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ANALYSIS OF THE EFFECTS OF INTRODUCTION OF AN ADDITIONAL CARBON TAX ON THE SLOVENIAN ECONOMY CONSIDERING DIFFERENT FORMS OF RECYCLING¹

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ABSTRACT: *This paper outlines some of the environmental and economic implications of an additional CO₂ tax of EUR 15/tCO₂ in Slovenia in the period 2012-2030 in order to determine whether it yield a double dividend. Authors analyze (using E3ME model) different forms of revenue recycling by reducing the social security contributions of either the employers or the employees or by reducing the public deficit, in order to identify the optimal fiscal instrument for improving the environmental and economic welfare (double dividend). In this policy orientated paper authors argue that a reduction of employee social security contributions has more favourable effect than a reduction in employers' social security contributions.*

Keywords: *green tax, environmental tax reform, double dividend, carbon tax, recycling, E3ME model*

JEL Classification: E17, H23, Q50

1. INTRODUCTION – GREEN TAXES AND ENVIRONMENTAL TAX REFORM (ETR)

The idea of a green tax dates back to Arthur C. Pigou (1920); hence, green tax is also referred to as a Pigouvian tax. It is based upon a fundamental principle that the polluters should pay a tax in the amount equal to the damages resulting from their impact on the environment (i.e. negative externalities). The costs are namely not incurred only by the company whose emissions pollute the environment; rather, the costs are sustained by the entire society. It is then the task of the government to impose the green tax to internalize the pollution costs as much as possible. In such case, the polluting industrial activity is reduced to a socially desirable level (Turner, 1994).

Introduction of the green tax represents also an important development in the public finance reform since it involves also a reconsideration of the present tax system, aimed

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predominantly at taxing labour and capital. The environmental tax reform (ETR) argues in favour of green taxes in a revenue-neutral fashion to reduce other distortionary levies. Instead of taxing “good things” like labour, income and capital, the government should start taxing “bad things” like pollution, use of natural resources etc. (Bousquet, 2000; Patuelli et al., 2005). The main goal of an environmental tax reform is therefore an improvement in both environmental (first dividend) and economical aspects (second dividend). Environmental dividend involves reduction in emissions and economic dividend stems from lower costs, improved competitiveness, and higher employment. Therefore, the term “double dividend” is increasingly used to describe the environmental tax reform (Glomm et al., 2008; Ekins, 2009).

Experience from European countries has shown, that effects of a comprehensive ETR have been positive in most cases (Sweden, Denmark, Netherlands, UK, Finland, Norway, Germany). Therefore, the environmental tax reforms (ETR) have become a relevant instrument in the economic policies of the developed world in recent years.

Our primary goal is to determine the effect of an additional carbon tax (EUR 15 per ton of CO₂ i.e. EUR 55 per ton of carbon) in the period 2012–2030 on the Slovenian economy, in order to determine whether an additional carbon tax would indeed yield a double dividend. We shall examine the possibilities of different recycling options either through reduction of budget deficit or reduction of employer/employee social security contributions, in the form of different scenarios (using E3ME model) in order to identify the optimal fiscal instrument for improving the environmental (first dividend) and economic welfare (second dividend).

The article is structured as follows. In section two the concept of double dividend is introduced. In section three we present the E3ME model and the impact of green taxes within the model. Results regarding the environmental and economic implications of an environmental tax reform are presented in section four. Finally, the last section deals with the conclusions and policy implications derived from the contents of the paper.

2. A DOUBLE DIVIDEND

The two central dilemmas regarding the green tax have to do with regressiveness and loss of competitiveness. Many authors have argued that incidence of green taxes falls largely on the low-income class (Roed, 2006; West, Williams, 2004; Labandeira, Labeaga, 1999; Tiezzi, 2001; Clinch et al., 2006). Negative effect on cost competitiveness of the economy will be greater when (1) elasticity of demand for a certain good is relatively high; (2) there is strong competition in the industry; (3) a particular sector is highly energy-intensive; (4) ecotax is introduced in a small number of countries; and (5) there is no option to substitute the polluting activity with an environmentally friendlier technology (Kosonen, Nicodème, 2009; Clinch et al., 2006; Patuelli et al., 2005; Baron, 1997; Envoldsen et al., 2009). Thus, if the government introduces ETR without recycling the tax revenue within the system, an economic downturn would likely occur.

Recycling in this case refers to targeted use of green tax revenue, especially for reducing the taxation of labour and social security contributions. Besides a reduction of social security contributions or personal income taxes, other forms of financial recycling are also possible by transfers to households/industries for greater energy efficiency⁴ or interventions in corporate income taxes and value added tax. In case of total recycling, the total tax burden remains unchanged (fiscal neutrality) (Speck, Jilkova, 2009; Ludewig et al., 2010; OECD, 2007; Hoerner, Bosquet, 2001; Clinch et al., 2006; Patuelli et al., 2005; Hansen, Holger, 2000).

We expect an environmental tax reform to lead to an improvement from environmental aspects, e.g. owing to lower carbon dioxide emissions, as well as to improve the cost competitiveness of the economy as a result of lower labour costs and higher technological efficiency of businesses. Hence, economic growth and employment will actually increase (Benoit, 2000; Hoerner et al., 2001; Patuelli et al., 2005; Tuladhar, Wilcoxon, 1999). Not surprisingly, the European countries with the highest tax on labour were the first to implement the environmental tax reform and look for double dividend (Finland, Sweden, Denmark, Netherlands, Germany, and Norway).

The first (environmental) dividend of the double dividend hypothesis is widely accepted. Johansson (2000) argues that in Sweden the CO₂ emissions were 15% lower than they would have been in the absence of the green taxes. Berkhout and Linderhof (2001) point out that in the Netherlands, the price of electricity and fuel for domestic use rose dramatically as a result of the green tax and ex-post studies show that consumers now use 15% less electricity and 5–10% less fuel. Baron (1997) pointed out that in Denmark recycling of tax revenues through investment in energy efficiency has led to about 4.7% reduction in CO₂ emissions. Labandeira et al. (2004) show that in Spain a tax on CO₂ emissions has resulted in environmental improvement. Ludewig et al. (2010) demonstrate that use of all motor fuels in Germany was decreasing in the period from 1995 to 2006 by an average rate of 0.3 percent per year. At the same time, use of public transport was rising. Based on an analysis of 139 simulation models, Bosquet (2000) found that a considerable drop in carbon dioxide emissions is among the expected effects of a green tax reform in the short to medium run.

The second (economic) dividend depends mainly on the structure of the economy (e.g. labour market, pre-existing tax structure), time lag and explicit model assumptions. Since the present tax system creates significant disincentives to work and hire, virtually any environmental policy can compound these existing distortions (Carraro et al., 1996; Morgenstern, 1995; Tuladhar, Wilcoxon, 1999; Schöb, 2003). Ludewig et al. (2010) find that 250,000 new jobs were created in Germany in this way. Experience from Denmark (Hansen, Holger, 2000) and Spain (Manresa, Ferran 2005) is similar. However, many authors argue that the “double dividend” theory oversimplifies a number of points and that certain conditions have to be fulfilled for a double dividend.

4 Alternative recycling method are: (1) improvements in the energy efficiency of the building stock, (2) grants for improving energy efficiency in buildings, (3) recycling into local environmental projects to foster community acceptance of ETR, (4) recycling to public transport, (5) subsidising renewable energy and combined heat and power production, (6) subsidising ‘cleaner’ technology in industry, (7) subsidising R&D (Clinch et al., 2006).

Firstly, ETR is expected to improve the quality of the environment and to reduce the distortions of existing taxes. This view has been questioned in several papers (Goulder, 1995; Benoit, 2000; De Mooij, 1999; Li, Ren, 2012). The basic point is that the double dividend hypothesis ignores the interaction between environmental taxes and pre-existing tax structure. If the initial tax system is suboptimal then ETR can generate a significant double dividend. Similarly Fraser and Waschik (2013) using a CGE model to empirically examine the double dividend hypothesis provide support for the existence of a strong double dividend when revenue is recycled through reductions especially in consumption taxes.

Secondly, the outcome depends very much on labour market conditions in the country (Clinch et al., 2006; Carraro et al., 1996; Schöb, 2003; Koskela and Schob, 1999; Holmlund and Kolm, 2000; Albrecht, 2006; Ciaschini et al., 2012). If there are labour rigidities (as in some countries of Europe), then there will be an employment dividend resulting from the recycled carbon tax revenue. But in the long run, such rigidities become less relevant.

Thirdly, green taxes represent, as a rule, a relatively small share of overall tax revenue of any given country⁵. Hence, a dramatic increase would be required to offset the lower personal income tax revenue. Thus, if green taxes are set high enough to achieve meaningful reductions in emissions, they may cause significant distortions in the tax system. Policy makers will then be forced to trade off cleaner environment against other policy targets (Coxhead, 2000).

Fourthly, Carraro et al (1996) find that the unions' negotiating strength affects the possibility of gains in employment. In the short run the employment may increase due to lower taxes; however, in the long run, net wages completely absorb the tax change, thus bringing employment back to its baseline value. Many authors argue that the effects of a green tax reform are doubtful in the long run.

Nevertheless, while the second dividend may be in doubt, the first dividend remains a powerful argument for the introduction of ETR. Obviously, a strong double dividend occurs under rather "constrained" circumstances. We do not go more into the details since the rise and fall of the double dividend hypothesis and conditions for it has been discussed at length elsewhere (Bovenberg and Goulder 1997; Parry and Oates, 1998; Goulder, 1995; Bosquet, 2000; Fraser and Waschik, 2013). All authors agree that validity of the double-dividend hypothesis cannot be settled as a general matter. In other words, each reform must be evaluated on its own merits by keeping in mind the characteristics of respective countries and the explicit model assumptions.

⁵ In most EU countries, revenue from green taxes is between 2% and 3% of GDP. There are only four EU countries where such share is lower than 2% (1.9% in Slovakia, 1.9% in Lithuania, 1.6% in Spain, 1.8% in France), and only three countries where this share exceeds 3.5% of GDP (4% in Denmark, 4% in the Netherlands, 3.6% in Slovenia). Green taxes represent the largest share of total tax revenue in Bulgaria (10.7%), the Netherlands (10.3%), and Slovenia (9.6%). The lowest contribution of green taxes to overall tax revenue was observed in France (4.2%), Belgium (4.7%), and Spain (5.2%). Slovenia is considerably above the EU27 average (6.2%) with its 9.6-percent share of green tax revenue in overall tax revenue (European Commission, 2012).

3. THE MODEL

There are two different methodological approaches to modelling the relation between the environment and the rest of the economy. The first approach is based on highly precise modelling of a certain sector; as a rule, however, such models do not yield the best explanations as to the interaction between the sector at hand and the economy as a whole. The other approach is based on structural macroeconomic models. A key advantage of these models, each of them is based on certain underlying assumptions, is that they allow a fairly accurate prediction of macroeconomic results in case of different scenarios. These models provide a better understanding of the economic consequences of environmental measures as they allow studying the economic processes that lead to final results. The downside of these models is that each sector is modelled at the aggregated level⁶.

Our analysis is based on the latter approach. We employed the E3ME⁷ model, widely used among European researchers in recent years. This is a dynamic simulation econometric model intended for analysis of the effects of E3 policies (economy, energy, environment), especially those pertaining to environmental taxes and regulation. The model allows examining the short-term (annual) and medium-term economic effects, as well as long-term effects of E3 policies for a period of 20 years. Hence, E3ME combines the features of short-term and medium-term sector models estimated using econometric methods with the features of computational general equilibrium models. The E3ME model includes 42 product/industry sectors (OECD classification), with energy sector further disaggregated to include energy-environment interaction and 16 service sectors. It is intended for analysis of macroeconomic effects (with emphasis on environmental components) of environmental economic policies, especially from the aspect of environmental taxation and regulation, for 33 European countries (EU27, Norway, Switzerland, Iceland, Croatia, Turkey, and Macedonia) as a whole. It also allows analysis of environmental effects in each country⁸.

