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Economic Instruments for Reducing CO_2 Emmissions and their Consequences

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ABSTRACT

This contribution is an economic evaluation of various combinations of economic instruments for reducing CO_2 emissions. The evaluation of effects linked to the achievement of Kyoto and post-Kyoto goals was developed by using the GEM-E3 general equilibrium model as developed within the framework of the 5. and 6. EU OP (project ENG2-CT-1999-00002). We are calculating the effects of varying environmental policies for Slovenia based on variations in key macroeconomical markers. The most important finding is, that the loss of competitive advantages for Slovenia due to enforced environmental protection measures is not sizeable. The most favorable scenario in macroeconomic terms is the scenario of emissions trading in energy intensive sectors with a gradual transition to auctioning and carbon taxation in other sectors, whereby the tax revenues are returned to reduce the rate of social security contributions.

Key words: Emission trading, carbon tax, general equilibrium model

JEL: Computable General Equilibrium models (C68)

1. Introduction

The issue of anthropogenic emissions of carbon dioxide is in times of economic crisis somewhat less topical due to automatically reduced emissions from reduced economic activity and reduced consumption, yet it remains a priority due to ambitious post-Kyoto goals. The reason behind the strive for a solution is not limited to alleged greenhouse effects of carbon dioxide emissions. There is also the massive dependence on oil-based resources, particularly due to population increases, and also the lowering of air quality due to other energy-bound emissions. In this sense, certain transnational external impacts occur, which render unilateral national actions or even actions of individuals utterly ineffective. This leads to a need for concluding voluntary international treaties and agreements. Emissions of greenhouse gases fall into the group of environmental externalities, which can realistically be addressed and where intervention makes economic sense. That is why the European Union adopted a decision concerning the trade of carbon dioxide emissions (Directive 2003/87/EC), as was foreseen by the Kyoto protocol (1997). Additions and corrections of the trading system are included in the Climate Action and Renewable Energy Package, adopted by the European Council in early 2007. At the same time individual countries are deciding on additional measures at the local level, mostly in the form of economic instruments for reducing greenhouse gas emissions. Such activities require changes in manufacturing patterns in the sense of new technologies and substitution of fuels on one side and changes in consumer habits - such as shifting towards sparing use of energy - on the other. The aims are therefore not to be met through reducing production and consumption, as is the case in these times of crisis, but rather through altering the patterns of production and consumption. Nevertheless, the enforced environmental measures do influence or alter macroeconomic aggregates - gross domestic product, employment, consumption, investments, import, export, industry structure and others. We are thus dealing with changes in the most important macroeconomic aggregates and changes in the energy and processing sectors. Such complex alterations of the economy and society can be painful, so it is essential that actual decisions made to environmental policies are based on accurate estimates of the positive and negative aspects of the process. An accurate analysis of such projects can be achieved by the use of corresponding quantitative tools as otherwise necessary partial analyses cannot be used to accurately appraise the complex interconnected effects at an aggregate level.

The aim of this contribution is the acquisition of that quantitative information with the purpose of evaluating environmental policies and choosing the appropriate combination of economic instruments to minimize the environmental burden of Slovenia under EU policies while allowing for maximum economic and environmental prosperity in the given circumstances. A rational choice of political instruments can protect the competitiveness of the economy while at the same time increasing social and environmental sustainability.

The evaluation of the effects of achieving Kyoto goals and goals of the Climate Action and Renewable Energy Package on the Slovenian economy, which is presented in this article, was developed using a CHE model, namely the GEM-E3 model *(General Equilibrium Model for Energy – Economy – Environment*) on an application for analyzing energy-environment policies (TECH-GEM-E3). The model was originally developed as a multinational project under the 5th and 6th EU framework program and has been appropriately extended and adjusted for our purposes.

The following article is divided into three parts. The first chapter details the functioning of the GEM-E3 model and lists its basic characteristics and its use. The second chapter contains results of the simulations. Its first part consists of a description of the reference and environmental scenarios and the second part shows the effects of environmental policies in the form of changes to macroeconomic markers. The chapter is closed with an interpretation of the results. Key results, limitations of the used method and suggestions for improvements are listed in the conclusion.

2. Modeling macroeconomic effects of policies for reducing CO_2 emissions in the GEM-E3 model

An ever increasing political interest in greenhouse issues has spurred on the discoveries of numerous empirical models for analyzing the interaction of the economy and environment. In their works, Nordhaus (1994), Jorgenson and Wilcoxen (1990), Manne and Richels (1997), Blitzer and Eckaus (1986), Bergmann (1988 in 1991), Proost and Van Regemorter (1992) and others focus on the economic consequences of reducing carbon dioxide emissions by using carbon tax. Facing such a political challenge demands the assurance of consistent observance of interconnections between the economy, energy system and carbon dioxide emissions.

