WORKING PAPERS

88

Viliam Páleník – Tomáš Miklošovič

CGE MODELLING OF MACROECONOMIC EFFECTS OF ENVIRONMENTAL TAXES AS AN EU OWN RESOURCE – CASE OF SLOVAKIA

ISSN 1337-5598 (electronic version)

The WORKING PAPER SERIES is intended to convey preliminary, partial results of ongoing research achieved by fellows or research groups of the Institute of Economic Research which can be prepared for later publications.

AUTHORS
RNDr. Viliam Páleník, PhD.
Mgr. Tomáš Miklošovič, PhD.

REVIEWERS
Ing. Karol Frank, PhD.

Ing. Marek Radvanský, PhD.

The article was written as a part of the project VEGA 2/0181/15„Analyzing the Impact of European Legislation in the Field of Taxes and Pensions on Slovak Economy with the Emphasis on the Sustainability of Public Finance“.

ABSTRACT

CGE Modelling of Macroeconomic Effects of Environmental Taxes as an EU Own Resource – Case of Slovakia

This study continues in the previous work of authors that describes the concept of EU own sources reform through the introduction of environmental tax in the amount of 1 % of the gross domestic product with a parallel decreasing of the tax burden by the same amount. Calculations of macroeconomic effects were executed with the help of CGE model with the focus on Slovakia. Calculations of macroeconomic effects were executed with the help of CGE model with the focus on Slovakia proved positive macroeconomic effects. The extent of those effects depends on reaction of enterprises and their employees to decreasing of labour tax in those ranges (medium term effect):
– Positive aspects on GDP (between 1.2 % to 3.9 %) and the income of households (between 2.9 % to 5.1 %).
– Number of employees increases from between 30 thousand (1.5 % negative scenario) to 150 thousand (6.5 % positive scenario).
Macroeconomic effects of scenarios with the profit of enterprises from decrease of labour tax are significantly higher than the influence of scenarios with profiting households. Differences among scenarios introducing reforms in Slovakia only and introducing reforms in whole EU are quite small.

KEYWORDS: environmental tax, CGE model, EU own resource

JEL CLASSIFICATION: C68, H23

ABSTRAKT

CGE modelovanie makroekonomických dopadov environmentálnej dane ako nového typu vlastného zdroja EÚ – prípad Slovenska

Táto štúdia je pokračovaním práce autorov, ktorí v predchádzajúcich štúdiách navrhovali zavedenie konceptu novej environmentálnej dane vo výške 1 % hrubého domáceho produktu ako nového vlastného zdroja Európskej únie. Zároveň so zavedením tejto novej dane by prišlo k poklesu iného daňového zaťaženia v rovnakej výške. Kalkulácie takto navrhovaných dopadov boli vykonané za pomoci modelu všeobecne vypočítateľnej rovnováhy so zameraním na Slovensko. Výsledky kalkulácií indikujú pozitívne makroekonomické efekty. Rozsah dopadov závisí od reakcií zamestnávateľov a ich zamestnancov na zníženie daňového zaťaženia z práce. Namodelované boli tieto predpokladané dopady (v strednodobom horizonte):
– Pozitívny vplyv na HDP (medzi 1,2 % až 3,9 %) a príjem domácností (medzi 2,9 % až 5,1 %).
– Počet pracujúcich vzrástol od 30 tisíc (1,5 %, negatívny scenár) až 150 tisíc (6,5 %, pozitívny scenár).
Makroekonomické efekty v scenári, v ktorom primárne zo zníženia daňového zaťaženia profitovali podniky, boli signifikantne pozitívnejšie ako v prípade scenára, v ktorom primárne profitovali domácnosti. Celkové rozdiely scenárov, kde bola nová environmentálna daň zavedená len na Slovensku a v EÚ sú pomerne malé.

The views expressed in the WP and the language revision is those of the authors.
Layout by: Hajnalka Maršovská

Institute of Economic Research SAS/ Ekonomický ústav SAV, Šancová 56, 811 05 Bratislava, www.ekonom.sav.sk
CONTACT: viliam.palenik@savba.sk, tomas.miklosovic@savba.sk

Contents

INTRODUCTION

This study continues in the previous work of authors that describes the concept of EU own sources reform through the introduction of environmental tax in the amount of 1 % of the gross domestic product with a parallel decreasing of the tax burden by the same amount (Páleník, Miklošovič; 2015). Calculations of macroeconomic effects were made with the CGE model with the focus on Slovakia. Authors used CGE model for one country with social matrix for Slovakia and constructed five scenarios. Authors disaggregated the foreign counties in the model on two parts. First one consists from EU countries and second one represent rest of the world. This disaggregate was useful for construct another two alternative scenarios. Particular parts of the study are focused on the description of applied CGE model, the definition of modelled scenarios, the final discussion of achieved results and conclusion.

1 CGE MODEL METHODOLOGY

Relations among individual variables in all models of computable general equilibrium are calibrated on data bases of so-called benchmark balance (from the year of data collection). Calibration process generates ratio and sub-parameters depending on exogenously defined elasticity of behaviour, so the model could duplicate input data. The majority of CGE models are comparatively static. This is why CGE models benefit from the assumption ceteris paribus while modelling the launch of exogenous shocks and sudden changes of economic policies.

Macroeconomic theory of balance forms the basis of models of computable general equilibrium and was presented by a French economist León Walras in 1874. His theory was further elaborated, mathematically defined and numerically described by Arrow and Debreu (Arrow, Debreu; 1954). Computable general equilibrium model is a numerical result of this theory.