The structure of E3ME is based on the System of National Accounts (ESA 95), with additional links to demand for energy and environmental emissions. The model includes a total of 33 sets of econometrically estimated equations which also include components of the GDP (consumption, investment, international trade), prices, demand for energy, and demand for raw materials. Each set of equations is broken down by countries and by sectors. E3ME also allows analyzing the effects of particular scenarios as measured by numerous economic, energy, and environmental indicators. The model is based on the data for the period from 1970 to 2010 and annual projections until the year 2050. The main sources of data include Eurostat, AMECO DC ECFIN database, and IEA; this data set is further complemented by OECD STAN and other databases. Any gaps in the data are estimated using adjusted software algorithms. For a detailed description of the E3ME model, see E3ME Manual (2012).

⁶ For a detailed description of methodological approaches in modelling the relations between the environment and the economy, see Ščasný et al. (2009).

⁷ The model was developed and is maintained by the company Cambridge Econometrics.

⁸ See E3ME Manual (2012) for more detailed description.

3.1. EFFECTS OF ECOLOGICAL TAXATION (GREEN TAX) IN THE E3ME MODEL

One of the purposes of the E3ME model is to provide consistent and coherent analysis of fiscal policy and its relation to greenhouse gas emissions. The E3ME model allows examining how carbon and energy taxes affect the reduction of environmental emissions, as well as how other taxation and economic policies affect reduction of emissions.

The effect of a taxing carbon dioxide emissions (and energy consumption) in the E3ME model on prices and wages is based on two key assumptions. The first assumption is that the effect of tax is transmitted through the price of fuel and any use of subsequent tax revenue to reduce other taxes. Other effects are not modelled. The second assumption is that import of fuels and domestic production are taxed in proportion to the CO₂ emission rate and energy value of the fuel, while fuel exports are not taxed. It is assumed that this tax is paid by the fuel producers and importers. This tax is then levied on the final users through higher fuel prices. Another assumption is that the industry will transmit these additional fuel costs on its buyers in the form of higher prices of commodities (goods and services). An increase in the final price is therefore a result of direct and indirect effect of tax on a particular good or service. If tax revenue is used to reduce the rates of taxes levied on the employers, this will result in a decrease of labour costs and, in turn, a drop in production costs. These changes, too, will then be transmitted forward within the E3ME model (E3ME Manual, 2012).

Net effect of tax on prices of products and imports will be transmitted to consumer prices, resulting in a change in the consumption of goods and services. Such change will depend on individual ecotax and the price elasticity of the affected commodities. Higher prices of goods and services will lead to demands for higher wages. Econometric studies have confirmed that in the long run, entire tax is levied on the consumers. This fact is integrated into the E3ME model as a part of its long-term solution.

In the E3ME model, ecotaxes indirectly influence (through direct effect on prices and wages) the macroeconomic parameters such as fuel consumption, production, employment in particular sectors etc.). Namely, a change in the price of fuels resulting from ecotax will, depending on the elasticity of substitution, lead to a change in fuel consumption. Increase of fuel prices due to higher taxes will cause changes in consumer prices, which will be reflected in substitution in consumer expenditure, change of export activity, and change in the relation between domestic production and imports. These changes will in turn affect, via feedback loop, the use of various types of fuel. A reduction in labour costs resulting from “recycling” of tax revenue will initially have a direct positive effect on employment, followed by an indirect effect through relative price competitiveness thereon as more commodities (goods and services) are produced in labour intensive industries.

4. RESULTS OF THE MODEL

Below we present the results of the introduction of the additional carbon tax. We firstly assume that all revenue generated from ecotax is allocated for reduction of the budget

deficit or increase of the budget surplus. In subsequent analyses, ecotaxes will be recycled in various ways, e.g. they will be used to reduce the taxes levied on labour costs.

The analysis will be based in section 4.2. on a comparison to a base projection (baseline scenario), and in section 4.3. on a comparison to a budget recycling projection. Results will be presented in the form of a deviation from the base projection and the budget recycling projection. Therefore, we continue by presenting the assumption underlying the base projection, and the way in which this projection was generated.

4.1. DESCRIPTION OF THE BASE PROJECTION (BASELINE SCENARIO) AND UNDERLYING ASSUMPTIONS AND THE ESTIMATION METHODOLOGY TOGETHER WITH PARAMETER RESULTS

It is important that the baseline projection (baseline scenario) in the framework of the E3ME model is consistent with the forecasts used in other analyses. The underlying assumption of the baseline projection was that the E3ME projection was consistent with the slightly modified projection of the European commission (modified projection PRIMES BASELINE 2009). PRIMES BASELINE 2009 forecasts are also presented in Table A1 in the Appendix.

Following is a description of the key stages in modelling of the base projection. Inputs for the base projection include historical data (data on economic indicators, energy, and the environment, obtained from different sources (Eurostat, IEA etc.), estimates of parameters for endogenous variables, and fundamental assumptions.

Historical data on economic indicators for Slovenia (employment, output, consumption, exports etc.) is used up to and including 2010. The indicators were calculated from the data published by Eurostat in February 2012. Historical data on energy components (energy consumption by types of fuel etc.) and environmental components is derived from the World Energy Outlook for the period up to 2009.

Endogenous variables are determined using the functions estimated based on historical data. There are around 33 variables for which stochastic functions are estimated. However these variables may well be disaggregated in two dimensions (e.g. there are 19 fuel users and 33 countries) so we will not provide the specification of each variable. Below we first describe the general procedure how these stochastic functions are estimated and then show one example of such function and its parameters for Slovenia.

The functional form of the equations and the parameters are based on the cointegration and error-correction methodology (Engle and Granger, 1987, and Hendry et al., 1984). The process involves two stages. The first-stage is a levels relationship, where an attempt is made to identify the existence of a cointegrating relationship between the chosen variables, selected on the basis of economic theory and a priori reasoning. For example the aggregate energy demand (FRO) is specified as follows:

$$\text{FR0}_{i,j,t} = a_{i,j,0} + a_{i,j,1} \text{FRY}_{i,j,t} + a_{i,j,2} \text{PREN}_{i,j,t} + a_{i,j,3} \text{FRTD}_{i,j,t} + a_{i,j,4} \text{ZRDM}_t + a_{i,j,5} \text{ZRDT}_t + a_{i,j,6} \text{FRK}_{i,j,t} + u_{i,j,t}$$

where FRY is economic output of energy users i in region j , PREN is average fuel price (across all fuels) deflated by unit cost in region j , FRTD is R&D expenditure by energy user i in region j , ZRDM is EU investment of R&D in machinery, ZRDT is EU investment of R&D in transport, and FRK is investment by energy user i in region j

If a cointegrating relationship exists, then the second stage regression, known as the error-correction representation, is implemented. It involves a dynamic, first-difference, regression of all the variables from the first stage, along with lags of the dependent variable, lagged differences of the exogenous variables, and the error-correction term (the lagged residual from the first stage regression). Due to limitations of data size, however, only one lag of each variable is included in the second-stage. For example in case of aggregate energy demand the error correction equation is specified as:

$$\Delta \text{FR0}_{i,j,t} = b_{i,j,0} + b_{i,j,1} \Delta \text{FRY}_{i,j,t} + b_{i,j,2} \Delta \text{PREN}_{i,j,t} + b_{i,j,3} \Delta \text{FRTD}_{i,j,t} + b_{i,j,4} \Delta \text{ZRDM}_t + b_{i,j,5} \Delta \text{ZRDT}_t + b_{i,j,6} \Delta \text{FRK}_{i,j,t} + b_{i,j,7} \Delta \text{FR0}_{i,j,t-1} + g_{i,j} \text{ECM}_{i,j,t-1}$$

where Δ is difference and ECM is error correction.

Stationarity tests on the residual from the levels equation are performed to check whether a cointegrating set is obtained. Due to the size of the model, the equations are estimated individually rather than through a cointegrating VAR. For both regressions, the estimation technique used is instrumental variables, principally because of the simultaneous nature of many of the relationships (for example wage, employment and price determination).

E3ME's parameter estimate is carried out using a customised set of software routines based in the Ox programming language (Doornik, 2007). The main advantage of using this approach is that parameters for all sectors and countries may be estimated using an automated approach.

The estimation produces a full set of standard econometric diagnostics, including standard errors and tests for endogeneity. However all the estimation procedures and test are carried out by Cambridge Econometrics, the developer of the software⁹.

In Table A2 in appendix we provide a summary of the model equations, giving an overview of which variables are used, units of measurement and functional form. A full list of the variables included in E3ME model is available on request. In Appendix 1 we also present in more detail the aggregate demand for energy function and the estimated parameters for Slovenia. The other functions and parameters for Slovenia are available upon request.

⁹ A list of equation results can be made available on request. For each equation, the following information will be given: summary of results, full list of parameter results, full list of standard deviations.

The gaps in any of the E3ME time series was filled by software that was developed by the Cambridge Econometrics. This software uses growth rates and shares between sectors and variables to estimate missing data points, both in cases of interpolation and extrapolation. More precisely, “The most straightforward case is when the growth rates of a variable are known and so the level can be estimated from these growth rates, as long as the initial level is known. Sharing is used when the time-series data of an aggregation of sectors are available but the individual time series is not. In this case, the sectoral time series can be calculated by sharing the total, using either actual or estimated shares. In the case of extrapolation, it is often the case that aggregate data for a number of sectors are available, although the sectoral disaggregation at the E3ME level is not; for example, government expenditure is a good proxy for the total growth in education, health and defence. A special procedure has been put in place to estimate the growth in more disaggregated sectors so that the sum of these matches the known total, while the individual sectoral growth follows the characteristics of each sector. Interpolation is used when no external source is available, to estimate the path interval, at the beginning and end of which data are available”. (E3ME, 2014, page 34)

Basic assumptions are derived from various sources. The sources are presented in Table A3 in the Appendix. For Slovenia, the values of these assumptions for the period 2010–2013 are presented in Table A4 in the Appendix. In the same table values of assumptions for particular commodities (e.g. energy prices, fuel prices etc.) are also presented. The baseline scenario is therefore based on all government measures implemented until mid 2010. For example, the CO₂ price is determined on the measures introduced by the Slovenian government by mid 2010.

The process of ensuring compliance of the base projection in the E3ME model involves three stages. This is in fact a calibration process. The first stage in reconciling the E3ME projections with the published and slightly modified forecast PRIMES BASELINE 2009 (EU Energy trends to 2030, Baseline scenario 2009, European Commission, 2010). It includes ensuring consistency and transformation of the data into a suitable form. This means that different model dimensions have to be brought into line (geographic coverage, temporal aspect, sector coverage etc.). Transformed data are then saved in a separate file. In the next stage, the model is resolved in such way that model results match the slightly modified PRIMES BASELINE 2009 forecasts saved in a separate file. This is the calibrated forecasting process. In this forecast, the model solves its equations and compares the differences in results with the data saved in the database. Model results are substituted with values from the forecast database. Differences between results and forecasts are saved in a separate database called the “residual” database. In the last stage, the model is solved again using the “residual” database as well. This is the so-called endogenous baseline projection. According the theory, the final result should be the same as in the case of calibrated forecast. In practice, the match is not 100-percent (see, E3ME manual, pages 40–41).

In the E3ME model framework, the calibration process with modified PRIMES BASELINE 2009 forecasts is carried out based on the trends (growth rates) rather than based on levels. This is because historical data in the E3ME model are newer than the data from the modified PRIMES BASELINE 2009. Calibrations for PRIMES BASELINE 2009 forecasts are made for

the key economic variables and demand for energy (variables FRO, FRO1, FRO2 ... FRO12) and data on emissions (variables GHG, FCO2 etc.). However, since PRIMES BASELINE 2009 forecasts are based on the year 2010 and they do not include the most recent changes in the economic environment (the economic crisis), short-term calibration for macroeconomic variables is conducted based on AMECO short-term forecasts. Therefore, the baseline scenario is made based on the modified PRIMES BASELINE 2009 forecasts.