The integral GEM-E3 model was devised under the sponsorship of the European Commission (DG-Research) in an international consortium of the following institutions: CES KULeuven, NTUA, ZEW and ERASME, BUES and PSI (Research Project ENG2-CT-1999-00002)[1]. For our purposes we used its single county version and adapted it accordingly. It is a calculable model of general equilibrium (CGE), based on a single base year (2000), where the economy is supposed to be in a state of equilibrium, and a social accounting matrix (SAM), which assures the consistency of the data the system works with. The model listing and calibration reproduce base year values in the SAM matrix and calculate missing parameters. The model is based on the behavior of companies and individuals micro theory and optimizes the benefits of individual subjects with non linear programming with additional conditions. It devises separate subject behaviors on the supply side and the demand side, which are considered separate in their optimization of individual goals, while market oriented prices guarantee equilibrium. The model simultaneously calculates competitive equilibrium under Walras' law and an optimal balance of supply and demand of energy and reducing emissions[2]. The model explicitly takes into account the mechanism of "market purging" and its influence on prices in the energy, environment and economy markets. Prices in the model are calculated as a result of interactions between market supply and demand and various market purging mechanisms.

The model designs production technologies in an endogenous manner by enabling a price-driven extrapolation of intermediate supply and demand of capital and labor. On the side of demand, the behavior of consumers is devised on the basis of a nested Stone Geary utility function. Behaviour of consumers is based on time model with two stages. On the first stage consumers every year decide on allocation of resources between current and future consumption and free time. Decision is based on maximization of satisfaction function during the whole life cycle, which is determined by available resources.

1 NTUA: National Technical University of Athens; CES KULeuven: Centre for Economic Studies, KULeuven, Belgium; ZEW: Environmental and Resource Economics, Environmental Management, Centre for European Economic Research, Deutschland; ERASME: Ecole Centrale Paris; BUES: Budapest University of Economic Sciences, Hungary; PSI: General Energy Research, Paul Scherrer Institute, Switzerland.

2 Walras law: the sum of expenses is always equal to the sum of revenues and the sum of excess demands is always zero, regardless of prices.

The assumption of the model is that consumers spend all their resources during lifetime. On the second stage consumers divide their resources among lasting (equipment) and consumable goods and services. The model is dynamic and is run by accumulation of capital and equipment. Technological progress is explicitly included via production functions for each separate production factor.

In the environmental module the model takes into account energy--bound emissions (CO_2, NOX, SO_2, VOC, PM), which can also be transformed into concentrations or dumped pollutants, whereby the incurred damage is monetized through appropriate functions. The model calculates the prosperity effects of various environmental policies, such as vouchers, taxes, standards, and also considers various options of returning tax revenues into the economy/society (CES KULeuven and NTUA, 2002a).

2.1 Basic characteristics of the GEM-E3 model

The model is based on four key characteristics. The first is the modular development of the model around a central core of general equilibrium, so that various options of modeling, market regimes and closing rules are supported by the same model specification. The second defining characteristic are entirely flexible (endogenous) coefficients of production and consumption. The following characteristic is the calibration of series of data for the base year, including the Social Accounting Matrix. The final characteristic is a line of dynamic mechanisms, which function through the accumulation of capital stores.

Following the example of the World Bank models, GEM-E3 is based on SAM matrix and explicitly shapes the equilibrium of supply and demand. The technical coefficients of production and demand are flexible in the sense that manufacturers are able to change the structure of their production, not only in terms of production factors but also in terms of intermediate products. Production is modeled by KLEM - the production functions of capital, labor, energy and material. At the same time, consumers define the structure of their demand for goods and services. Their consumption combination is defined through a variable structure of expenses for durable and consumable goods. Specifications of manufacture and consumption follow Leontief[3] type generalized models. The model is limited to a comparatively static valuation of policies while it is dynamic

3 The Leontief model is based on the premise that each item of goods may only be produced by one production method. This equals the premise that all production factors are limited. A generalized Leontief model does away with this limitation.

in the sense of influences of a certain shock - in this case an environmental measure - in varying periods of time.

The model is calibrated to datasets (SAM matrix) of the base year 2000. Consumption and investments are created around transitional matrices which link consumption of purpose to demand for goods and investments by source of investment with investments by purpose. Total consumption (final and intermediate) is optimally allocated among local and imported goods on the premise, that they are incomplete substitutes[4].