The structure of used CGE model comes from (Dervis, De Melo, Robinson; 1982). The structure of program code comes from the model USDA (Robinson, Kilkenny, Hanson; 1990). The basis of the static part of the model comes from authors McDonald, Robinson and Thierfelder (McDonald, Robinson, Thierfelder; 2005). Entry database for the model is the social accounting matrix (SAM) for Slovakia and year 2010 created by authors and to be found in the annex. The model contains 92 endogenous variables which they are calculated in 92 linear and non-linear equations.

We constructed a market balance assuming a rational behaviour of all subjects. In this situation would a total supply equal to a total demand.

The first formulas create a budget limitation of households that maximized their effectiveness while using only their income. There was no profit of firms in the economy since any positive results would create a potential for establishing a new company and a market wouldn't be ideally competitive. CGE model is a macroeconomic model so it is not necessary to use real values

of goods but only relative prices. We opted for the index of consumer prices as a numeraire. All other prices were relatively compared with those numeraire.
Foreign were for the purpose of environmental tax simulation divided into two groups. The first group represents European Union (marked as $w1$ in equations) and the second group represents the rest of the world (marked as $w2$ in equations). All relations among domestic institutions and foreign were subsequently transformed to this two group of foreign. One of the main assumptions is the fact, that there is no labour movement between domestic and foreign countries. Then, we chose the aggregation of production commodities and production activities. It means that Slovakia is represented by one production sector producing just one commodity (product).
The used CGE model was created in IER SAS and is being recursive dynamic. But only its static feature was used for each simulation (all exogenous shocks were applied in the same time).

We used the principle of nested functions while modelling the production in order to copy the real world and it reflects better specific features of economy. General production can be divided into two parts. First part represents a demand for work and capital while the other represents the demand for consumption of inputs. The advantage of using nested production functions is that each nested function can have different elasticity of substitution for demand (after the function describing added value (L, K)) and different for the function that models the intermediate consumption demand.
Prices of domestic products used at home (or at domestic country) are defined as PQD and their price is always the same regardless the consumer. Domestic demand is divided to the intermediate consumption demand $QINTD$ and the final demand. The final demand splits into the demand of household QCD, the demand of government QGD, the demand of es $QENTD$, investments QINVD and changes in stock d$stockconst$. The value of domestic demand (costs of acquisition) is $\mathrm{PQD} * \mathrm{QQ}$, where QQ is composite commodity. Export is marked as QE_w and a price for particular exported goods is $PE_w = PWE_w * ER_w$. Word export price is PWE_w and exchange rate for foreign country is ER_w. The difference in the price of exported goods and the price of domestic products used inland is formed by export taxes TE_w depending on the group of foreign country.
Domestic producers form a commodity supply and receive a common price PXC for each commodity unit. Overall domestic commodity production is marked as QXC. Domestic price of import PM_w is applied to commodity import QM_w and is influenced by a global price PWM_w, exchange rate ER_w and tax rate of imported goods TM_w.
All commodities, which are consumed on a domestic market, are influenced by various production taxes, value added tax, sales tax, other taxes and product subventions. Domestic production is evaluated by average output price PX that is formed by aggregated inputs on one unit of output. The necessary primary inputs for a production FD_f are already consists in average price WF_f.

Domestic demand for fixed assets consists from demand of fixed capital $QINVD$ and changes in stock $dstocconst$. Change in stock is defined as an exogenous variable in the model and remains constant. Domestic savings consists of household savings, corporate savings and savings of government. Abroad savings $CAPWOR_w$ balance overall external account.

Abroad income is constituted by expenses of domestic economy that consists of imported production and the use of production factors. Income of domestic economy, including exported commodities and net transfers from abroad to particular institutions, basically represents abroad expenses. Exchange rates (different for both categories of foreign countries) step into all international transactions (for example foreign country and government).

The price of supply for composite commodity PQS is defined as a weighted average price of commodities produced and consumed by domestic market PDD and the domestic price of imported commodities PM.

The price of imported commodity is composed of a worldwide price PWM_w and an exchange rate $ER_w$with additionally applied income tax TM_w. Weights of prices are calculated through first order conditions for optimal solution.

Average prices don't include sales tax yet TS to get overall consumer price of composite commodity PQD. Production price of commodities PXC is defined in the same way. This price consists of weighed average prices of commodities from domestic producers sold on a domestic market and exported abroad PE_w.

The price of export is calculated from the world price of export PWE_w and exchange rate ER_w adjusted by tax additionally imposed on exported commodities TE_w.

Average price for one unit of output obtained from activity PX is defined as the weighted average of domestic producers' prices whose weights are constant. Those prices are divided after paying production taxes TX into paid aggregated value added price PVA and an aggregated price of intermediate inputs $PINT$. The aggregated value added price includes prices paid for primary production inputs. Overall payments for intermediate inputs against one unit of aggregated intermediate inputs are defined as a weighed sum of prices of inputs into tion PQD.

The consumption of households was modelled through the function of utility maximisation (Stone – Geary utility function). This form of utility function is the completion of Cobb – Douglas utility function. With suitable parameters it is possible to reduce Stone Geary form to Cobb – Douglas utility function. Products and services are consumed by households based on their budget limitations. They choose from the basket of „composite“ product that consists of goods produced at home and from imports. This „composite“ product is modelled by the means of CES[1] utility function (Armington assumption).

$$QCD = \frac{\left(\left(PQD*qcdconst+beta*(HEXP-PQD*qcdconst)\right)\right)}{PQD} \quad (1)$$

[1] CES – Constant Elasticity of Substitution.

