	-0.05	-0.06	-0.02	0	0	
						15 % tax on carbon							
Pg	0	24.18	-0.23	6.24	-0.11	0.3	0.27	0.25	0.01	3.81	3.74	-0.27	
Pm	-0.02	-0.72	-0.23	-1.96	-0.18	0.42	0.75	0.29	0.01	-0.05	4.03	-0.29	
Ps	-0.02	-0.72	-0.23	-1.93	-0.18	0.42	0.75	0.29	0.01	-0.05	4.03	-0.29	
Qo	-0.03	-0.92	0.67	-10.13	0.12	-1.19	-2.23	-1.04	-0.83	-1.28	-2.56	-0.13	
Vdem		-0.67	-1.51	2.48	1.93	1.88							
Vxwcom	0.01	0.02	0	1.68	0	0.01	0.01	0.01	0.01	0	-0.02	0	
Qow	0	0.01	0	-0.17	0	0	0	0	0	0.01	-002	0	

Table 7. Equivalent variation, $ US million.

			Increase	Increase	scenarios
	20%	**15%**	**10%**	**5%**	
equivalent variation, $ US million	457.93	547.63	447.11	394.72	Iran
regional EV computed in an alternative way	-180.33	175.51	429.96	395.04	

From economical perspectives, it can be observed that the insertion of the temporal value of money along with inflation in bioenvironmental pollutants' dispersion considerations at the same time and with simultaneous

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implementation of scenario of tax on carbon and its concomitant allocation efficiency is another aspect of these models' expansion. Temporal value of money has not been considered in the studies carried out in this regard. As it can be seen considering the positive effect of money value by executing green tax scenario in the Table, the temporal value of pollution money in coal sector is reduced by -0.19%; the effect of the money value for energy carriers on oil by -0.67 and the percentage of reduction is equal to -0.1 generally in contrast to the other countries. The amount of gas pollutants is equal to 1.36% that is indicative of the lowest effect amongst the other sectors.

Table 8. Money value of energy usage at agent's prices.

Vdem	1 IRN	2 ROW
Coal	-0.19	0.01
Oil	-0.67	-0.01
Gas	1.36	0
Oil_pcts	1.05	0
Electricity	1.18	0

Conclusion and Recommendations

The general multiregional equilibrium model (GTAP-E) has been drawn on 2017 database and it includes four energy sectors, namely coal, petroleum, gas and oil products as well as four regions in Iran. The analysis of the data was conducted based on GTAP software outputs. The carbon tax rate exhibited no effect on the economy and energy consumption under the current status of affairs. According to the changes in the prices of the goods and services and the final demand structure, the imposition of tax on carbon can contribute to the reduction in the inflation, hence, the consumption demand is reduced and the consumer price index that somehow indicates inflation, is upraised in all of the scenarios. Considering the reduced workforce under the current circumstances, the use of advanced technologies leads to an increasedeconomic production in industrial sectors. Economic production has not reached a level in Iran such that can cause reduced bioenvironmental pollutants emission. Based thereupon, as shown in Table 1, employing electricity in a standard method is followed by the least emission of greenhouse gases compared to the other business fuels. Due to the low awareness regarding the bioenvironmental problems in the preliminary stages of the economic growth, it is not so much important to pay attention to the environmental problems and the environmentally-friendly technology which is not available. Thus, the destruction of the environment is increased in line with the increase in the GDP income. However, a gradual deterioration in the environment has occurred in higher stages of the growth through creating structural changes, increasing bioenvironmental awareness, implementing bioenvironmental regulations and making efforts in line with creating superior technologies followed by improvedenvironmental quality. The immethodical use of fossil fuels not only is deemed as a threat to the future uses but it is also known to have adverse effects on the environment and this has to be taken into account by the statesmen as a critical issue.

REFERENCES

Burniaux, Jean-Marc, Truong, Truong 2002, GTAP-E: An Energy-Environmental Version of the GTAP Model.

Boqiang, Lin, Zhijie Jia 2018, The energy, environmental and economic impacts of carbon tax rate and taxation industry: A CGE based study in China. Energy, 2018.06.167.