Institutional regimes which influence the behavior of economic subjects and the search for market equilibriums are explicitly modeled, including public finance, taxation and social policies. All the instruments of common politics, which influence the economy, energy and environment are included. The model represents total competition, capital mobility between sectors and fixed labor offer. It does however support the definition of alternative regimes and rules of closure without repeated specification or calibration - these are (i) flexible or fixed current accounts and (ii) fixed or flexible public deficit[5].

The internalization of environmental externalities is carried out through taxation, emission trading or enforcement of technical standards, all of which influence the decisions of economic subjects. Consequences of the presumed environmental scenario are measured by estimating the effect on the welfare of the consumer or an equivalent change of the function of consumer welfare, which is directly linked to one of the endogenous variables (consumption, employment, rate of costs) (CES KULeuven and NTUA, 2002c).

2.2 Use of the model

The model utilizes EUROSTAT databases (IO table, data on national accounts and energy balances), UNFCCC database (*United Nations Framework Convention on Climate Change*) for CO_2 emissions, data on emission coefficients of other energy-bound emissions is gathered from the ExternE project (EC, 1997 and 2000) and some other parameters are either econometrically estimated or gathered from literature (i.e. substitution elasticity of labor and capital).

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4 Armington premise: the elasticity between local and imported goods is arbitrarily small.
5 Rules of model closure define the manner in which supply and demand for goods, macroeconomic identities and factor markets balance each other.

The model takes into account four types of economic subjects, namely households, companies, the state and the foreign sector. Furthermore, the model includes the following categories of public income: indirect and direct taxes, VAT, energy and environment taxes, real-estate tax, capital tax, social security contributions, manufacturing grants, import charges and duties, transfers with the foreign sector, income from state-owned companies. Labor and capital are treated as the basic factors of production.

The model distinguishes 18 sectors: farming, energy (solid fuels, crude oil and refined oil products, gas, electric energy), processing (ore mining and production of metal and non-metal mineral products, production of chemicals and chemical products, production of energy intensive products, production of electrical equipment, production of consumer goods), construction, telecommunications, transport, financial intermediation and insurance, other market services and non-market services. Accordingly, the SAM matrix must be prepared in a manner which separates 4 energy sectors, 14 non-energy sectors and labor and capital which are characteristic for individual sectors (CES KULeuven in NTUA, 2002a). Table 1 displays sectors in a model of general equilibrium.

Table 1: CGE sectors

Sektor	CGE 18	NACE	SKD
Agriculture	1	010	A1+A2+B5
Solid fuel	2	060/031+033+050	CA10
Oil and gas	3	060/071+073	CA11+DF23
Natural gas	4	060/075+098	-
Electricity	5	060/097+110+099	CA12+E40
Mining and quarrying	6	130	CB13+DJ27
Manufacture of chemicals	7	170	DG24
Other energy intensive production	8	150+190+470	CB14+DE21+DE22+DI26+DJ28
Manufacture of electrical equipment	9	250	DL30+DL31+DL32+DK29(77%)
Manufacture of transport equipment	10	280	DM34+DM35
Manufacture of other equipment	11	210+230	DK29(23%)+DL33
Manufacture of consumption products	12	360+420+490+480	DA15+DA16+DB17+DB18+DC19+DD 20+DH25+DN36+DN37
Construction work	13	530	F45
Telecommunications	14	670	I64
Traffic	15	610+630+650	I60+I61+I62+I63
Financial intermediation and insurance	16	690	J65+J66+J67
Other market services	17	560+590+740	G50+G51+G52+H55+K70+K71+K72+ K73+K74+090
Non-market services	18	860	L75+M80+N85+091+092+093+E41

Source: CES KULeuven in NTUA: Annex: The GEM-E3 Model and User's Documentation, 2002.

The following procedures were executed for our results:

- Simulation of Operative Program for Reducing Greenhouse Gases in a Reference Scenario (Ministry of the Environment and Spatial Planning, 2003).
- Establishment of procedures for reducing emissions up to 2030, namely: Kyoto emissions to be reached until 2010; from 2010 to 2020 energy intensive sectors maintain Kyoto levels while others may increase up to 4% compared to 2005 levels; after 2020, the scenario of environmental politics is geared to maintain an absolute difference between reference and scenario emissions.
- Choice of instruments for reducing emissions in environmental scenarios.
- Gradual transition to auctioning of emission licenses - half in 2010 and fully in 2020.
- Annuity for freely distributed coupons in the beginning of the monitored period is transformed into profits for manufacturers.