Demand for products QCD is expressed in the equation 1 that divides consumption to inevitable (basic goods) and the rest that increase living standards of households.

Inevitable consumption $qcdcons,$ is calculated through Frisch parameter in the calibration part of the model. A consumption increasing living standards is modelled as a marginal utility from each additional product of consumption. This marginal utility is expressed by ter $beta$. Expended resources for an additional consumption are calculated as a difference between overall household expenses and used resources to secure inevitable consumption. Household income, the equation 2, consists of obtained payments for using factors of production via transfer from enterprises $HOENT$, via transfer from abroad $howor_w$ (adjusted by exchange rate) and a real transfer from government $hogovconst$ adjusted with scale ble $HGAD$. Overall size of household expenses is described by the equation 3. It specifies the amount of household expenses used for consumption. It is overall household income, amended by paid direct taxes and the volume of savings.

$$YH = \left(\sum_f hovash_f\, YFDISP_f\right) + HOENT + (hogovconst * HGADJ * CPI) + \left(\sum_w howor_w\, ER_w\right) \tag{2}$$

$$HEXP = \left(\left(YH * (1 - TYH)\right) * (1 - SHH)\right) \tag{3}$$

The price of commodity shaped by the supply on the domestic market PQS (the equation 4) is designed as a weighted price of domestic production PD and an import PM_w reflecting the volume of domestic production QD the import from abroad QM_w. This value is calibrated by the overall quantity of the composite commodity QQ.

The model generates the price of commodity produced on the domestic market PXC (the equation 5), calculated as a weighed price of a domestic production and prices for export PE_w. This value is calibrated by the overall quantity of commodity produced on the domestic market QXC.

Domestic institutions consume composite commodities consisting from import and domestic commodities, whose price is derived according to the equation 6. The price of these composite commodities consists of the price of domestic market supply including sales tax rate TS and a consumption tax TEX.

$$PQS = \frac{PD * QD + \sum_w (PM_w * QM_w)}{QQ} \tag{4}$$

$$PXC = \frac{PD * QD + \sum_w (PE_w * QE_w)}{QXC} \tag{5}$$

$$PQD = PQS * (1 + TS + TEX) \tag{6}$$

The equation 7, 8 and 9 describe the optimal domestic output QXC between an export abroad QE_w and an output for domestic market QD while using CET[2] transformation function. Equations 7 and 8 describe first order conditions accomplished for optimal quantity of outputs in the equilibrium. This equation determines the share of the export and the domestic production based on export prices PE_w and a domestic price PD.

$$QXC = at * \left(\gamma_{w1} * QE_{w1}^{rhot} + \gamma_{w2} * QE_{w2}^{rhot} + (1 - \gamma_{w1} - \gamma_{w2}) * QD^{rhot}\right)^{\frac{1}{rhot}} \quad (7)$$

$$\frac{QE_{w1}}{QD} = \left[\frac{\frac{PE_{w1}}{PD} * (1 - \gamma_{w1} - \gamma_{w2})}{\gamma_{w1}}\right]^{\frac{1}{(rhot-1)}} \quad (8)$$

$$\frac{QE_{w2}}{QD} = \left[\frac{\frac{PE_{w2}}{PD} * (1 - \gamma_{w1} - \gamma_{w2})}{\gamma_{w2}}\right]^{\frac{1}{(rhot-1)}} \quad (9)$$

The supply of commodity on the domestic market is modelled by CES function, the equation 10, with following variables: imported commodities QM_w, an output for domestic market QD elasticity of substitution $rhoc$, the effectiveness of commodities ac and a commodity parameter δ. Optimal ratio between the quantity of imported commodities and the supply for domestic market is calculated using the first order conditions (equations 11, 12), based on relative prices of imported commodities PM_w and a domestic price PD.

$$QQ = ac * \left(\delta_{w1} * QM_{w1}^{-rhoc} + \delta_{w2} * QM_{w2}^{-rhoc} + (1 - \delta_{w1} - \delta_{w2}) * QD^{-rhoc}\right)^{\frac{-1}{rhoc}} \quad (10)$$

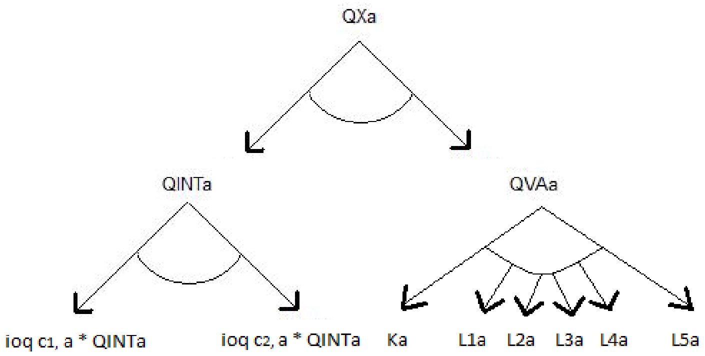
$$\frac{QM_{w1}}{QD} = \left[\frac{\frac{PD}{PM_{w1}} * \delta_{w1}}{(1 - \delta_{w1} - \delta_{w2})}\right]^{\frac{1}{(rhoc+1)}} \quad (11)$$

$$\frac{QM_{w2}}{QD} = \left[\frac{\frac{PD}{PM_{w2}} * \delta_{w2}}{(1 - \delta_{w1} - \delta_{w2})}\right]^{\frac{1}{(rhoc+1)}} \quad (12)$$

We used two level structure of production in the model. The CES production function was used in the upper production level. In the lower production level was used Leontief production function or CES production function. Upper level is descripted in the equation 15. In this formula, we combine value added and intermediate consumption as the basic parts of products.