The key advantage of the endogenous baseline projection is that it allows us to analyse different scenarios in order to find out how the results change relative to the baseline scenario. There are two baseline endogenous projections: SI endogenous baseline projection and EU endogenous baseline projection. For the SI endogenous baseline projection, calibration is only carried out for Slovenia while other European regions are treated as exogenous. This projection is used in analysis of scenarios that only affect Slovenia (e.g. a change in domestic tax rate). EU endogenous baseline projection involves simultaneously solving the E3ME model for the entire Europe. This projection is used for scenarios that will affect the entire Europe (e.g. a change in oil prices). If this solution is used, results for Slovenia will also include secondary effects from other European regions, brought about through international trade.

Since the introduction of the additional carbon tax in Slovenia is only affecting the Slovenian economy, SI endogenous projection will be used. The remaining part of Europe is treated as exogenous¹⁰.

It is important to stress, that all scenarios that will be presented¹¹ are based on (1) historical data up to and including the year 2009 (energy and environmental components) or the year 2010 (economic components); (2) on government measures implemented by mid 2010; (3) and on long-term and short-term trends energy and environmental components, that are based on the European Commission projections from 2009 (PRIMES BASELINE 2009). Long-term trends for macroeconomic components are also based on European Commission projections from 2009 (PRIMES BASELINE 2009) while short-term macroeconomic components are based on the AMECO projections. This means that the effects of the economic crisis are only partially included and, as a result, the below results should be used with caution.

4.2. ANALYSIS OF INTRODUCTION OF AN ADDITIONAL CARBON TAX ON THE SLOVENIAN ECONOMY

It is assumed within the E3ME model that payment of carbon tax (tax on carbon dioxide) is levied on the users of fuels based on their emissions; however, only sectors outside ETS are taxed in order to avoid double taxation. The cost, or burden, of the tax is then shifted to the consumers through higher fuel prices.

10 We have also introduced the additional carbon tax in Slovenia by using EU endogenous baseline projection. The results were very similar.

11 Values of particular variables for all scenarios to be used herein are presented in Table A5 in the appendix.

In consequence, this means that we can expect the prices to rise while demand for fuel drops. It is assumed that higher prices will lead to a drop in real income. We can expect household consumption expenditure to decrease, which will in turn decrease demand and cause a drop in gross domestic product. As we assumed this change would not affect the European economy, we expect this will result in a drop of export competitiveness of the Slovenian economy due to higher prices, which will lead to a further decrease in GDP.

According to economic theory, the amount of carbon tax should be equal to the social cost incurred as a result of carbon pollution. Yohe et al. (2007) reviewed the estimates and found that costs estimates are highly unpredictable as they range from USD 1 per ton of carbon (tC) up to USD 1,500 per ton of carbon (tC). Average estimate of social cost of pollution with carbon dioxide for 2005 was USD 43/tC, with a standard deviation of USD 83/tC. The authors found that these costs rise at a rate of 2 to 4 percent per year. Assuming 4-percent annual growth since 2005, carbon pollution cost in 2012 would amount to an average of USD 55/tC or EUR 42/tC (i.e. EUR 11.5/tCO₂). We set the amount of extra carbon tax to EUR 15/tCO₂ (i.e. EUR 55/tC)¹².

In the article we compare two scenarios: baseline scenario in which no extra carbon tax is introduced and the projection of an introduction of an additional annual carbon tax in the amount of EUR 15 per ton of CO₂ (EUR 15 per ton of carbon) for sectors beyond ETS, where all ecotax is recycled into the government budget. Comparison between the two projections is made for some key economic (household consumption expenditure, exports, gross domestic product, total manufacturing output, employment), energy (average fuel prices, demand for energy), and environmental variables (greenhouse emissions) which are presented in detail below.

Average fuel prices including tax (PJRT¹³) change the most in the first year following the introduction of the carbon tax in the amount of EUR 15/tCO₂ (EUR 55/tC) (2012) when they rise by 3.67% relative to the baseline scenario in which no extra carbon tax is introduced. After the initial price hike, the price reaches a steady state at a higher figure which is maintained throughout the examined period. The difference in the average fuel price between the baseline scenario and projection that assumes an additional carbon tax of EUR 15/tCO₂ (or EUR 55/tC) is approximately 3.5% throughout the period at hand (until 2030).

As expected, the introduction of an extra carbon tax of EUR 15/tCO₂ (EUR 55/tC) drives up the average prices of fuel, which in turn causes a decrease in demand for fuels for energy production (FRO¹⁴). This drop relative to the baseline scenario is relatively the largest in the initial period, after which the decrease in demand for energy is steadied or slowed down. In 2013, for example, demand for energy resulting from the introduction of the carbon tax was projected to be lower by 0.83% compared to the baseline scenario; in 2020 by

12 Determination of the size of the ecotax has been aligned with the Institute of Macroeconomic Analysis and Development (UMAR). We have also used other numbers for ecotax, but we do not report them in the article.

13 PJRT = Average fuel price including tax (in EUR/toe). The model assumes 12 different fuel consumers.

14 FRO = Total demand for energy is in E3ME model measured in thousand tons toe. Model assumes 12 different fuel consumers.

1.64%; and in 2025 by 1.9%. Initial increase in prices and a considerable drop in demand relative to the baseline scenario are followed by a higher and steady level of fuel prices and accordingly lower demand for energy throughout the period of examination.

Household consumption expenditure (RSC¹⁵) is one of the most important macroeconomic aggregates, since it takes the largest share of GDP structure. Introduction of extra annual carbon tax of EUR 15/tCO₂ (EUR 55/tC) would lead to the highest relative drop of household consumption expenditure in 2013 when the decrease amounts to 0.45% relative to the baseline scenario with no introduction of carbon tax. In principle, higher average prices of fuel lead to a decrease in real income which in turn decreases household consumption expenditure. This would result in a drop in aggregate demand and cause a decrease in gross domestic product. After 2013, the difference relative to the baseline scenario gradually decreases and by 2020, for example, consumption is only 0.27% lower compared to the baseline scenario. As expected, the difference between the two scenarios is the largest at the beginning of the period; after 2013, it is gradually decreasing. Moreover, the data shows a relatively low effect of the introduction of the carbon tax on the change in consumption. The reasons can be found in the time lag as the consumers require some time to adjust their behaviour and consumption pattern.

If the extra annual carbon tax in the amount of EUR 15/tCO₂ (EUR 55/tC) is introduced, exports (RSX¹⁶) will decrease relative to the baseline scenario in which no carbon tax is introduced in the short run (until 2017), and increase after 2018. Such development is expected as we assumed the change would not affect the European economy. Higher prices expectedly hinder the export competitiveness of the Slovenian economy; however, the export sector's agility and dynamic character in terms of development of new technological solutions and updates will allow it to neutralize relatively quickly such loss of competitiveness. It should also be noted that changes in exports relative to the baseline scenario are very small (up to a maximum of 0.009%), which points to a relatively low impact of the carbon tax on Slovenian exports.

Introduction of extra annual carbon tax in the amount of EUR 15/tCO₂ (EUR 55/tC) would lead to the highest drop of Slovenia's GDP (RGDP¹⁷) in 2013 when the decrease would amount to 0.3% relative to the baseline scenario with no introduction of carbon tax. This is consistent with our expectations. It has been shown in our previous analysis that higher fuel prices lead to a decrease of real income. As a result, household consumption expenditure will decrease, which will in turn decrease demand and cause a drop in gross domestic product. As we assumed this change would not affect the European economy, higher prices would also result in a drop of export competitiveness of the Slovenian economy, which would lead to a further decrease in GDP. Moreover, the data shows a relatively low effect of the introduction of the said tax on the change in GDP. After 2013, the difference between the two scenarios gradually decreases and by 2020, for example, GDP is only

15 RSC = Household consumption expenditure is in E3ME model measured in EUR million. The model assumes 43 different types of expenditure.

16 RSX = Exports are measured in E3ME model in million euro.

17 RGDP = Gross domestic product is in E3ME model measured by the expenditure method in current market prices in millions of euro.

0.12% lower in case of introduction of the carbon tax compared to the baseline scenario. This conforms to our expectations and the theoretical findings as economic agents require some time to adjust to the new circumstances. Businesses need time to implement technological improvements and updates, and consumers need time to adjust their consumption behaviour and patterns.

We are also interested in the effect of an extra yearly carbon tax of EUR 15/tCO₂ (EUR 55/tC) on manufacturing output (QR¹⁸). The highest drop relative to the baseline scenario would be in 2015. In that year, the difference would amount to 0.32%. Here too, it is evident that introduction of carbon tax in the amount of EUR 15/tCO₂ (or EUR 55/tC) has a relatively small effect on production. The difference between the two scenarios is, expectedly, the highest at the start of the period. After 2013, this difference is gradually decreasing so that the deviation from the baseline scenario in 2015 is no more than 0.01%. Technological and organizational updates allowed the enterprises to adapt to the new conditions after a certain period of time. According to the projection, the latter effect prevails in the long run, after 2027.

Employment (YRE¹⁹) shows a similar dynamics as manufacturing output. Employment is gradually decreasing relative to the baseline scenario. The highest drop in comparison to the baseline scenario can be seen in 2016 when it amounts to 0.36%. There are hardly any differences between the two scenarios at the end of the period. The effect of an additional carbon tax of EUR 15/tCO₂ (or EUR 55/tC) on employment appears to be relatively low, similarly to the effect on GDP and manufacturing output.

As expected, the introduction of an extra carbon tax of EUR 15/tCO₂ (EUR 55/tC) gradually decreases greenhouse gas emissions (RGHG²⁰) in CO₂ equivalents. This includes emissions of CO₂, CH₄, N₂O, HFCs, PFCs and SF₆. For example, the highest drop in emissions relative to the baseline scenario is seen in 2012 (by 0.6%) and 2013 (by an extra 0.5%) to -1.2%. The decrease in emissions in comparison to the baseline scenario is steadied at approximately 2% after 2020.

4.3. ANALYSIS OF DIFFERENT FORMS OF REVENUE RECYCLING IN CASE OF EXTRA CARBON TAX IN THE SLOVENIAN ECONOMY

Introduction of an extra annual carbon tax of EUR 15/tCO₂ (EUR 55/tC) on an annual basis for the period 2012–2030 would result in additional annual tax revenue ranging from a minimum amount of EUR 144.6 million in year 2012 to a maximum amount of EUR 160.1 million in year 2020. The additional tax revenue can be allocated to the economy through different revenue recycling options. We compare the following five revenue recycling options (in each option we have introduced a yearly carbon tax of EUR 15/tCO₂ (EUR 55/tC), while other assumptions remain the same as in the baseline scenario):

18 QR = total manufacturing output (EUR million). The model is based on an analysis of 42 different sectors.

19 YRE = Employment (thousands). The model is based on an analysis of 42 different industries.

20 RGHG = Greenhouse gas emissions (in CO₂ equivalent thousands of tons)

- a) The first scenario analyses the effects of introduction of the extra carbon tax and revenue recycling through a decrease in the budget deficit and tax revenue.
- b) In the second scenario, we study the effects of revenue recycling through a decrease in social security contributions for the workers/employees, equivalent to the amount of green tax revenue (fiscal neutrality). Although the yearly decrease of workers' social contributions varies by year, depending on the green tax collected, the average decrease in the period 2012-2030 was 0.6 percentage points i.e. the worker social contributions were on average equal to 18.0% in the observed period (2012-2030).
- c) In the third scenario we analyse the effects of revenue recycling through a corresponding decrease in social security contributions payable by the employers subject to the principle of fiscal neutrality. Although the yearly decrease of employers' social contributions varies by year, depending on the green tax collected, the average decrease in the period 2012-2030 was 0.6 percentage points i.e. the employers' social contributions were on average equal to 13.0% in the observed period.
- d) In the fourth scenario we allocate the green tax revenue for covering the budget deficit in the period from 2012 to 2016, and for a decrease in workers' social security contributions in 2017 and thereafter. Assuming fiscal neutrality, green tax revenue were first allocated to the budget (period 2012-2016) and for the period 2017-2030 we decreased the workers' social security contributions on average to 18.1%.
- e) In the fifth scenario, revenue is recycled through a decrease in budget deficit in the first five years (2012-2016); then, social security contributions payable by the employers are decreased by the relevant amount. Applying the principle of fiscal neutrality, the latter were decreased on average to 13.1% (0.5 percentage points) in the period 2017-2030.