3. Simulation results

3.1 Description of reference and environmental scenarios

The reference scenario (*Business as usual*) brings a consistently general evolution of economic activities with given exogenous premises of the main driving forces and represents a benchmark for comparing different environmental scenarios. Exogenous premises in the reference scenario are as follows: technical progress, bound to individual production factors, global sector growth, prices of fuels, investments, public consumption and population. Global and European growth and global energy prices are based on the propositions of CEPII (Croissance economique mondiale: un scenario de référénce à l'horizon 2030, N. Kousnetzoff, J. Gene tet S. Fahr) for POLES and the results of POLES for DG_TREN Energy Projections. Population growth forecasts are based on Eurostat. Endogenous variables of the model include production and export on the supply side and intermediate, private, public, investments and export (quantities by sector), resources and consumption of energy, material, labor and capital on the demand side. The model also calculates the prices of local production, export, import and changes in primary factor incomes for each individual sector (average labor costs and average capital yields) (CES KULeuven, 2002b). The European Commission scenario is the original scenario being performed in the integral version of GEM-E3 model for all European countries. Our reference scenario also foresees moderate GDB growth rates according to EC forecasts, ranging from 2,3% in 2010 to 2% in 2030. Furthermore, our reference scenario uses technical progress in the field of energy, materials and motor fuels to simulate the Operational program of reducing emissions TGP 2008-2012, which forecasts a reduction of emissions by 3.812 kT of CO_2 with additional measures.

As mentioned previously, the key purpose of CGE models is to compare a reference scenario with various defined scenarios, in our case those concerning the environment. Environmental scenarios are based on reducing emissions by including energy intensive sectors into a system of emission trading and reducing emissions by enforcing a carbon tax in other sectors, an exception being the technical standard scenario. Also, emissions are reduced due to technical progress and a generally reduced output, but increased due to the foreseen moderate economic growth. We are monitoring net emissions.

The path towards reducing emissions in environmental scenarios is defined in such a way as to achieve Kyoto goals by 2010, increase emissions in non-trading sectors by 4% by 2020 in accordance with Climate Action and Renewable Energy Package (2008), while trading sectors maintain their Kyoto levels and an absolute difference of total emissions between reference and environmental scenario from 2020 being maintained until 2030. We are concentrating only on those executed simulations, which consider a gradual transition from 100% freely distributed coupons to 50% free coupons in 2010 and auctions in 2020.

3.2 Macroeconomic effects of environmental policies

Table 2 displays results relevant to the comparison of environmental scenarios to the reference scenario of the EC (annual percentage variations). The environmental scenario is a combination of local carbon tax and emission trading with the option of using tax revenues from sectors excluded from emission trading for (1) reducing the rate of social security contributions (ECMASSR marking in the table), (2) increasing social receivables of households (ECMAISB marking in the table) and (3) reducing public deficit (ECMARPD marking in the table).

When coupons are distributed freely, the acquired annuities are transformed into company revenues (more likely option) or they reduce prices, which is less likely, particularly in short term. That is why table 2 only displays the results of simulations carried out using the first option. Interpretations of following results pertain to 2020.