[2] Constant Elasticity of Transformation.

Picture 1
Two level structure of production



Source: Authors.

The value of activity output is considered to be the sum of expenses for inputs into production with a production tax TX already applied. This is reflected in the equation 13. But it is necessary to define an aggregated price of intermediate inputs $PINT$, (equation 14) that is calculated as a weighed sum of intermediate input matrix $ioqtdqd$ and prices of domestic commodities.

We calculate the output of activity QX through CES production function and with the help of added value QVA and aggregated quantity of intermediate inputs INT. This relation is expressed in the equation 15. There are following variables that are already incorporated in the elasticity CES production function: the elasticity of substitution $rhoc^x$, the parameter of activity ratio δ^x and a variable efficiency of activity ADX. The optimal ratio between used added value and the intermediate input is calculated through the first order conditions for optimal solution with the help of the relative change of prices for these inputs and is reflected in the equation 16.

$$PX * (1 - TX) * QX = (PVA * QVA) + (PINT * QINT) \tag{13}$$

$$PINT = ioqtdqd * PQD \tag{14}$$

$$QX = ADX\left(\delta^x QVA^{-rhoc^x} + (1 - \delta^x) QINT^{-rhoc^x}\right)^{\frac{-1}{rhoc^x}} \tag{15}$$

$$\frac{QVA}{QINT} = \left[\frac{\frac{PINT}{PVA} * \delta^x}{(1 - \delta^x)}\right]^{\frac{1}{(1+rhoc^x)}} \tag{16}$$

The second level of production level is divided into two parts. The first part is modelled added value. The second part is modelled intermediate consumption. The model used on modelling added value the CES production function. Factors like labour and capital are inputs for this part of production. Apart from those production factors, there are others inputs into the equation 17 like the parameter of factor proportion δ_f^{va}, the elasticity of factor substitution ρ_a^{va}, the variable for effectiveness of value added production $ADVA$ and the variable of effectiveness for individual production factors $ADFD_f$.

The first order condition of the function that maximise utility is reflected in the equation 18. It describes the payment for individual factors (capital, labour) that were used for the production. There is the quantity of used factor FD_f and the variable of effectiveness for individual production factors $ADFD_f$ apart from the price of factors WF_f and proportional share of factor on the activity $WFDIST_f$ in this equation.

We consider the use of Leontief production function for the modelling of intermediate input commodity from activity to be the part of above mentioned preconditions of this model.

The equation 19 reflects the calculation of intermediate input demand $QINTD$ that is acquired with the help of the intermediate input supply coming from the activity $QINT$ and intermediate inputs matrix $ioqtdqd$.

$$QVA = ADVA * \left[\sum_f \delta_f^{va} * \left(ADFD_f * FD_f\right)^{-\rho^{va}}\right]^{\frac{-1}{\rho^{va}}} \tag{17}$$

$$WF_f * WFDIST_f * \left(1 + TF_f\right) = PVA * QVA * ADVA * \left[\sum_f \delta_f^{va} * ADFD_f * FD_f{}^{-\rho^{va}}\right]^{-1} * \delta_f^{va} * ADFD_f^{-\rho^{va}} * FD_f{}^{(-\rho^{va}-1)} \tag{18}$$

$$QINTD = ioqtdqd * QINT \tag{19}$$

Factors' income YF_f comes from two sources and is expressed in the equation 20. The first parts of income are payments for the production factors which enter into home production process. The second parts of income are payments for production factors coming from foreign $factwor_{f,w}$ that enter into production process in the foreign countries. The size of factors' income distribution $YFDISP_f$ depends on the equation 21 that adjusts overall income of factors by the depreciation rate of factor $deprec_f$ and eventually by tax for the use of tors TYF_f.

$$YF_f = \left(WF_f WFDIST_f * FD_f\right) + \left(\sum_w factwor_{f,w} * ER_w\right) \tag{20}$$

$$YFDISP_f = \left(YF_f * \left(1 - deprec_f\right)\right) * \left(1 - TYF_f\right) \tag{21}$$

Incomes of government mainly consist from various types of taxes. The overall government income YG (equation 22) consists of selected taxes, an income from government share on production factors, inland transfers from companies to government and transfers from abroad recalculated by exchange rates.

Overall government expenses EG are calculated as a sum of government consumption and real transfers of households and real transfers of companies. Those transfers can proportionately change through scaling variables[3] $HGADJ$ or $EGADJ$. This relation is reflected in the equation 23.

---

[3] The scaling variables are helpful for different type of exogenous shocks in the model. We can use this variable as exogenous or endogenous variable in the calculation.

$$YG = MTAX + ETAX + STAX + EXTAX + FTAX + ITAX + FYTAX + DTAX + \left(\sum_f govvash_f * YFDISP_f\right) + GOVENT + (\sum_w govwor_w * ER_w) \tag{22}$$

$$EG = (QGD * PQD) + (hogovconst * HGADJ * CPI) + (entgovconst * EGADJ * CPI) \tag{23}$$

An important part of the model is the block of capital to calculate the level of household savings SHH and company savings SEN. Total savings in economy are calculated (equation 24) as the sum of household savings, company savings, government savings and savings from the income of production factors and the balance of foreign trade.