A comparison between different types of recycling will be made especially for some key economic variables (household consumption expenditure, gross domestic product, manufacturing output, employment). Analysis of revenue recycling will be based on a comparison of the second, third, fourth, and fifth scenario, respectively, to the first one. We wish to determine the existence of the double dividend based on a decrease of some social security contributions, improvement in cost competitiveness and the resulting rise in GDP and employment.

Effect on household consumption expenditure

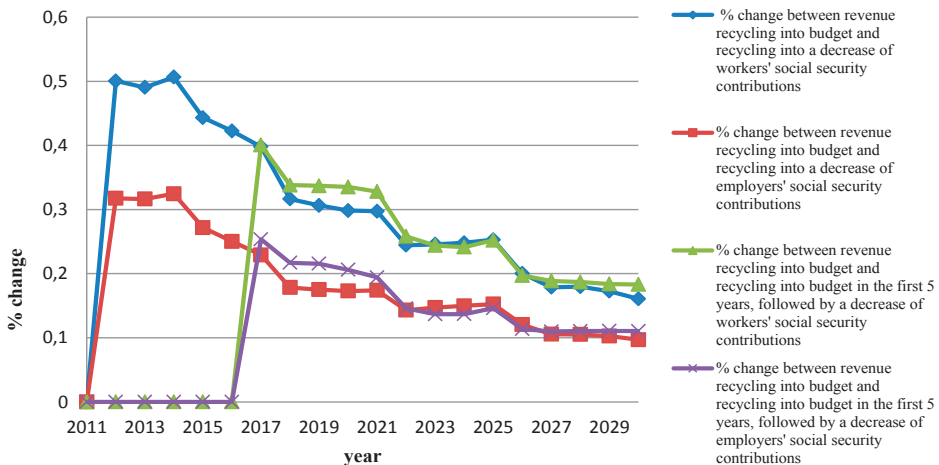
Figure 1 presents the effect on household consumption expenditure (RSC) in case of different options of recycling of the revenue generated by the extra yearly carbon tax in the amount of EUR 15/tCO₂. In our analysis, four scenarios (2nd, 3rd, 4th, and 5th scenario) are compared to the projection in which all carbon tax revenue is allocated exclusively for covering the budget deficit (first scenario). Figure 1 shows that the positive effect on household consumption expenditure in all four scenarios is stronger than in case of the projection in which all generated tax revenue is allocated exclusively for covering the budget deficit (first scenario). This is expected as additional relief through lower social contributions may increase the general population's purchasing power as net wages rise.

Furthermore, it can be observed that revenue recycling through workers' social contributions has a higher effect on household consumption expenditure than recycling through

social security contributions payable by the employers in the entire period at hand (both relative to the first scenario). The difference in household consumption expenditure between the two revenue recycling options is decreasing through the years. The reasons can be found in the fact that a decrease in employers' social security contributions would translate to a lower extent into an increase in net wages and the resulting increase in consumption than it would be the case if social security contributions were decreased for the workers.

The result is similar in the case where we allocate the green tax revenue for covering the budget deficit in the period from 2012 to 2016, and for a decrease in workers' social security contributions in 2017 and thereafter. In this case, too, decrease of social security contributions for the workers has a stronger positive effect on household consumption expenditure than a decrease of social security contributions for the employers (both in comparison to the first scenario). Similar as before, the differences between the two scenarios through the years are gradually decreasing. Figure 1 also shows that the best scenarios from the aspect of revenue recycling are the ones that decrease social security contributions for the workers (scenarios 2 and 4). These two scenarios are only different in the first five years; after that, their results tend to match. Similar match can be seen between the two scenarios in which the employer's social security contributions are reduced. It should also be noted that the differences between all scenarios referred to are relatively small.

Figure 1: Comparison between different forms of carbon tax revenue recycling from the aspect of effect on household consumption expenditure, RSC.



Source: E3ME program and own calculations.

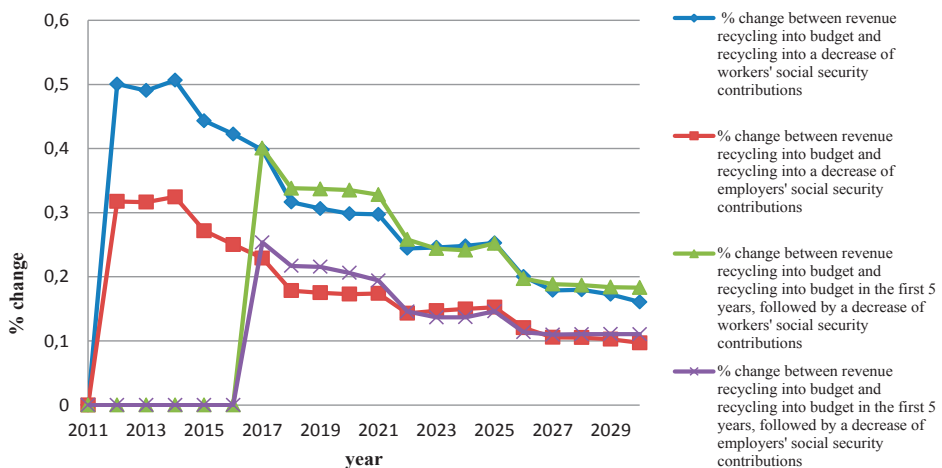
Effect on gross domestic product

Figure 2 shows the effect of introduction of a yearly carbon tax in the amount of EUR 15/ tCO₂ on GDP (RGDP) in different cases of tax revenue recycling. In our analysis, four scenarios (2nd, 3rd, 4th, and 5th scenario) are compared to the first scenario in which

all carbon tax revenue is allocated exclusively for covering the budget deficit. It is evident from Figure 2 that the positive effect on GDP in all four scenarios is stronger than in case of the projection in which all generated tax revenue is allocated exclusively for covering the budget deficit. This matches our expectations as additional relief of labour costs through a decrease in social security contributions payable by the employers or the workers translates into an increase in household purchasing power and in turn an increase in GDP. The positive effect is stronger in case of revenue recycling through a decrease in worker's social security contributions in the entire period at hand (both relative to the first scenario). The difference between the two revenue recycling options is decreasing through the examined period. The reasons for this can be found in higher household consumption expenditure (see previous section) which is the largest component of GDP.

The result is similar in the case where green tax revenue is allocated for covering the budget deficit in the period from 2012 to 2016, and for a decrease in social security contributions in 2017 and beyond. Decrease of social security contributions for the workers has a stronger positive effect on household consumption expenditure than a decrease of social security contributions for the employers (both in comparison to the first scenario). In this case, too, the differences between the two scenarios are gradually decreasing through the years. Figure 2 also shows that the best scenarios from the aspect of revenue recycling are the ones that decrease social security contributions for the workers (scenarios 2 and 4). These two scenarios are only different in the first five years; after that, their results tend to match. Similar match can be seen between the two scenarios in which the employer's social security contributions are reduced. It should again be noted that the differences between all scenarios in terms of discrepancy relative to the first scenario are relatively small.

Figure 2: Comparison between different forms of carbon tax revenue recycling from the aspect of effect on gross domestic product, RGDP.



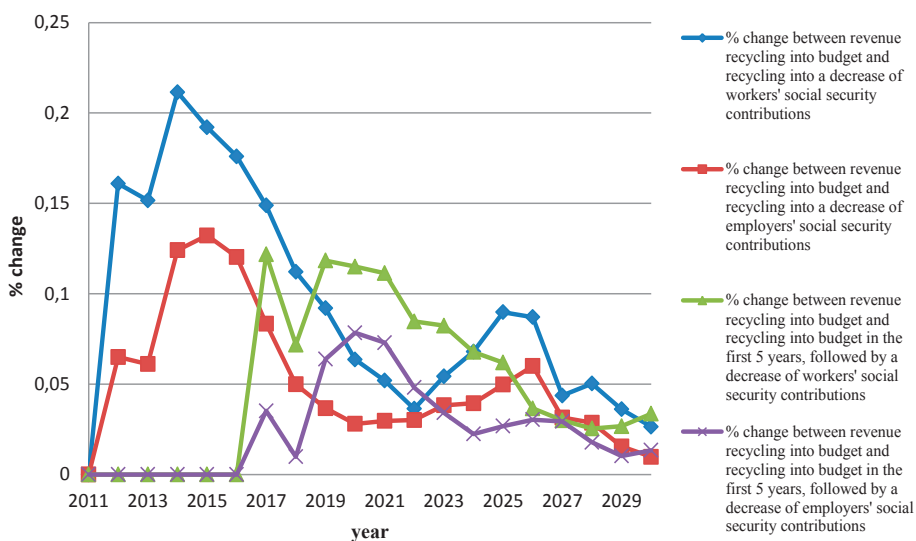
Source: E3ME program and own calculations.

Effect on total manufacturing output

Following is a presentation of the effect of carbon tax introduction on manufacturing output (QR) in case of different forms of recycling. Figure 3 compares four scenarios to the projection in which all carbon tax revenue, is allocated exclusively for covering the budget deficit (first scenario). It is evident from Figure 3 that the positive effect on manufacturing output in all four scenarios (2nd, 3rd, 4th, and 5th) is stronger than in case of the projection in which all generated tax revenue is allocated exclusively for covering the budget deficit. Higher cost relief through a decrease in social security contributions of the employer or the worker and the resulting improvement in cost efficiency appears to motivate total manufacturing output as well.

Recycling through a reduction in social security contributions of the workers has a more positive effect on production than recycling through decrease in social security contributions for the employers in the period 2012–2030 (both relative to the first scenario). The result is similar in the case where we allocate the green tax revenue for covering the budget deficit in the period from 2012 to 2016, and for a decrease in social security contributions in 2017 and thereafter. In both cases, decrease of social security contributions for the workers has a stronger positive effect on manufacturing output than a decrease in the employer's social security contributions. Again, the differences between all scenarios in terms of discrepancy relative to the first scenario are relatively small.

Figure 3: Comparison between different forms of carbon tax revenue recycling from the aspect of total manufacturing output, QR.



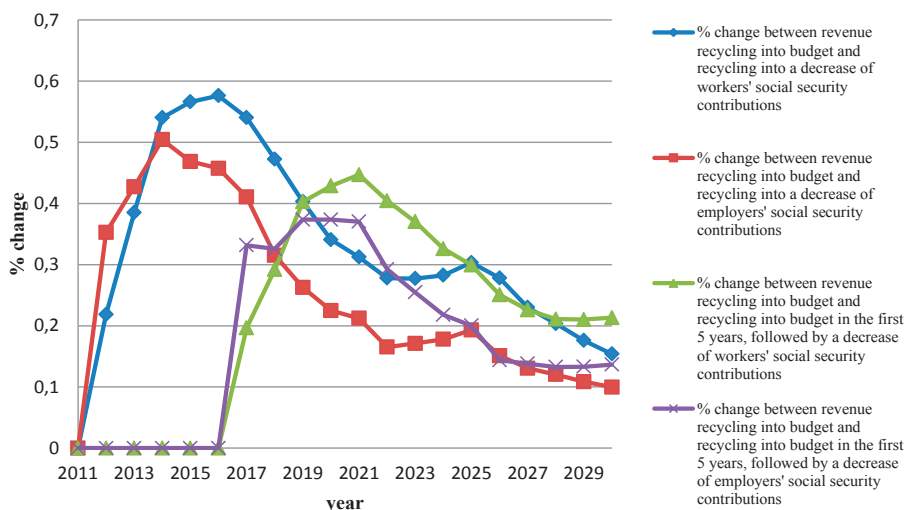
Source: E3ME program and own calculations.