Table 2: Macroeconomic indicators change

% change to reference scenario, except at *

Macroeconomic aggregates	ECMASSR 2010	ECMASSR 2020	ECMASSR 2030	ECMAISB 2010	ECMAISB 2020	ECMAISB 2030	ECMARPD 2010	ECMARPD 2020	ECMARPD 2030
GDP	0,02%	-0,01%	-0,07%	-0,25%	-0,28%	-0,20%	-0,05%	-0,08%	-0,15%
Employment	0,27%	0,21%	0,04%	-0,24%	-0,22%	-0,12%	0,05%	0,02%	- 0,03%
Private consumption	-0,06%	-0,07%	-0,02%	-0,23%	-0,25%	-0,13%	-1,64%	-1,50%	-0,62%
Investments	-0,22%	-0,24%	-0,15%	-0,31%	-0,34%	-0,23%	-0,40%	-0,46%	-0,31%
Final consumption of energy	-6,23%	-6,44%	-3,16%	-6,28%	-6,50%	-3,20%	-6,42%	-6,66%	-3,28%
Export	-0,41%	-0,40%	-0,31%	-0,77%	-0,72%	-0,45%	0,65%	0,54%	0,01%
Import	-0,56%	-0,57%	-0,28%	-0,70%	-0,66%	-0,35%	-0,79%	-0,73%	-0,40%
Real labour cost	0,85%	0,66%	0,13%	-1,04%	-1,03%	-0,55%	-1,62%	-1,53%	-0,77%
Relative consumer prices	0,89%	0,75%	0,18%	1,07%	0,91%	0,25%	0,24%	0,15%	-0,02%
Real interest rate	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Exchange conditions	0,18%	0,21%	0,24%	0,36%	0,39%	0,32%	-0,36%	-0,31%	0,04%
Public finance suficit (% GDP)*	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,96%	0,83%	0,30%
Balance of payments (% GDP)*	0,21%	0,19%	0,09%	0,16%	0,16%	0,09%	0,74%	0,67%	0,28%
Emissions									
CO_2 emission	-8,49%	-9,72%	-6,67%	-8,49%	-9,72%	-6,67%	-8,49%	-9,72%	-6,67%
NOX emission	-7,09%	-8,07%	-4,87%	-7,13%	-8,12%	-4,89%	-7,12%	-8,11%	-4,91%
SO_2 emission	-3,60%	-5,77%	-7,17%	-3,68%	-5,86%	-7,22%	-3,57%	-5,70%	-7,16%
VOC emission	-5,25%	-5,19%	-2,41%	-5,33%	-5,29%	-2,47%	-5,64%	-5,60%	-2,61%
PM emission	-5,42%	-6,75%	-6,29%	-5,46%	-6,80%	-6,33%	-5,82%	-7,18%	-6,49%
NH_3 emission	-0,32%	-0,29%	-0,06%	-0,46%	-0,45%	-0,16%	-0,46%	-0,52%	-0,25%
Environment policy									
Taxes on energy (% GDP)*	-0,09%	-0,08%	-0,02%	-0,09%	-0,08%	-0,02%	-0,09%	-0,08%	-0,02%
Environmental taxes (% GDP)*	0,92%	0,78%	0,35%	0,91%	0,77%	0,35%	0,88%	0,75%	0,34%
Social security contributions decrease*	2,35%	2,01%	0,73%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Increase in social security revenues	0,00%	0,00%	0,00%	22,86%	25,60%	12,19%	0,00%	0,00%	0,00%
CO_2 MAC (Euro00/tn CO_2)	27,26569	25,45721	9,50419	26,80140	25,00035	9,31805	26,16373	24,26913	9,02591
Welfare									
Economic welfare	-0,23%	-0,29%	-0,05%	-0,05%	-0,08	-0,03	-1,50%	-1,33%	-0,51%

Environmental measures lead to an increase of the costs of energy intensive inputs and production prices in most sectors. These increases are to a certain extent transferred onto consumers through price elasticity, so relative prices of consumer goods are increased by 0.75% (in 2020), leading to slight decreases in consumption (0.07%), investments (0.24%) and GDP (0.01%). These are indeed only small changes and they are brought about also by the following concurrent process. Environmental revenues are directed towards reducing social security contributions (2,01%), so individuals have more funds at their disposal and are able to realistically purchase more (real price of labor is increased by 0.66%), thus increasing consumption. At the same time, employment is increased by 0.21%. This mechanism of returning tax revenues thus partially compensates reduced consumption and investments, leading to a lesser reduction in comparison to a scenario where tax revenues are used to increase social transfers to households (consumption: -0,25 % or investments: -0,34 %). Increased energy costs lead to a deterioration of the terms of trade (TOT= export prices/import prices, 0.21%) and a reduction of export (-0.40%). The energy tax as part of the GDP is reduced (-0.08%) due to increased energy efficiency (reduced energy consumption per GDP unit, reducer energy consumption by 6.44%). Marginal costs of reducing emissions stand at approximately 25 EUR/ton of CO_2 with the costs of reducing emissions at 0.78% of GDP. Variations in other non-greenhouse emissions are a result of comparing emissions in the reference script (using emission coefficients from ExternE) and emissions in the Kyoto scenario with assumed energy efficiency. The economic welfare of individuals is reduced more if the environmental tax revenues are used to reduce social security contributions than if they were used to increase the social receivables of households (-0.29%), since the compensation of costs of reducing emissions or raised prices by reducing the contribution rate (indirect) is lower than compensation by transfers (direct). The current account of the balance of payments (as GDP share) is increased (0.19%). The surplus of private savings due to decreased investments must be transferred abroad (with equal public deficit) into exports, which experience a lesser decrease than imports. Marginal costs of reducing emissions are reduced due to the effects of energy efficienca and lowered projections of economic growth in subsequent periods, upon maintaining the absolute difference between reference and scenario emissions after 2020. This means that environmental goals become easier to realize. In 2030 costs of reducing emissions reach an annual level of about 9 EUR/ton of CO_2 or 0,35% of GDP. As tax revenues from environmental tax are also reduced, an ever decreasing amount of funds is transferred into reducing social security contributions thus equally reducing the influence on employment rates.[6]