The final calculation of total investment $INVEST$ is expressed in the equation 25 where is also the change of stock except the demand for investments.

$$TOTSAV = \left(YH * (1 - TYH)\right) * SHH + \left(YE * (1 - TYE)\right) * SEH + \sum_f \left(YF_f * deprec_f\right) + KAPGOV + \sum_w (CAPWOR_w * ER_w) \tag{24}$$

$$INVEST = PQD * (QINVD + dstocconst) \tag{25}$$

The equation 26 aggregates input production factors from individual activities into an aggregated variable FS_f.

The equation 27 summarizes a composite commodity QQ through a consumption methodology (by demand for commodity). This demand includes a consumption of intermediate input, the consumption of government, companies and households, a demand for investments and the change of stock. Other two equations in this part model size of savings of government and the foreign. Savings of government, the equation 28, are made up of the difference between the income of the government and its expenses. The last equation 29 represents the outland savings $CAPWOR_w$ or the foreign balance. There is an income for imported commodities and income from outland production factors in the foreign income. The foreign expenses include expenses for commodity export, transfers abroad for used production factors and transfers from foreign to households, companies and government.

The difference between foreign incomes and expenses creates the balance of the foreign or foreign savings. Each type of foreign has its own balance expressed in the subset w.

$$FS_f = FD_f \tag{26}$$

$$QQ = QINTD + QCD + QED + QGD + QINVD + dstocconst \tag{27}$$

$$KAPGOV = YG - EG \tag{28}$$

$$CAPWOR_w = PWM * QM_w + \left(\sum_f \frac{YFWOR_{f,w}}{ER_w}\right) - PWE * QE_w - \left(\sum_f factwor_{f,w}\right) - howor_w - entwor_w - govwor_w prew1, w2 \tag{29}$$

The overall consumption of all domestic institutions $VFDOMD$ (equation 30) is defined through the demand for commodities of domestic institutional sectors (households, enterprises and government) and by the price of commodity. We can calculate shares of all domestic institutional sectors and investments (except households) with other equations. Those particular shares of consumption for companies, the government and investments are used for the definition of macroeconomic conclusion (equations 31, 32 a 33).

Particular shares can be calculated as a share of the overall consumption of institutional sector on the overall domestic demand. The equation 34 describes total savings in the economy $TOTSAV$ that are equal to total investments in the economy $INVEST$.

The variable WALRAS is used for the first check of the model calibration. In case the model is correctly calibrated and all equations function well, the value of this equation is equal to zero (if the calibration is not correct, the value of this equation is not equal to zero). The last equation (35) descripted the gross domestic product with the help of the added value. This variable is additional and serves only to assess the total macroeconomic impact of the exogenous shock.

$$VFDOMD = PQD * (QCD + QED + QGD + QINVD + dstocconst) \quad (30)$$

$$VENTDSH = \frac{VENTD}{VFDOMD} \quad (31)$$

$$VGDSH = \frac{VGD}{VFDOMD} \quad (32)$$

$$INVESTSH = \frac{INVEST}{VFDOMD} \quad (33)$$

$$TOTSAV = INVEST + WALRAS \quad (34)$$

$$GDPVA = \left(\sum_f WF_f * WFDIST_f * FD_f\right) + MTAX + ETAX + STAX + EXTAX + FTAX \quad (35)$$

Other equations used in the model are predominantly identities and linear relations that create limits for particular institutional sectors.

We descripted almost all exogenous variables that entered mainly into CES function. Definition and calibration of others variables in CES function is important for the result of simulation while an incorrect setup of exogenous parameters can lead to deviated results. Right calibrations of exogenous variables are crucial for a behavioural modelling of particular subjects on the market because those variables enter various behavioural equations. There exists few works focusing on exogenous variables for production sectors in Slovakia (Lichner, Miklosovic; 2011), (Lichner; 2013). Those research papers can't be compared to specific econometric studies[4] that have dealt with calibration of those variables in different countries and various sectors. Due to this lack of related studies we have used GTAP[5] database to determine various exogenous variables. Import of services and products is defined through CES function stated above (10). The parameter of substitution rhoc enters this equation as an exogenous variable and is calculated with the help of the elasticity of substitution σ_A:

$$rhoc = \frac{1}{\sigma_A} - 1 \tag{36}$$

Values of elasticity of substitution σ_A between a domestic production and an import were used according to study made by Hertel, Hummels, Ivanic and Keeney (2004) who estimated the elasticity of substitution through econometric model.

The export of products and services is modelled through CES function already presented in the equation 7. The parameter of transformation $rhot$ which enters into the equation and is calculated as:

$$rhot = \frac{1}{\sigma_T} + 1 \tag{37}$$

Value of elasticity of transformation σ_T is stated in the table 1. Since there are no values of elasticity of transformation in the GTAP[6], we opted for defining this value based on NZIER (NZIER; 2011). It states values of elasticity of transformation in the range between from -1.46 to -20. We set value on -2 since we assumed a strong interconnection between a foreign trade and European partners.