Borischer, M 1955, An Introduction to Calculable General Equilibrium Models (Text in Persian) Fatemeh Bozazan and Maryam Soleimani Movahed 2013, Tehran: Publishing Nayer Ney.

Dong, HJ, Dai, HC, Dong, L, Tsuyoshi Fujita, Geng, Y 2015, Pursuing air pollutant co-benefits of CO_2 mitigation in China: a provincial leveled analysis. *Applied Energy*, 144: 165–174.

Pearson, K & M, Horridge 2005, Hands-on Computing With Run GTAP and WinGEM to Introduce GTAP and GEMPACK, GEMPACK Center: 58.

Fu, R 2011, Technical and economic analysis on the new emission standard of air pollutants for thermal power plants. Energy Technol. *Econ*, 23: 56-60.

Mousavi, SN, Mozaffari, Z, Motamed, MK,"The effect of higher fuel price on pollutants emission in Iran" *Caspian J. Environ. Sci*, 2018, Vol. 16, No. 1, pp. 1~11

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He, YX, Zhang, SL, Yang, LY, Wang, YJ, Wang, J 2010, Economic analysis of coal price-electricity price adjustment in China based on the CGE model. Energy Policy (38), 6629–6637. https://www.gtap.agecon.purdue.edu/resources/res display.asp?Record ID = 923.

Lin, BQ, Jia, ZJ 2018, Impact of quota decline scheme of emission trading in China: A dynamic

Lin, BQ, and Li, AJ 2012, Impacts of removing fossil fuel subsidies on China: How large and how to

Liu, Y, Lu, YY 2015, The Economic impact of different carbon tax revenue recycling schemes in China: a model-based scenario analysis. Appl. Energy (141), 96–105.

Mahmoodi 2017, Oil price reduction impacts on the Iranian economy Zb. rad. Ekon. fak. Rij, 35: 353-374.

Mahmoodi, A 2015, “Global trade analysis project”. Islamic Azad University, Tehran, Iran.

mitigate? Energy, 44: 741-749.

Purdue University Purdue e-Pubs recursive CGE model. Energy, 149, 190-203. energy.

Technology Management Co. and the Tehran Stock Exchange.

Ziaee 2013, Construction and application of multiregional computable general equilibrium model of Iran. Thesis Submitted for Fulfil the Degree of Ph. D. (Agricultural Economics) January 2013.

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اثر انتشار آلاینده‌ها بر متغیرهای کلان اقتصادی براساس مدل تعادل عمومی چند منطقه‌ای (GTAP-E)

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چکیده

در این مطالعه با استفاده از روش تعادل عمومی چند منطقه‌ای GTAP-E اثر انتشار آلاینده‌ها و تغییرات آلاینده دی اکسید کربن،GDP، رفاه و تورم در غالب سناریوهای مالیاتی به همراه پیشرفت فنی بخش‌های زغال سنگ،نفت، گاز و فراورده‌های نفتی ارزیابی شد. نتایج نشان می‌دهد در مورد مالیات کم کربن ۵٪، تولید ناخالص داخلی تقریبا بی‌تاثیر خواهد بود. با افزایش نرخ مالیات کربن، احتمال افرایش تولید ناخالص داخلی، افرایش مصرف انرژی،کاهش تورم و افرایش رفاه اجتماعی را در پی نخواهد داشت و قادر به کاهش شاخص آلاینده زیست محیطی نبوده ولی سناریو افزایش کارایی تخصیصی به همراه پیشرفت تکنولوژی در جهت خلاف انتظار و در جهت کاهش انتشار آلاینده‌های زیست محیطی و رشد GDPگردید. که منجر به افزایش درآمد مالیاتی دولت می‌گردد. در حوزه انرژی نیز توصیه می‌گردد ایران میزان تولید دی اکسید کربن خود را نسبت به آنچه در حال حاضر تولید می‌شود را کاهش دهد. که با اعمال سیاست افزایش مالیات در بخش انرژی می‌توان سرعت انتشار آلاینده‌ها را کاهش داد.

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