In the scenario containing an increase of social receivables of households, the carbon tax and emission trading in 2020 lead to an increase of the relative prices of consumer goods, namely prices with tax, of 0.91% (more than the previous scenario) leading to a reduced purchasing power of individuals (actual price of labor is reduced by 1,03%), reduced consumption (-0.25%), investments (-0,34%) and GDP (-0.28%). Export and import are also reduced (-0.72% and -0.66% respectively). Terms of trade are reduced (0,39%). At the same time, social receivables are increased by a healthy 25% compared to the reference scenario, thus reducing the economic welfare of individuals by a mere 0.08%, less than in the previous scenario (-0.29%), thus constituting a lower compensation of the major costs of reducing emissions or increased prices. The energy tax as part of the GDP is reduced (-0.08%) due to increased energy efficiency (reduced energy consumption per GDP unit, reducer energy consumption by 6.50 %). Marginal costs of reducing emissions stand at approximately 25 EUR/ton of CO_2 with the costs of reducing emissions at 0.77 % of GDP. The current account of the balance of payments (as GDP share) is increased (0.16%) due to increases in private savings, which is compensated with the balance of the current account, Environmental welfare is increased on a scale similar to other scenarios.

In the scenario where environment tax revenues are used to reduce public deficit, the economic welfare is reduced most of all scenarios (-1.33% in 2020) as households do not participate or compensate for increased energy costs. Environmental measures lead to an increase in relative prices of consumer goods (0.15%, least of all scenarios due to export pressure and lowering of prices) bringing a reduction in the purchasing power of individuals (actual price of labor is reduced by 1.53%, the most yet, as there is no compensation for increased prices consumers are forced to pay), consumption is reduced (-1.50%) as are investments (-0.46%) and GDP (-0.08%). Meanwhile, another process is taking place: public deficit is reduced and is not compensated with the surplus of the public sector in the short term, because interest rates remain unchanged (i.e. current account of the balance of payments remains unchanged). However, the current account of the balance of payments is improved,

6 Environmental welfare, measured as reduction of monetarized damages due to concentration and sedimentation of primary and secondary pollutants, shall in 2020 be increased by 10% compared to environmental welfare in reference scenario.

as is export (0.54%) which generates employment (0.02%) and has favorable effects on GDP which remains largely unchanged. The positive effect of improvement of the current account of the balance of payments on export is therefore not compensated entirely with pricing effects on the local market, so this policy is in fact more expensive. The energy tax as part of the GDP is reduced (-0.08%) due to increased energy efficiency (reduced energy consumption per GDP unit, reducer energy consumption by 6.66 %). Marginal costs of reducing emissions stand at 24 EUR/ton of CO_2, namely the lowest, since the prices of investment goods are also lowest. The costs of deducing emissions represent 0.75% of GDP. Environmental welfare is increased on a scale similar to other scenarios.

If we compare the loss of competitiveness and reduction of welfare in used instruments, we can see that the loss of competitiveness is negligible. In 2020 the difference between GDP levels in reference and environmental scripts range from -0.01% GDP (scenario with the option of reducing social security contributions) to -0.28% (scenario with the option of increasing social revenues). Economic welfare is not reduced substantially in 2020 because of environmental measures. Reduction is limited to below 1%, except in the scenario with the option of reducing public deficit, where welfare is reduced by 1.33%.

Comparisons between environmental scenarios with taxes and trading show that from an individual's viewpoint it is better to see increases in social revenues (lesser decrease of economic welfare), while from the viewpoint of the economy it is better to direct environmental revenues towards reducing the rate of social security contributions as this leads to the least decrease in competitiveness. In the long term, the difference in economic welfare in both scenarios is reduced, thus setting the scenario of reducing contribution rates as the most favorable in macroeconomic terms.

4. Conclusion

Macroeconomic effects of policies for reducing CO_2 emissions, shown in this article, pertain to the single-country model, where model specifications are the same as in the integral model. End results may be somewhat overestimated due to the use of the single-country model. The first reason being, that emission trading in the EU market or even a global market generally reduces total economic costs in comparison to national trading, as in the first case trading is geographically more extensive and allows for more low-cost opportunities for reducing emissions than in case of national trading. The second reason for a slight overestimation of results is the fact that in an integral model, other countries would also be adopting environmental measures. In such a case, our terms of trade would not deteriorate as much. Nevertheless, the overestimate of costs is not great as Slovenia is a small country with relatively little emissions. We feel our results may be overestimated also, because we presumed greater economic growth rates for the EU than recent forecasts show. When our calculations were made, the recession was not yet as apparent as to cause thoughts of lowered economic growth. Though the model assumes that energy efficiency is increased with the dynamics of economic growth, economic costs of executing environmental policies are reduced in more pessimistic scenarios of economic growth. The reason lies in the fact that energy efficiency does not completely compensate increased emissions due to increased economic growth.