The elasticity of substitution is used as the first parameter between added value and an intermediate consumption σ_X. This parameter is crucial for formula which calculates final output in the model. We calculate the parameter of substitution $rhocx$ with the help of elasticity of substitution:

$$rhocx = \frac{1}{\sigma_X} - 1 \tag{38}$$

Individual values of elasticity of substitution between the added value and the intermediate consumption were placed equal to 2 according to the model by McDonald, Robinson and Thierfelder (2005). We model the added value in the second level of production through CES production function as well, when particular production factors are inputs into the function.

We need to define the elasticity of substitution for production factors σ_{VA} for specifying overall added value. It helps us to count the parameter of substitution of production factors as well $rhocva$:

$$rhocva = \frac{1}{\sigma_{VA}} - 1 \tag{39}$$

Values of elasticity of substitution come from GTAP database, in particular from the study of Jomini et al. (1991). There is an international overview of studies that assessed this parameter for production sectors using data for multiple countries.

[4] Main reason why exists only few works with specific methodology is missing longer time series without gap.

[5] Global Trade Analysis Project- organisation of researchers dealing with quantitative methods.

[6] Databases supposes a global model, where the elasticity of substitution in imports means the elasticity of transformation in exports.

Income elasticity of demand is used to calculate Stone Geary utility of household function of parameter $beta$ in the model of household demand for a consumption of commodity as described in the equation 1.

This parameter represents a marginal utility from an additional consumption, while an inevitable consumption is already saturated. Values of income elasticity come from Reimera and Hertela study (2004). They state an income elasticity of demand for 10 types of products and 87 countries. Particular values of elasticity of substitution are set up according to a classification of product types into sectors. We used Fisher parameter to define a subsistence minimum of households and set it up to the value of -1.05 according to McDolnald, Robinson a Thierfelder (2005).

Table 1
Values of individual elasticities used in the model

	σ_A	σ_T	σ_X	σ_{VA}	Income elasticity of demand
Value	2	-2	2	1.12	0.81

Source: Prepared by authors.

2 Scenarios

We created five scenarios while modelling inputs of introducing the environmental tax in Slovakia. The first one presents an economic balance of Slovakia based on data from a social accounting matrix for 2010 (to be found in annex).

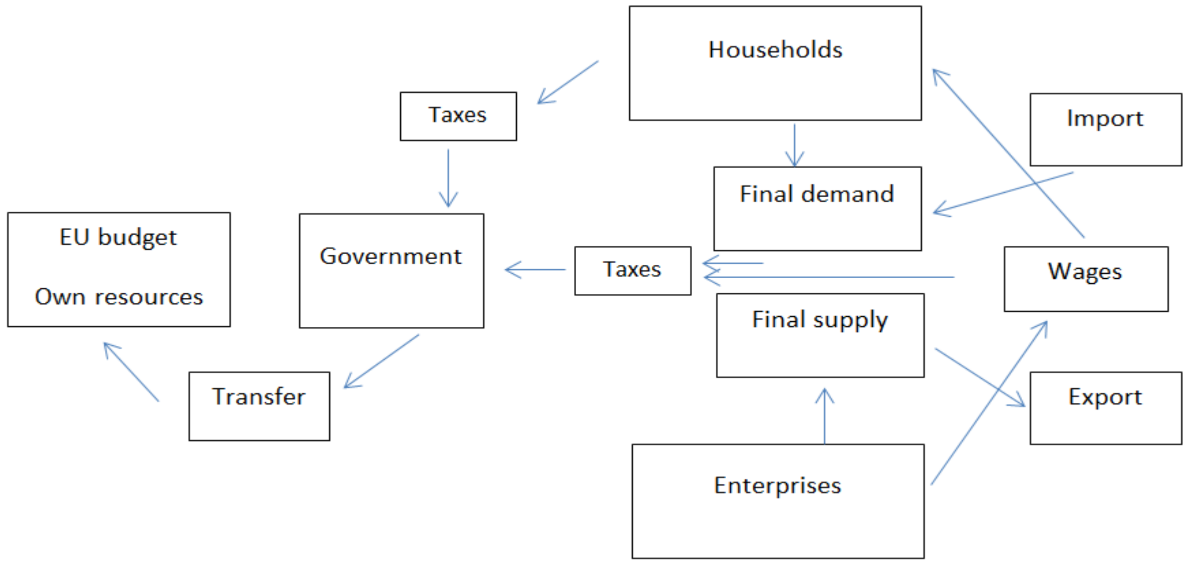
Results of all other scenarios were compared with this fundamental scenario and thereby were able to determine clear effects of incorporating exogenous shocks into the model. There can be observed a simple scheme of economy functions for the fundamental scenario in the picture 2. There are main institutional sectors of economy like household, enterprises, government and foreign. Households and enterprises meet on the market through their final demand or the final supply and it should achieve a balance after saturating their demand. Different subjects pay taxes that form the income of government. The government sends transfer payments into EU budget that finally constitute own sources of EU.

The second scenario represents the introduction of the environmental tax in Slovakia in the amount of 1 % of the gross domestic product (EUR 659 million in 2010). Transfers to EU budget were decreased by the same amount, but on the other hand, by this volume was increased the tax burden of the final consumption. The government compensated smaller transfers to EU budget by decreasing an income tax burden for households. The amount is the same in both cases. The introduction of the environmental tax is fiscally neutral. Subjects that profit the most are households that decrease their labour taxes paid to government. Taxes for enterprises stay unchanged, but the disposable income of households goes up. The simple scheme of the introduction of the environmental tax in Slovakia with the case of most benefits for households is depicted in the picture 3. Let's call this scenario as the alternative scenario H.