Effect on employment

Following is a presentation of the effect of carbon tax introduction on employment (YRE) in case of different forms of recycling. Four scenarios are compared to the projection in which all carbon tax revenue, is allocated exclusively for covering the budget deficit (first scenario). Figure 4 shows that the positive effect on employment in all four scenarios (2nd, 3rd, 4th, and 5th) is stronger than in case of the projection in which all generated tax revenue is allocated exclusively for covering the budget deficit. Higher cost relief through a decrease in social security contributions (of the employer or the worker) evidently has a positive effect on employment, which is also consistent with the previous two figures.

Revenue recycling through a decrease of the employer's social security contributions has a stronger effect on employment than revenue recycling through worker's social security contributions, but only in the short run until the year 2014. In the long run, the opposite is true; after 2015, the difference between the second and the third scenario is constant. If carbon tax revenue is allocated for covering the budget deficit in the period 2012–2016 and for a decrease in social security contributions in 2017 and beyond, the conclusion is similar. In this case, too, revenue recycling has a stronger effect in the short run (until 2018) if the employer's social security contributions are decreased. Differences between all analyzed scenarios are relatively small in terms of discrepancy relative to the first scenario.

Figure 4: Comparison between different forms of recycling in case of carbon tax introduction from the aspect of employment, YRE



Source: E3ME program and own calculations.

5. CONCLUSION

The main goal of the environmental tax reform is economic and environmental improvement. Environmental dividend involves reduction in emissions, while economic dividend has to do with improved cost competitiveness, higher growth, and higher employment. Our primary goal was to determine the effect of an extra carbon tax (EUR 15 per ton of CO₂ i.e. EUR 55 per ton of carbon) in the period 2012–2030 on Slovenian economy, in order to determine whether a carbon tax would indeed yield a double dividend.

In the first section, we analysed the effects of the introduction of a yearly carbon tax (EUR 15 per ton of CO₂) relative to the baseline projection (in which no tax is introduced) in the period 2012–2030, using the E3ME model. Our analysis has shown that average prices of fuels will increase which will reduce demand for fuels. Higher prices will also lead to lower household consumption expenditure, which would decrease aggregate demand and result in a drop of GDP. GDP would be additionally decreased in the short run by lower export competitiveness of the Slovenian economy, resulting from higher prices, as we assumed that the change in prices would not affect the European economy. In the medium and long run, the effect of carbon tax on the change in GDP, relative to the baseline scenario (i.e. no carbon tax), is always lower. This conforms to our expectations and the theoretical findings as economic agents require some time to adjust to the new circumstances. The E3ME model has shown that Slovenian export sector would look to introduce new technological solutions and updates, thereby neutralizing relatively quickly the negative effects of the introduction of the carbon tax on the competitiveness of the Slovenian economy. Similar dynamics and oscillation as in GDP can be observed in manufacturing output and employment. Greenhouse emissions, too, are reduced in the model, at approximately the same rate.

Economic policy developers in Slovenia, as in many other European countries with implemented environmental tax reform, should be aware that introduction of a carbon tax in Slovenia would have more negative effects in the short run than in the medium and long run. It is therefore of key importance for the success of the green tax reform to introduce the extra carbon tax gradually, transparently, and predictably. This would allow enough time for economic agents to adapt, and for economic policy developers to evaluate the first effects of the green tax reform and to make any adjustments if discrepancies from the planned goals are identified in the course of the reform. This would also prevent recurring discussions as to the urgency of increase of some tax rates and political pressure to decrease such rates as a result of higher prices of oil and petrochemicals in the global market.

In the second section, we used the E3ME model to analyze the effects of different forms of tax revenue recycling, either through a decrease in the budget deficit or through a decrease of social security contributions payable by either the employers or the workers, in case of a yearly carbon tax in the amount of EUR 15 per ton of CO₂ in the period 2012–2030. Our analysis has shown that recycling through lowering the social security contributions for workers (2nd and 4th scenario) and employers (3rd and 5th scenario) have a stronger positive effect on household consumption expenditure than the scenario in which all revenue is allocated exclusively for covering the budget deficit (first scenario). Differences between the

recycling scenarios are relatively small. Additional relief through a decrease in social security contributions in case of an extra carbon tax would increase the purchasing power of the general population (household consumption expenditure), which would in turn increase the GDP. Higher cost relief through a decrease in social security contributions also has a positive effect on total manufacturing output and employment. We have also shown that recycling through a decrease in social security contributions of workers has a stronger positive economic effect than recycling through a decrease in employers' social security contributions in the entire period at hand. The result is similar in the case where we allocate the green tax revenue for covering the budget deficit in the period from 2012 to 2016, and for a decrease in workers' or employers' social security contributions in 2017 and thereafter.

Policy implications for the Slovenian government are twofold. Firstly, scenarios in which all revenue is allocated exclusively for lowering the social security contributions for workers/employers have a stronger positive economic effect than the scenario in which all revenue is allocated exclusively for covering the budget deficit. Secondly, the optimal fiscal instrument for improving the environmental (first dividend) and economic welfare (second dividend) seems to be recycling through a decrease in social security contributions of workers. The reasons can be found in the fact that a decrease in employers' social security contributions would translate to a lower extent into an increase in net wages and the resulting increase in consumption than it would be the case if social security contributions were decreased for the workers.

However, an environmental tax reform cannot be successful if the political reality in Slovenia is disregarded. As a rule, economists design optimum policy mixes for the attainment of certain goals; however, politics often requires compromises. Experience from other countries has shown that the key to their success was the high rate of consent of all political parties and civil society regarding the urgency of an environmental tax reform. Therefore, the Slovenian government should inform the public about the negative effects of an extra carbon tax. Public support will be higher, if an effective system of measures is put into place to neutralize the harmful effects of the additional carbon tax.

REFERENCES

- Albrecht, J. (2006). The use of consumption taxes to re-launch green tax reforms. *International Review of Law and Economics*, 26(1), 88–103.
- Barker, T.S. & Ekins, P. & Johnstone, N. (1995). *Global Warming and Energy Demand*. London: Routledge.
- Baron, R. (1997). *Economic/Fiscal Instruments: Competitiveness Issues Related to Carbon/Energy Taxation Policies and Measures for Common Action*. Working Paper No. 14. Paris: OECD.
- Benoit, B. (2000). Environmental tax reform: does it work? A survey of the empirical evidence. *Ecological Economics*, 34(1), 19–32.
- Berkhout, G., Ferrer-i-Carbonell A. & Muskens, A.C. (2001). *Het effect van de REB op huishoudelijk energieverbruik*. EEN econometrische analyse. Amsterdam.
- Bentzen, J. & Engsted, T. (1993). Short- and long-run elasticities in energy demand: a cointegration approach. *Energy Economics*, 15(1) 9-16.
- Bovenberg, L. & Goulder, L.H. (1997). Cost of environmentally motivated taxes in the presence of other taxes: general equilibrium analyses. *National Tax Journal*, 50(1), 59–87.

- Camecon (2012). *Teaching course*. 15th-16th March, 2012.
- Carraro, C., Galeotti, M. & Gallo, M. (1996). Environmental taxation and unemployment: Some evidence on the 'double dividend hypothesis' in Europe. *Journal of Public Economics*, 62(1/2), 141-181.
- Ciaschini, M., Pretalori, R., Severini, F., Socci, C. (2012): Regional Double Dividend from Environmental Tax Reform: An Application from the Italian Economy. *Research in Economics*, 66(3): 273-283.
- Clinch, P., Dunne, L. & Dresner, S. (2006). Environmental and wider implications of political impediments to environmental tax reform. *Energy Policy*, 34(8), 960-970.
- Coxhead, I. (2000). *Tax Reform and the Environment in Developing Economies: Is a Double Dividend Possible?* Wisconsin-Madison Agricultural and Applied Economics Staff Paper No. 431. Madison: University of Wisconsin-Madison.
- Doornik, J. (2007). *Ox: An Object-Oriented Matrix Language*. London: Timberlake Consultants Press.
- De Mooij, R.A. (1999). The double dividend of an environmental tax reform. In Bergh, V. (Ed.), *Handbook of Environmental and Resource Economics* (pp. 600-613). London: Edward Elgar.
- E3ME Manual (2012).
- http://www.camecon.com/Libraries/Downloadable_Files/E3ME_Manual.sflb.ashx (Accessed on 20.12.2012)
- E3ME (2014). *Technical Manual, Version 6.0*. Cambridge: Cambridge Econometrics.
- Ekins, P. (2009). *Resource Productivity, Environmental Tax Reform and Sustainable Growth in Europe*. Berlin: Anglo-German Foundation.
- Engle, R.F. & C.W.J. Granger, C.W.J. (1987). Cointegration and error correction: representation, estimation and testing. *Econometrica*, 55, 251-76.
- European Commission (2010). *EU energy trends to 2030 – update 2009*. Brussels: European Commission.
- European Commission (2012). *Taxation trend in the EU*. Brussels: European Commission.
- Franzén, M. & Sterner, T (1995). Long-run Demand Elasticities for Gasoline. In Barker, T. & Johnstone, N. & Ekins, P. (eds.), *Global Warming and Energy Elasticities*. London: Routledge.
- Fraser, I. & Waschik, R. (2013): The Double Dividend Hypothesis in CGE Model: Specific factors and the Carbon Case. *Energy Economics*, 39, 283-295.
- Gimenez, E. & Rodriguez, M. (2010). Reevaluating the first and the second dividends of environmental tax reforms. *Energy Policy*, 38(11), 6654-6661.
- Glomm, G., Kawaguchi, D. & Sepulveda, F. (2008). Green taxes and double dividends in a dynamic economy. *Journal of policy modeling*, 30(1), 19-32.
- Goulder, L.H. (1995). Environmental taxation and the "double dividend": a reader's guide. *International Tax and Public Finance*, 2(2), 155-182.
- Hansen, M. & Holger, H. (2000). Green tax reform in Denmark. In Schlegelmilch, Kai (Ed.), *Green Budget reform in Europe: Countries at the forefront* (pp. 139-145). Berlin: Springer.
- Hendry, D. F. & Pagan, A. & Sargan, J.D. (1984). Dynamic specification. In Griliches, Z. & Intriligator, M.D. (eds), *Handbook of Econometrics, Vol II* (pp. 1023-1100). Amsterdam: Elsevier.
- Hoerner, B. (2001). *Environmental tax reform: The European Experience*. Washington DC: Center for Sustainable Economy.
- Holmlund, B. & Kolm, A.S. (2000). Environmental tax reform in a small open economy with structural unemployment. *International Tax and Public Finance*, 7(3), 315-333.
- Hunt, L. & Manning, N. (1989). Energy price- and income-elasticities of demand: some estimates for the UK using the cointegration procedure. *Scottish Journal of Political Economy*, 36(2), 183-193.
- Johansson, O. & Schipper, L. (1997). Measuring the long-run fuel demand of cars. *Journal of Transport Economics and Policy*, 31(3), 277-292.
- Johansson, B. (2000). The carbon tax in Sweden. In: *OECD, Innovation and the Environment* (pp. 85-94). Paris: OECD.