There are other reasons for possible overestimation of our results. When the calculations for this contribution were carried out, it was not yet clear what the demands of the latest Climate Action and Renewable Energy Package would be. Accordingly, we did not consider the fact that Slovenia is obliged to by 2020 reduce emissions in sectors included in the ETS system (emission trading system) by 21% in comparison to emissions in 2005 and we left the emissions at Kyoto levels. In this sense the model goal is more reachable than in real life, thus making the costs possibly underestimated.

The most important finding of our project is, that the loss of competitiveness in Slovenia is not great, since we (i) suppose increases in emissions with increases in economic growth, (ii) free distribution of coupons in initial stages of the monitored period brings revenues to energy intensive sectors, (iii) sectors are able to substitute energy intensive inputs from imports, (iv) increased energy costs are compensated by a form of green tax reform (recycling of tax revenues), (v) the price elasticity of demand for fuels is low, enabling manufacturers to transfer the burden onto customers and (vi) both manufacturers and consumers are adapting to the current state of affairs in order to realize their goals (maximize benefits). Other EU member states are also seeing only a moderate loss of competitiveness.

The most favorable scenario in macro economic terms is the scenario of emissions trading in energy intensive sectors with a gradual transition from freely distributed licenses to auctioning and carbon taxation in other sectors, whereby the tax gains are returned to reduce the rate of social security contributions[7]. In this way budget neutrality can be reached. The mechanism of returning tax revenues partly compensates for reduced consumption and investments due to increased fuel prices, thus making said reductions smaller in comparison to other scenarios. A slight reduction of GDP and economic welfare can be detected, as increases of private revenues are enabled through decreased losses in the export market. Although all sectors benefit from returns of tax revenues into reducing social security contribution rates, a much larger influence is seen in labor intensive sectors, thus also positively influencing employment.

Considering the fact that a declaration has recently been passed to support the use of assets gained at auctions, let us spare a few words to popular policies of achieving tax neutrality. For the purpose of our case, this means that all tax payments of a certain sector are returned to this sector. Bovenberg and Goulder (2001) have proved the ill effects of such policies, as they create high profits in carbon intensive sectors. The reason being, that carbon taxes are significantly greater that the reduction of manufacturers' surplus. Policies which include 100% free distribution of licenses or use the concept of tax neutrality (flat rate return of carbon tax payments) are most ineffective and generate greater profits in carbon intensive sectors. The most effective policies are those which return tax revenues through tax cuts for companies income tax or tax on wages, as well as those which reach equal neutrality values through distributing a lesser number of licenses (2 to 15%) (Proost and Van Regemorter, 2003). These theoretical findings correspond our results concerning the benefits of environmental scenarios.

Our results do not display environmental damage and welfare due to theoretical shortcomings, namely the supposition of linear damage per unit of emissions. Environmental damage cumulates over time due to increased irreversibility of damage to ecosystems and greater difficulties in repairs through environmental measures. Due to this characteristic irreversibility of existing environmental damage, environmental welfare is reduced with economic growth. Environmental measures may only reduce the rate of this reduction.

7 Other options include using tax revenues to increase social revenues of households or for decreasing the deficit in public finances. There is also the option of enforcing a technical standard for lowering emissions without economic instruments. Furthermore, there are a number of options for distributing coupons ranging from free distribution to immediate auctioning

In time, the reduction may become negative and the rate of results measured by the relative difference between welfares in the reference and political scenarios loses its true informational value. We experimentally also calculated environmental damages due to concentration and sedimentation and environmental welfare and established, that they are independent of the choice of political instrument. This leads us to the conclusion that it is sufficient to base environmental policies on assessments of relative changes to environmental welfare.