The third scenario, the scenario H+EU, represents a simplified reaction of EU economy to similar exogenous shocks introduced in all EU. In scenario H, we expect impact on the disposable income of households, the change in price of products and services in Slovakia due to increased domestic demand and increased the tax burden of the final consumption. Prices of imported goods from EU are expected to grow by the same amount as in the scenario H. The introduction of the environmental tax in EU thus shows most profiting subjects are households not only in Slovakia, but in whole EU.

Picture 2

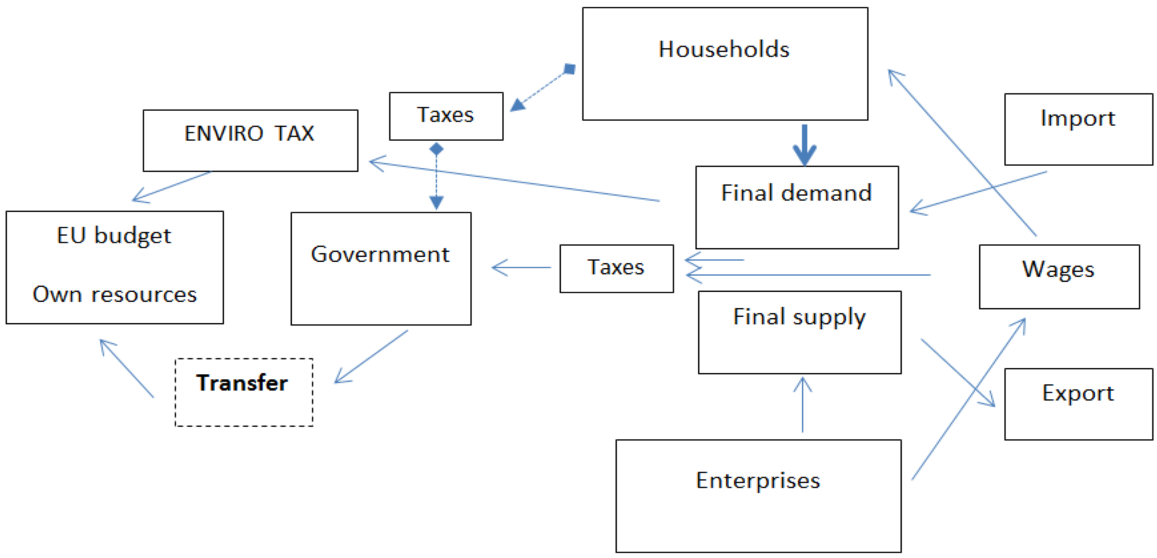
The scheme of economy functions, the baseline scenario



Source: Prepared by authors.

Picture 3

The scheme of economy functions, the alternative scenario H[7]



Source: Prepared by authors.

[7] Rectangle TRANSFER in this picture represents cancelled payment from government to the EU budget.

The fourth scenario represents the introduction of the environmental tax in the amount of 1 % of the gross domestic product. Transfers to EU budget were decreased by the same amount, as in scenario 2 and 3. On the other hand, this volume increased the final consumption. The government compensated smaller transfers to EU budget by decreasing an income tax burden for enterprises in the amount of 1 % of GDP. In the end, the introduction of the environmental tax is fiscally neutral.

Subjects that profit the most are enterprises that decrease their expenses by 1 % of GDP. A total labour costs falls down, but a gross salary remains unchanged. The same happens with a disposable income of households, which remain unchanged. The tax burden of the final consumption increases. Enterprises become more competitive due to decreasing of expenses and are able to increase their production.

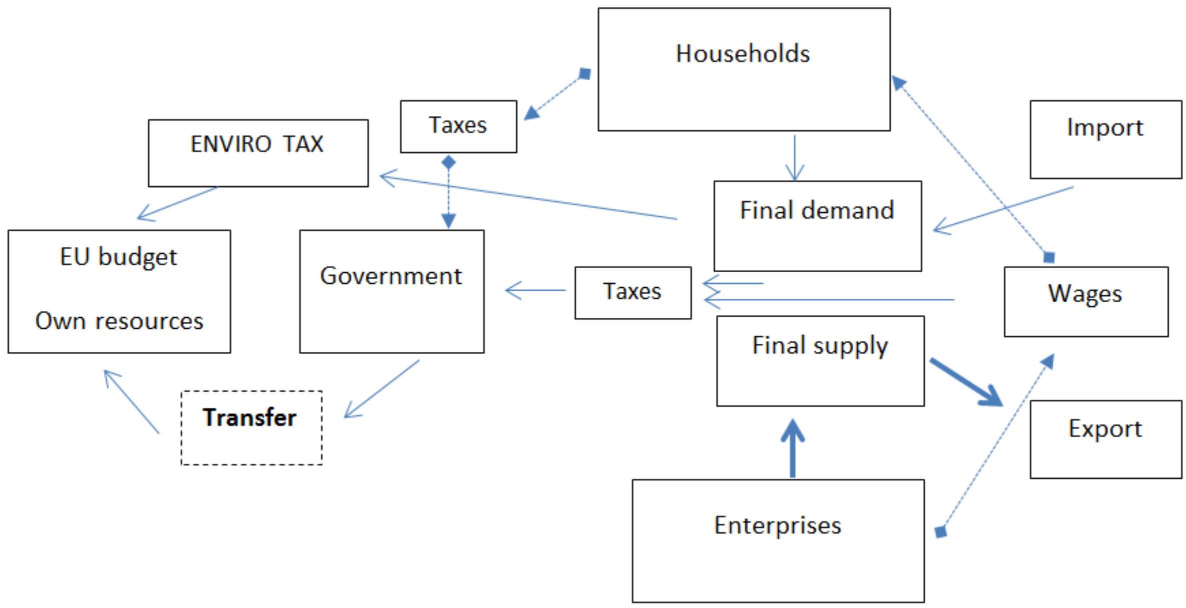
The simple scheme of the introduction of the environmental tax in Slovakia with the case of most benefits for enterprises is depicted in the picture 4. Let's call this scenario as the alternative scenario E.