- Koskela, E. & Schob, R. (1999). Alleviating unemployment: the case for green tax reform. *European Economic Review*, 43(9), 1723–1746.
- Kosonen, K. & Nicodème, G. (2009). *The role of fiscal instruments in environmental policy*. Working paper No. 2719, Munchen: CESifo.
- Labandeira, X. & Labeaga, J. (1999). Combining input-output analysis and microsimulations to assess the effects of carbon taxation on Spanish households. *Fiscal studies*, 20(3), 305–320.
- Labandeira, X., Labeaga, J.M. & Rodríguez, M. (2004). Green tax reforms in Spain. *European Environment*, 14(5), 290–299.
- Hua Li, Longyang Ren (2012). China's Provincial Tax Structure Optimization: Double Dividend of Energy and Efficiency. *Finance & Trade Economics*, 10(3).
- Ludewig, D., Meyer, B. & Schlegelmilch, K. (2010). *Greening the Budget: Pricing Carbon and Cutting Energy Subsidies to reduce the financial deficit in Germany*. Washington DC: Heinrich Boll Stiftung.
- Manresa, A. & Sancho, F. (2005). Implementing a double dividend: recycling ecotaxes towards lower labour taxes. *Energy Policy*, 33(12), 1577–1585
- Morgenstern, R. (1995). *Environmental Taxes: Dead or Alive?* Discussion Paper 95-03. Washington, DC: Resources for the Future.
- OECD (2007). *Employment Outlook*. Paris: OECD.
- Parry, I. & Oates, W. (1998). *Policy Analysis in a Second Best World*. Discussion paper No. 98-48. Washington, DC: Resources for the Future.
- Patuelli, R., Nijkamp, P. & Pels, E. (2005). Environmental tax reform and the double dividend: A meta-analytical performance assessment. *Ecological Economics*, 55(4), 564–583.
- Pigou, A.C. (1920). *The Economics of Welfare*. London: Weidenfeld and Nicolson.
- Roed, L. (2006). Distributional effects of environmental taxes on transportation – evidence from Engel curves in the USA. *Journal of Consumer Policy*, 29(39), 301–318.
- Sandmo, A. (1975). Optimal taxation in the presence of externalities. *Swedish Journal of Economics*, 77(1), 86–98.
- Schöb, R. (2003). *The Double Dividend Hypothesis of Environmental Taxes: A Survey*. Working paper No. 946. Munchen: CESifo.
- Speck, S., Jilkova, J. (2009). *Design of environmental tax reforms in Europe. Carbon energy taxation: lessons from Europe*. Oxford: Oxford University Press.
- Ščasný, M., Píša, V., Pollitt, H. & Chewpreecha, U. (2009). Analyzing Macroeconomic Effects of Environmental Taxation in the Czech Republic with the Econometric E3ME Model. *Journal of Economics and Finance*, 59(5), 460–491.
- Tiezzi, S. (2001). *The welfare effects of carbon taxation in Italian households*. Working paper No. 337. Siena: Dipartimento di Economica Politica, Università degli Studi di Siena.
- Tuladhar, S.D. & Wilcoxon, P.J. (1999). An Econometric Look at the Double Dividend Hypothesis. *National Tax Association Proceedings*, 57–62.
- Turner, K., Pearce, D. & Bateman, I. (1994). *Environmental economics: An elementary introduction*. Prentice Hall: Pearson Education.
- West, S. & Williams, R. (2004). Estimates from a Consumer demands system: Implication for the incidence of environmental taxes. *Journal of Environmental Economics and Management*, 47(3), 535–558.
- Yohe, G.W., Lasco, R.D., Ahmad, Q.K., Arnell, N.W., Cohen, S.J., Hope, C., Janetos, A.C. & Perez, R.T. (2007). Perspectives on climate change and sustainability. In Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. & Hanson, C.E. (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 811–841). Cambridge: Cambridge University Press.

APPENDIX

Table A1: PRIMES (Baseline 2009) for Slovenia.

Slovenia: Baseline 2009										SUMMARY ENERGY BALANCE AND INDICATORS (A)				
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	'90-'00	'00-'10	'10-'20	'20-'30	
										Annual % Change				
Production	2902	3020	3085	3492	3657	4019	4221	4801	4928	0.6	1.7	1.4	1.6	
Solids	1432	1218	1082	1184	1252	1505	1573	745	823	-2.9	1.7	2.3	-3.3	
Oil	3	2	1	0	0	0	0	0	0	-10.4				
Natural gas	20	18	6	3	4	0	0	0	0	-11.4	-4.9			
Nuclear	1192	1245	1228	1518	1557	1557	1557	2904	2904	0.3	2.4	0.0	6.4	
Renewable energy sources	254	542	788	787	845	957	1091	1152	1201	12.0	0.7	2.6	1.0	
Hydro	254	279	330	298	338	353	365	366	368	2.7	0.2	0.8	0.1	
Biomass & Waste	0	263	458	489	502	598	653	690	715	0.9	0.7	2.7	0.9	
Wind	0	0	0	0	0	6	14	20	24				5.2	
Solar and others	0	0	0	0	6	31	57	74	92				26.2	
Geothermal	0	0	0	0	0	1	1	1	1				28.1	
Net Imports	2572	3063	3381	3825	4276	4824	5248	4846	4586	2.8	2.4	2.1	-1.3	
Solids	130	186	245	323	269	293	373	233	216	6.5	0.9	3.3	-5.3	
Oil	1804	2239	2430	2804	3075	3546	3735	3645	3474	3.0	2.4	2.0	-0.7	
- Crude oil and Feedstocks	598	589	151	0	1	1	1	1	1	-12.8	-38.2	1.9	-0.4	
- Oil products	1206	1650	2278	2804	3074	3544	3734	3644	3473	6.6	3.0	2.0	-0.7	
Natural gas	723	750	820	925	980	1073	1239	1153	1098	1.3	1.8	2.4	-1.2	
Electricity	-85	-142	-114	-28	-58	-115	-135	-246	-270					
Gross Inland Consumption	5523	6111	6427	7299	7904	8808	9431	9607	9473	1.5	2.1	1.8	0.0	
Solids	1645	1402	1306	1539	1521	1798	1946	978	1039	-2.3	1.5	2.5	-6.1	
Oil	1754	2290	2393	2554	3046	3511	3698	3606	3434	3.2	2.4	2.0	-0.7	
Natural gas	763	746	826	929	984	1073	1239	1153	1098	0.8	1.8	2.3	-1.2	
Nuclear	1192	1245	1228	1518	1557	1557	1557	2904	2904	0.3	2.4	0.0	6.4	
Electricity	-85	-142	-114	-28	-58	-115	-135	-246	-270					
Renewable energy forms	254	571	788	787	855	983	1127	1213	1280	12.0	0.8	2.8	1.2	
as % in Gross Inland Consumption														
Solids	29.8	22.9	20.3	21.1	19.2	20.4	20.6	10.2	11.0					
Oil	31.8	37.5	37.2	35.0	38.5	39.9	39.2	37.5	36.2					
Natural gas	13.8	12.2	12.8	12.7	12.5	12.2	13.1	12.0	11.6					
Nuclear	21.6	20.4	19.1	20.8	19.7	17.7	16.5	30.2	30.7					
Renewable energy forms	4.6	9.3	12.3	10.8	10.8	11.2	11.9	12.6	13.4					
Gross Electricity Generation in GWh	12440	12652	13622	15114	16193	18404	20168	22179	22930	0.9	1.7	2.2	1.3	
Self consumption and grid losses	1584	1477	1662	1943	1965	2244	2385	2400	2804	0.5	1.7	2.0	1.6	
Fuel Inputs for Thermal Power Generation	1543	1523	1342	1507	1622	1987	2246	1272	1349	-1.4	1.9	3.3	-5.0	
Solids	1296	1315	1253	1411	1431	1702	1849	886	959	-0.3	1.3	2.6	-6.4	
Oil (including refinery gas)	155	119	12	9	2	7	2	6	5	-22.8	-15.5	-0.9	10.6	
Gas	92	90	62	58	147	165	274	232	235	-3.8	0.0	6.4	-1.6	
Biomass & Waste	0	0	15	30	42	114	120	148	151		10.5	11.1	2.3	
Geothermal heat	0	0	0	0	0	0	0	0	0					
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0					
Fuel Input in other transformation proc.	596	582	253	90	93	175	225	315	343	-8.2	-9.5	9.2	4.3	
Refineries	542	505	170	1	1	1	1	1	1	-11.0	-38.9	1.9	-0.4	
Biofuels and hydrogen production	0	0	0	0	39	106	173	212	238				16.0	
District heating	53	76	83	89	53	68	50	102	103	4.7	-4.5	-0.5	7.4	
Others	1	1	0	0	0	0	0	0	0					
Energy Branch Consumption	122	121	112	104	112	131	137	134	166	-0.9	0.0	2.1	1.9	
Non-Energy Uses	6	122	238	310	351	406	446	465	468	43.8	4.0	2.4	0.5	
Final Energy Demand	3373	3948	4440	4892	5448	6167	6597	6576	6393	2.8	2.1	1.9	-0.3	
by sector														
Industry	1469	1180	1424	1657	1663	1835	1977	1908	1837	-0.3	1.7	1.6	-0.7	
- energy intensive industries	729	587	840	1038	1046	1149	1248	1201	1152	1.4	2.2	1.8	-0.8	
- other industrial sectors	740	593	585	619	647	686	730	707	685	-2.3	1.0	1.2	-0.6	
Residential	853	1180	1124	1186	1205	1305	1355	1371	1365	2.8	0.7	1.2	0.1	
Tertiary	122	259	580	575	569	604	610	609	593	16.9	-0.2	0.7	-0.3	
Transport	930	1329	1312	1475	1981	2423	2655	2688	2598	3.5	4.2	3.0	-0.2	
by fuel														
Solids	243	115	97	80	60	63	63	60	52	-8.8	-4.7	0.5	-1.9	
Oil	1513	2106	2239	2404	2857	3283	3450	3334	3153	4.0	2.5	1.9	-0.9	
Gas	603	468	569	685	655	695	753	679	630	-0.6	1.4	1.4	-1.8	
Electricity	837	807	905	1096	1153	1263	1382	1441	1447	0.8	2.5	1.8	2.5	
Heat (from CHP and District Heating) ^(M)	177	192	195	196	257	363	336	422	434	1.0	2.8	2.7	0.6	
Renewable energy forms	0	260	435	452	486	500	612	640	675	0.7	2.8	1.0	1.0	
Other	0	0	0	0	0	0	1	1	1				11.9	
RES in Gross Final Energy Consumption ^(B)			768	810	832	911	1093	1177	1230		0.8	2.8	1.2	
TOTAL GHGs Emissions (Mt of CO₂ eq.)	18.1		18.6	20.1	21.3	24.1	25.6	26.8	18.9	0.3	1.4	1.8	-3.0	
of which ETS sectors GHGs emissions				9.0	8.8	10.2	11.2	7.1	5.7				2.5	
-0.5														
CO₂ Emissions (energy related)	13.2	14.1	14.0	15.3	16.7	19.3	20.8	16.3	14.4	0.6	1.8	2.2	-3.6	
Power generation/District heating	6.2	6.2	5.5	6.2	6.4	7.6	8.4	4.4	3.2	-1.1	1.4	2.8	-9.1	
Energy Branch	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0				-0.9	
Industry	2.5	1.8	2.3	2.3	2.2	2.3	2.5	2.0	1.8	-0.7	-0.8	1.3	-3.1	
Residential	1.7	2.1	1.3	1.4	1.5	1.6	1.6	1.6	1.5	-2.5	1.3	0.8	-0.7	
Tertiary	0.0	0.0	1.0	1.0	0.9	1.0	0.9	0.9	0.9	47.0	-0.1	-0.1	-1.0	
Transport	2.7	3.9	3.8	4.3	5.8	6.9	7.4	7.4	7.0	3.5	4.3	2.5	-0.5	
CO ₂ Emissions (non energy related)	1.1	0.9	0.9	1.1	1.1	1.2	1.4	1.4	1.4	-1.9	1.8	2.1	0.2	
Non-CO ₂ GHGs Emissions	3.8		3.7	3.7	3.5	3.5	3.4	3.2	3.1	-0.4	-0.6	-0.1	-1.0	
TOTAL GHGs Emissions Index (1990=100)	100.0		102.8	110.8	117.6	133.1	141.2	115.1	104.4					