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Slabe Erker, Koman, Majcen
Economic Instruments for Reducing CO_2 Emmissions and their Consequences

POVZETEK

EKONOMSKI INSTRUMENTI ZA ZMANJŠEVANJE EMISIJ CO_2 IN NJIHOVE POSLEDICE

»Problematika antropogenih emisij ogljikovega dioksida je v času ekonomske krize po eni strani manj aktualna zaradi samodejnega znižanja emisij, ki izhajajo iz tokrat nižje gospodarske aktivnosti in tudi nižje potrošnje, po drugi strani pa ni nič manj aktualna, zaradi ambicioznejših post-kjotskih ciljev. Razlog za potrebno reševanje tega problema niso le domnevne toplogredne posledice emisij ogljikovega dioksida, pač pa še posebej velika odvisnost od naftnih virov, zlasti ob naraščanju števila prebivalstva in nenazadnje tudi zaradi vpliva drugih energetsko vezanih emisij na nižjo kakovost zraka. V tem smislu prihaja do nadnacionalnih eksternalij, kjer so unilateralne nacionalne akcije ali celo akcije posameznikov neučinkovite. Od tod izhaja potreba po sklepanju prostovoljnih mednarodnih sporazumov. Emisije toplogrednih plinov sodijo v tisto skupino okoljskih eksternalij, ki jih je realno mogoče reševati in je intervencija tudi ekonomsko upravičena. Zato je Evropska unija sprejela odločitev glede trgovanja z emisijami ogljikovega dioksida (direktiva 2003/87/EC), kot je predvideval že Kjotski protokol (1997). Dopolnitve in popravke sistema trgovanja pa vključuje Podnebno energetski sveženj zakonodajnih ukrepov, sprejetih na Evropskem Svetu v začetku leta 2007. Hkrati pa se posamezne države na nacionalni ravni odločajo za dodatne ukrepe, večinoma v obliki ekonomskih inštrumentov za zmanjševanje emisij toplogrednih plinov. Te aktivnosti terjajo v končni fazi po eni strani spremembo vzorcev proizvodnje, ki se nanašajo na primer na nove tehnologije ali substitucijo energentov in po drugi strani spremembo potrošniških navad, na primer glede varčne rabe energije. Ciljev torej naj ne bi dosegli z zmanjšanjem proizvodnje in potrošnje, kot se dogaja danes v času krize, temveč s spremembo vzorcev proizvodnje in potrošnje. Kljub temu pa sprejeti okoljski ukrepi vplivajo oziroma spreminjajo tudi makroekonomske agregate - bruto domači proizvod, zaposlenost, potrošnjo, investicije, izvoz, uvoz, sektorsko strukturo in drugo. Potemtakem imamo opraviti s spremembami zelo pomembnih makroekonomskih agregatov in s spremembami v energetskih in predelovalnih sektorjih. Proces tako kompleksnega spreminjanja gospodarstva in družbe je lahko boleč, zato je pomembno, da slonijo konkretne odločitve okoljske politike na ocenah njegovih pozitivnih in negativnih posledic. Analizo tovrstnih procesov omogočajo ustrezna kvantitativna orodja, saj

s sicer potrebnimi parcialnimi analizami ni mogoče oceniti kompleksnih medsebojnih učinkov na agregatni ravni.

Cilj tega prispevka je pridobitev prav teh kvantitativnih informacij, z namenom ovrednotenja okoljske politike in izbire tiste kombinacije ekonomskih inštrumentov, ki minimizira ekonomsko breme Slovenije v okviru evropske politike in hkrati zagotavlja največjo ekonomsko in okoljsko blaginjo v danih okoliščinah. Racionalna izbira političnih instrumentov namreč ščiti konkurenčnost gospodarstva ter hkrati povečuje socialno in okoljsko trajnost. Ocena učinkov, povezanih z doseganjem Kjotskih ciljev in ciljev Podnebno energetskega svežnja na slovensko gospodarstvo, ki so predstavljeni, je bila narejena z uporabo CGE-modela, to je GEM-E3-modela (ang. »General Equilibrium Model for Energy – Economy – Environment«) z aplikacijo za analizo energetsko-okoljske politike (TECH-GEM-E3). Model je bil sicer razvit kot multinacionalni projekt v okviru 5. in 6. okvirnega programa Evropske unije, za potrebe predstavljenih rezultatov pa je bil ustrezno dopolnjen in prilagojen. Z uporabo modela so bili izračunani učinki različnih okoljskih politik za Slovenijo kot spremembe temeljnih makroekonomskih kazalcev.

Najpomembnejša ugotovitev je, da zaradi sprejetih okoljskih ukrepov izguba konkurenčnosti za Slovenijo ni velika. Najugodnejši scenarij z makroekonomskega vidika je scenarij trgovanja z emisijami v energetsko intenzivnih sektorjih s postopnim prehodom na dražbo in z ogljikovim davkom v drugih sektorjih, pri čemer se davčni prihodek vrača za znižanje stopenj prispevkov za socialno varnost.