SUMMARY ENERGY BALANCE AND INDICATORS (B)										Slovenia: Baseline 2009			
	1990	1995	2000	2005	2010	2015	2020	2025	2030	'90-'00	'00-'10	'10-'20	'20-'30
										Annual % Change			
Main Energy System Indicators													
Population (Million)	1,996	1,989	1,988	1,998	2,034	2,053	2,058	2,047	2,023	0.0	0.2	0.1	-0.2
GDP (in 000 MEuro/05)	20.0	18.4	24.0	28.7	32.7	38.4	44.0	48.2	50.7	1.9	3.1	3.0	1.4
Gross Inl. Cons./GDP (toe/MEuro/05)	276.7	315.3	287.9	254.2	241.6	229.5	214.3	199.5	186.8	-0.3	-1.0	-1.2	-1.4
Carbon intensity (t of CO ₂ /toe of GIC)	2.39	2.30	2.18	2.09	2.12	2.20	2.20	1.89	1.52	-0.9	-0.3	0.4	-3.6
Import Dependency %	46.6	50.1	52.6	52.3	53.9	54.5	55.4	50.2	48.2				
Total Energy-related Costs ⁽¹⁾ (in 000 ME05) as % of GDP			3.6	3.9	4.8	6.2	7.9	8.9	9.2	3.0	5.0	1.6	
			15.0	13.6	14.8	16.2	17.9	18.4	18.1				
Energy intensity indicators													
Industry (Energy on Value added)	109.1	109.6	100.0	92.4	82.7	76.8	73.2	67.1	63.9	-0.9	-1.9	-1.2	-1.4
Residential (Energy on Private Income)	99.0	123.5	100.0	92.2	85.2	79.3	71.5	65.3	60.7	0.1	-1.6	-1.7	-1.6
Tertiary (Energy on Value added)	27.8	54.1	100.0	82.4	72.6	65.0	57.1	51.8	47.0	13.7	-3.2	-2.4	-1.9
Passenger transport (toe/MPkm)	33.4	45.5	38.5	32.6	32.1	31.2	30.3	27.5	24.6	1.4	-1.8	-0.6	-2.1
Freight transport (toe/Mtkm)	22.8	56.0	42.7	41.9	46.1	47.0	45.2	43.2	40.8	6.5	0.8	-0.2	-1.1
Carbon Intensity indicators													
Electricity and Steam production (t of CO ₂ /MWh)	0.42	0.41	0.34	0.34	0.32	0.32	0.34	0.16	0.11	-2.0	-0.7	0.5	-10.5
Final energy demand (t of CO ₂ /toe)	2.05	1.99	1.89	1.86	1.90	1.91	1.88	1.81	1.75	-0.8	0.0	-0.1	-0.7
Industry	1.72	1.55	1.65	1.39	1.28	1.23	1.25	1.08	0.98	-0.4	-2.5	-0.3	-2.4
Residential	1.98	1.81	1.17	1.21	1.24	1.23	1.19	1.14	1.11	-5.2	0.6	-0.4	-0.7
Tertiary	0.17	0.13	1.65	1.76	1.66	1.64	1.54	1.49	1.44	25.7	0.0	-0.8	-0.7
Transport	2.88	2.91	2.89	2.94	2.91	2.85	2.78	2.74	2.70	0.0	0.1	-0.4	-0.3
Indicators for renewables (excluding industrial waste) (%) ⁽²⁾													
RES in gross final energy demand (%)			16.7	15.9	14.7	14.2	15.9	17.2	18.4				
RES in transport (%)			0.5	0.3	2.3	4.7	6.8	8.3	9.6				
Gross Electricity generation by fuel type (in GWh)													
Nuclear energy	4760	5883	6035	6035	6035	6035	12480	12480		1.7	2.2	1.3	
Coal and lignite	4630	5314	5179	6738	7501	3182	3777			2.4	0.0	7.5	
Petroleum products	40	34	9	19	8	14	13			-14.0	-0.8	4.6	
Gas (including derived gases)	313	324	869	897	1604	1281	1306			10.8	6.3	-2.0	
Biomass & waste	45	100	171	529	555	645	659			14.3	12.5	1.7	
Hydro	3833	3460	3627	4100	4249	4266	4283			0.2	0.8	0.1	
Wind	0	0	0	66	167	234	278					5.2	
Solar, tidal etc.	0	0	0	3	20	48	86					32.5	10.9
Geothermal and other renewables	0	0	0	0	0	0	0						
Net Generation Capacity in MW_e													
Nuclear energy	2748	3684	3293	4039	3971	4548	4846			1.8	1.9	2.0	
Renewable energy	696	696	708	708	708	1515	1515			0.1	0.0	7.9	
Hydro (pumping excluded)	846	983	1041	1175	1388	1508	1623			2.1	2.9	1.6	
Wind	0	0	0	75	191	267	317			2.1	1.0	0.2	
Solar	0	0	0	3	21	50	90					32.5	10.9
Other renewables (tidal etc.)	0	0	0	0	0	0	0						
Thermal power	1206	1424	1647	2158	1877	1527	1707			2.5	2.0	-0.9	
of which cogeneration units	453	389	448	614	589	649	644			-0.1	2.8	0.9	
of which CCS units	0	0	0	0	0	0	185						
Solids fired	948	947	894	1495	1244	870	1039			-0.6	3.4	-1.8	
Gas fired	223	446	624	626	552	573	585			10.8	-1.2	0.6	
Oil fired	17	10	10	10	2	1	1			-5.2	-13.6	-12.0	
Biomass-waste fired	17	21	19	27	79	83	83			1.4	15.2	0.5	
Fuel Cells	0	0	0	0	0	0	0						
Geothermal heat	0	0	0	0	0	0	0						
Load factor for net electric capacities (%)	53.1	52.3	52.8	48.7	54.5	52.7	50.3						
Efficiency for thermal electricity production (%)	32.2	32.9	33.0	35.4	37.0	34.6	36.7						
CHP indicator (% of electricity from CHP)	7.2	8.2	12.5	18.7	19.0	16.9	16.4						
CCS indicator (% of electricity from CCS)	0.0	0.0	0.0	0.0	0.0	0.0	8.3						
Non fossil fuels in electricity generation (%)	63.4	62.5	62.6	58.4	54.8	79.8	77.8						
- nuclear	34.9	38.9	37.3	32.8	29.9	56.3	54.4						
- renewable energy forms and industrial waste	28.5	23.6	25.3	25.6	24.9	23.5	23.3						
Transport sector													
Passenger transport activity (Gpkm)	21.6	21.4	25.0	26.9	29.5	32.8	35.6	37.1	38.0	1.5	1.7	1.9	0.7
Public road transport	6.5	4.1	3.5	3.1	3.3	3.5	3.7	3.8	3.8	-0.0	-0.6	1.1	0.4
Private cars and motorcycles	13.5	16.5	20.5	22.7	24.9	27.8	30.1	31.4	32.1	4.3	2.0	1.9	0.6
Rail	1.4	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.1	-6.8	1.7	1.9	1.1
Aviation	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	3.7	4.9	4.7	3.3
Inland navigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Freight transport activity (Gtkm)	9.1	6.4	8.2	14.3	22.4	29.8	34.8	38.6	40.9	-1.1	10.6	4.5	1.6
Trucks	4.9	3.3	5.3	11.0	18.4	25.2	29.3	32.5	34.6	0.8	13.3	4.7	1.7
Rail	4.2	3.1	2.9	3.2	4.0	4.6	5.5	6.0	6.3	-3.8	3.4	3.3	1.3
Inland navigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Energy demand in transport (ktoe)													
Public road transport	51	33	27	23	25	26	26	26	25	-6.2	-0.9	0.3	-0.2
Private cars and motorcycles	942	918	809	829	862	961	1012	951	859	3.5	-0.2	1.3	-1.8
Trucks	191	329	316	570	1000	1362	1535	1625	1635	5.8	12.2	4.4	0.6
Rail	29	29	34	29	35	40	43	42	31	1.4	0.3	2.1	-3.2
Aviation	27	20	25	23	29	35	40	44	48	-0.8	1.6	3.3	1.9
Inland navigation	0	0	0	0	0	0	0	0	0				

Source: EU energy trends to 2030 – update 2009 (2010), pp. 114-115.

Table A2: Equation summary.

Equ'n set	Endog var	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	Units	NVAR 2
1	FR0	FRY	PREN	FRID	ZRDM	ZRDT	FRK	RDEU				th.toe	9
2-5	FRF	FR0	PFrf	FRID	ZRDM	ZRDT	FRK	RDEU				th.toe	9
6	RSCP	PRPDP	RRLR	CDEP	ODEP	RVD	RDEU	RUNR	RPSC			m euro 2000 prices	10
7	CR/RMAC	PRPDP	PRCR	RRLR	PRSC	CDEP	ODEP	RDEU				consumption ratio	9
10	KR	YR	PER/PYR	YRWC	PQRM(3)	RDEU	RRLR	YYN				m euro 2000 prices	9
11	QEX	QWXI	PQEX	PQRW	YRKC	YRKN	SVIM	RDEU				m euro 2000 prices	9
12	QIX	QZXI	PQRX	PQRZ	YRKC	YRKN	SVIM	RDEU				m euro 2000 prices	9
13	QEM	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM	RDEU	YYN		m euro 2000 prices	11
14	QDM	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM	RDEU	YYN		m euro 2000 prices	11
15	YRH	YNH	YRKC	YRKN	RDEU	YYN						hours per week	7
16	YRE	YR	LYLC	YRH	PQRM(3)	YRKC	YRKN	RDEU				thousd	9
17	PYH	YRUC	PQRM	YRKC	YRKN	PQRM(3)	REDU	YYN				index 2000=1	9
18	PQRX	PQRY	PQRE	PQWE	EX	YRULT	YRKC	YRKN	RDEU			index 2000=1	10
19	PQRM	PQRF	PQRE	PQWE	EX	YRUL	YRKC	YRKN	RDEU			index 2000=1	10
20	YRW	LYWE	LYRXE	LYRP	RUNR	RBNR	LAPSC	ARET	RDEU	DLAPSC	YYN	th. Euro per person-year	12
21	LRP	RSQ	RWSR	RUNR	RBNR	RSER	RDEU					rate [0,1]	8
22	RRI	RWS	RPSC	VRYM	RLR	RDEU						m euro	7
23	RDW	RRPD	RRLR	CDEP	ODEP	RDEU	RUNR	RPSC				m euro 2000 prices	9
24	YRN	YRY	YRX	RDEU								m euro 2000 prices	5
31	MU	QR	PMAT	YRD	KR	MUM	RDEU					th. tonnes	

Source: E3ME Manual (2012).

Table A3: Baseline assumptions, complete with sources.

DATA SOURCES	
World assumptions	
1. Commodity prices	
- food	CE own assumptions
- beverages	CE own assumptions
- agricultural raw materials	CE own assumptions
- metals	CE own assumptions
- energy	IEA, PRIMES
- oil	IEA, PRIMES
- global inflation	CE own assumptions
Region specific assumptions	
1. Exchange rates	DG ECFIN AMECO database over historical, fixed afterwards

- euro exchange rates (WREX)	
- purchasing power standard (WRPX)	
2. Interest rates	DG ECFIN AMECO database over historical, fixed afterwards
- short-term rate (WRSR)	
- long-term rate (WRLR)	
3. Macro variables	Not use for E3ME regions (endogenous) forecasts calibrated to PRIMES 2009 projection Historical data stored in databank from Eurostat Other Regions (CE own assumptions + results from E3MG modelling)
- GDP (WGDP)	
- GDP deflator (WHUC)	
4. Government consumption (WRSG, GW01, GW02, GW03)	Eurostat, Cambridge Econometrics
- defence	- fixed after last year of historical data
- education	- fixed after last year of historical data
- health	- fixed after last year of historical data
5. Fiscal policy	DG ECFIN AMECO database, DG TAX AND CUSTOMS “Taxes in Europe” database over historical period, fixed afterwards
- taxes on goods and services (WITR)	
- standard rate on VAT (WSVT)	
- taxes on income and capital gains (WDTR)	
- taxes on international trade (WTTR)	
- subsidies and other transfers to households (WBNR)	
- social security taxes paid by employees (WSSR)	
- social security taxes paid by employers (WERS)	
6. Population (WRPO, PAR1.... PAR6)	Eurostat population projections
- total population	
- male/female split	
- children/working-age/ old-age pensioner split	

7. Labor force (LRP1, LRP2)

Not use for E3ME regions (endogenous)
 Historical data stored in databank from Eurostat LFS

- male/female participation rates

Source: E3ME program.

Table A4: Baseline assumptions for Slovenia and the world in the E3ME model.

SLOVENIA			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Code	Description	unit																						
WEXCH	Exchange rate	local currency per euro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEXCH	Exchange rate PPP (not used)	local currency per euro	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
WEXR0	Interest rate: short run (not used)	percent	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
WEXR1	Interest rate: long run	percent	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
WGRPP_M006	GDP (not used for E3ME regions)	year on year growth	1.79	1.87	2.07	2.20	2.30	2.38	2.50	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
WINDU_M012	Inflation (not used for E3ME regions)	annual rate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WNSGO_M002	Government spending	year on year growth	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
WV DEFENCE	Government spending: Defence	share of total government spending	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
WV EDUCATION	Government spending: Education	share of total government spending	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
WV HEALTH	Government spending: Health	share of total government spending	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
WTRTD_TAX_GMS	Tax: indirect	% share of total tax spending	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
WSTTD_TAX_VAT	Tax: VAT	Rate	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
WSTTD_TAX_INC	Tax: Direct	Rate (years)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
WTRTD_TAX_TRADE	Tax: Import (not used)	Rate	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
WTRBDI_SCHOLTRANS	Scholarship Payment	share of wage	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
WSSDI_SS_TOTAL	Soc. sec employees' contribution	rate	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
WSSDI_SS_EBS	Soc. sec employees' contribution	rate	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
WPOP_WPV_TOTAL	Population	year on year growth	0.25	0.27	0.29	0.30	0.30	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
PARF_M_CHILD	Population: male 0-5	share of total population	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
PARF_F_CHILD	Population: female 0-5	share of total population	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
PARF_M_WORK_AGE	Population: male 16-64	share of total population	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
PARF_F_WORK_AGE	Population: female 16-64	share of total population	0.53	0.53	0.53	0.53	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
PARF_M_OLD	Population: male 65+	share of total population	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
PARF_F_OLD	Population: female 65+	share of total population	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
LRP1_M_PARTN_RATE	Participation rate: male (not used)	percent of male working population	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
LRP2_F_PARTN_RATE	Participation rate: female (not used)	percent of female working population	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675	0.675
WORLD																								
Code	Description	unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
PMG00	Commodity Price: Food	year on year growth	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	
PMG01	Commodity Price: Beverages	year on year growth	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
PMG02	Commodity Price: Agricultural Raw Material	year on year growth	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	
PMG03	Commodity Price: Metals & Minerals	year on year growth	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
PMG04	Commodity Price: Energy	year on year growth	6.03	6.02	6.02	6.02	6.02	6.02	5.86	5.86	5.86	5.86	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	
PMG05	Commodity Price: Brent oil	year on year growth	20.58	2.2	2.2	2.2	2.2	2.2	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	6.87	
PMG07	Aggregate Global Inflation	year on year growth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Source: E3ME program.

output for most sectors, but household fuel demand is a function of total consumers' expenditure. A restriction is imposed such that as activity increases then demand for energy use will not decline (all other factors being equal).

The average price ratio captures the effect of prices relative to the fuel used, and is deflated by unit costs. The equations have been tested so that relative price increases cause demand to fall but relative price decreases have no effect. Such asymmetrical price effects in aggregate energy demand equations have been the subject of other research (Gately, 1993; Walker and Wirl, 1993; Grubb, 1995). The idea is that because energy is used via capital stock with a long lifetime, and since technical change is progressive and is not generally reversed, when energy prices rise and energy savings are introduced, then when energy prices fall again, these savings are not reversed i.e. energy demand responds to rises in real prices, but not falls. The effect changes the properties of the model in a non-linear fashion: if in the base run real energy prices fall over the projection period, then increases in energy taxes will have no effect until they start to increase real prices (one year to the next, not compared to the base).

The long-run price elasticity for road fuel is imposed at -0.7 for all regions, also Slovenia, following the research on long-run demand (Franzen and Sterner, 1995) and (Johansson and Schipper, 1997).

The measures of research and development expenditure and investment capture the effect of new ways of decreasing energy demand (energy saving technical progress) and the elimination of inefficient technologies, such as energy saving techniques replacing the old inefficient use of energy. Research and development expenditure in industries 16-18 (machinery) and 19 (motor vehicles) for the EU as a whole take into account spillover effects from international companies.« (E3ME Manual, 2012, page 49-50).

Tabel A6: *Specification of aggregate demand for energy.*

Co-integrating dynamic equation:

DLN(FR0(.))	[total fuel used by fuel users]
= BFR0(.,1)	[constant]
+ BFR0(.,2) * DLN(FRY(.))	[activity measure]
+ BFR0(.,3) * DLN(PREN(.))	[average price ratio]
+ BFR0(.,4) * DLN(FRTD(.))	[R&D by fuel user]
+ BFR0(.,5) * DLN(ZRDM)	[EU R&D in machinery]
+ BFR0(.,6) * DLN(ZRDT)	[EU R&D in transport]
+ BFR0(.,7) * DLN(FRK(.))	[investment by fuel user]
+ BFR0(.,8) * DRDEU	[German unification]
+ BFR0(.,9) * D09R	[2009 recession dummy]
+ BFR0(.,10) * DLN(FR0(-1))	[lagged changes in fuel use]

Co-integrating long-term equation:

DLN(FR0(.))		[total fuel used by fuel users]
=	BFR0(.,11) * ECM(-1)	[lagged error correction]
+	BFR0(.,12)	[constant]
+	BFR0(.,13) * LN(FRY(.))	[activity measure]
+	BFR0(.,14) * LN(PREN(.))	[average price ratio]
+	BFR0(.,15) * LN(FRTD(.))	[R&D by fuel user]
+	BFR0(.,16) * LN(ZRDM)	[EU R&D in machinery]
+	BFR0(.,17) * LN(ZRDT)	[EU R&D in transport]
+	BFR0(.,18) * LN(FRK(.))	[investment by fuel user]
+	BFR0(.,19) * RDEU	[German unification]
+	BFR0(.,20) * D09R	[2009 recession dummy]
+	ECM	[error]

Identity:

PREN	=	PFR0(./PRYM	[average price ratio]
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Restrictions:

BFR0(.,3 .,4 .,5 .,6 .,7 .,14 .,15.,16 .,17 .,18) <=0	[‘right sign’]
BFR0(.,2), BFR0(.,13) >=0	[modeling energy demand/activity ratio]
0>BRF0(.,11)>-1	[‘right sign’]

Definitions:

BFR0	is a matrix of parameters
FR0	is a matrix of total fuel used by 22 fuel users for 33 regions, th toe.
PREN	is a matrix of average price used deflated by unit cost for 33 regions, euro/toe
FRY	is a matrix of activity for 22 fuel users and 33 regions, m euro at 2005 prices
FRTD	is R&D in machinery by the EU, m euro at 2005 prices
ZRDM	is R&D in transport by the EU, m euro at 2005 prices
ZRDT	is a matrix of investment by 22 fuel users for 33 regions, m euro at 2005 prices
FRK	is a matrix of prices of value added at market prices for each region (2005 = 1.0, local price)
PRYM	is a matrix of average prices in euro/tonne of all fuels used by each fuel user
PFR0	is a matrix of average prices in euro/tonne of all fuels used by each fuel user
RDEU	is a dummy matrix for German unification (=0 for other countries)
D09R	is a dummy matrix for 2009 recession (=0 until 2008, =1 from 2009 onward)
(.)	indicates that a matrix is defined across sectors
LN	indicates natural logarithm
DLN	indicates change in natural logarithm
ECM	[error]

Source: E3ME Manual (2012).

In Table A7 we show the values of estimated parameters of aggregated demand for energy for Slovenia.

Table A7: Values of parameters of aggregated demand for energy function for Slovenia.

FUEL USERS	COEFFICIENTS																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Power own use & trans.	0.055	0	-0.328	0	-0.456	0	-0.473	0	0	-0.2	-0.95	7.964	0.247	-0.177	0	-0.088	-0.058	-0.027	0	0
2 O energy own use & tra	-0.064	0	-0.031	0	-0.64	0	0	0	0	-0.2	-0.2	5.337	0.232	-0.331	-0.086	-0.019	-0.056	-0.044	0	0
3 Iron & steel	0.02	0	0	0	0	-1	0	0	0	0.6	-0.95	9.106	0.117	-0.263	-0.091	-0.249	-0.037	-0.013	0	0
4 Non-ferrous metals	0.005	0	-0.85	0	0	0	-0.169	0	0	0.095	-0.216	7.931	0.297	-0.311	-0.015	0	-0.184	-0.208	0	0
5 Chemicals	0.008	1.2	-1.3	0	0	0	0	0	0	0.093	-0.417	7.69	0.432	-0.253	-0.135	-0.073	-0.308	-0.011	0	0
6 Non-metallics nes	0.138	0.06	-0.273	-0.032	0	0	-0.021	0	0	0.01	-0.799	6.685	0.292	-0.279	-0.05	-0.027	-0.132	0	0	0
7 Ore-extra (non-energy)	0.153	0	-1.3	0	0	0	0	0	0	-0.2	-0.2	9.544	0.751	-0.331	0	-0.166	-0.653	-0.026	0	0
8 Food, drink & tob.	-0.008	1.2	-1.3	0	0	0	0	0	0	-0.2	-0.936	4.555	0.609	-0.221	-0.003	-0.14	-0.061	-0.251	0	0
9 Tex., cloth. & footw.	-0.078	1.2	-0.504	-0.295	-1	0	-0.111	0	0	-0.2	-0.2	7.24	0.546	-0.269	-0.015	-0.049	-0.44	-0.08	0	0
10 Paper & pulp	0.049	0	-1.024	0	0	-1	-0.06	0	0	0.159	-0.2	4.684	0.635	-0.387	-0.005	-0.029	-0.106	-0.091	0	0
11 Engineering etc	0.065	0	-0.871	0	-1	0	-0.27	0	0	0.134	-0.2	6.39	0.406	-0.214	-0.005	-0.162	-0.155	-0.04	0	0
12 Other industry	0.076	0	0	0	0	0	-1.56	0	0	0.228	-0.95	12.476	0.709	-0.492	-0.02	-0.512	-0.278	-0.358	0	0
13 Rail transport	-0.042	0.844	-0.344	0	0	0	-0.024	0	0	-0.2	-0.723	5.764	0.19	-0.212	0	-0.136	-0.043	-0.016	0	0
14 Road transport	-0.107	0	-0.095	0	0	0	0	0	0	0.454	-0.574	6.184	0.602	-0.7	0	0	-0.021	-0.008	0	0
15 Air transport	0.035	0	0	0	0	0	-0.013	0	0	0.249	-0.2	5.399	0.457	-0.403	0	-0.174	0	-0.065	0	0
16 Other transp. serv.	0	0	0	0	0	0	0	0	0	0	0	0	0.146	-0.359	0	-0.08	-0.38	-0.327	0	0
17 Households	-0.004	0	0	0	0	0	0	0	0	-0.2	-0.2	3.875	0.718	-0.217	0	-0.026	-0.072	-0.258	0	0
18 Other final use	0.362	0	-0.91	-0.228	0	0	-3	0	0	0.6	-0.95	5.73	0.666	-0.248	-0.049	-0.085	-0.038	-0.361	0	0
19 Non-energy use	0.124	0	-0.681	0	-1	0	0	0	0	-0.2	-0.2	7.721	0	-0.221	0	-0.003	-0.133	0	0	0

Source: E3ME model.

The price elasticities of energy demand for fuel users are for example shown in column 3 and 14. Column 3 shows price elasticities of demand based on co-integrating dynamic equation, while column 14 shows long term elasticities of demand based on co-integrating long-term equation.. For example, 1% increase of average price ratio (variable PREN) causes decrease in quantity demanded for energy in road transportation for 0.7%.