The last, the fifth scenario features a simplified reaction of EU economy to a flat introduction of exogenous shocks in the whole EU. We expect impacts mainly to product and service price changes in Slovakia due to raising foreign demand and increased tax burden of the final consumption.

With the alternative scenario E+EU, we expect the change of import prices from EU by the same percentage level that occurred in Slovakia in the scenario E. In the end, we can simply present this scenario as the introduction of the environmental tax in EU, when it represents the biggest benefit for both Slovak and EU enterprises.

Picture 4

The scheme of economy functions, the alternative scenario E



Source: Prepared by authors.

3 RESULTS OF SCENARIOS

We described five scenarios in the previous part. Results of model simulations are in absolute values (Table 2), in absolute changes against basic scenario (Table 3) and in relative changes in percentage points (Table 4). We can conclude that all alternatives would positively influence economy. It is visible in the picture 5 that the influence of scenarios E and E+EU is significantly higher than scenarios H and H+EU. On the contrary, the difference between scenarios H and H+EU and scenarios E and E+EU is rather small. More detailed analysis of individual scenarios reveals additional specific information.

Table 2

Results: simulated scenarios of introducing carbon tax in Slovak economy, absolute values, mil. Euro, number of people

	B	H	H+EU	E	E+EU
Gross domestic product	65 897	66 705	66 774	68 468	68 323
Consumption of households	37 142	38 208	38 278	39 048	38 905
Export to EU	44 804	45 396	45 476	46 467	46 302
Export to ROW	8 155	8 262	8 277	8 457	8 427
Import from EU	39 966	40 715	40 741	40 996	40 942
Import from ROW	13 290	13 540	13 574	13 633	13 564
Netto export EU	4 838	4 681	4 735	5 471	5 360
Netto export ROW	-5 136	-5 277	-5 296	-5 176	-5 137
Intermediate consumption	101 126	102 842	103 075	104 101	103 627
Domestic production	164 622	167 105	167 442	170 097	169 408
Income of households	42 858	44 089	44 169	45 058	44 893
Employment (qty of people)	2 316 255	2 350 304	2 354 927	2 466 809	2 457 059

Source: Calculations of authors.

Table 3
Results: simulated scenarios of introducing carbon tax in Slovak economy, absolute changes against scenario B, mil. Euro, number of people

	H	H+EU	E	E+EU
Gross domestic product	808	877	2 571	2 426
Consumption of households	1 066	1 136	1 907	1 764
Export to EU	592	672	1 663	1 498
Export to ROW	108	122	303	273
Import from EU	749	776	1 030	976
Import from ROW	249	283	343	274
Netto export EU	-157	-104	633	522
Netto export ROW	-141	-161	-40	-1
Intermediate consumption	1 715	1 949	2 975	2 501
Domestic production	2 483	2 820	5 475	4 786
Income of households	1 231	1 311	2 200	2 035
Employment (qty of people)	34 048	38 671	150 554	140 804

Source: Calculations of authors.

Let's analyse the scenario H. It affects tax changes in Slovakia only. Households would be sole recipient of a profit from decreased tax burden since salary would remain unchanged in used CGE shock. Salary after taxation would rise, earnings/income and consumption of households as well. Domestic demand would increase and GDP too. Introduction of environmental tax would negatively affect the final domestic demand that would be reflected in the rise of price level and decrease a real economic growth. Based on results of CGE simulation, there would be a positive influence of decreased labour tax over a negative impact of introducing the environmental tax with the GDP growth by 1.2 % and household consumption rise by 2.9 %. On top of that, there are more secondary effects that lead to this result in CGE model. For example, a primary growth of household demand will result in secondary growth of the demand for labour. This leads to employment increase (by 1.5 %), GDP growth and living standards of households measured by their income (by 2.9 %).

Table 4

Results: simulated scenarios of introducing carbon tax in Slovak economy, relative changes against scenario B in %

	H	H+EU	E	E+EU
Gross domestic product	1.2	1.3	3.9	3.7
Consumption of households	2.9	3.1	5.1	4.7
Export to EU	1.3	1.5	3.7	3.3
Export to ROW	1.3	1.5	3.7	3.3
Import from EU	1.9	1.9	2.6	2.4
Import from ROW	1.9	2.1	2.6	2.1
Netto export EU	-3.3	-2.1	13.1	10.8
Netto export ROW	2.8	3.1	0.8	0.0
Intermediate consumption	1.7	1.9	2.9	2.5
Domestic production	1.5	1.7	3.3	2.9
Income of households	2.9	3.1	5.1	4.7
Employment	1.5	1.7	6.5	6.1

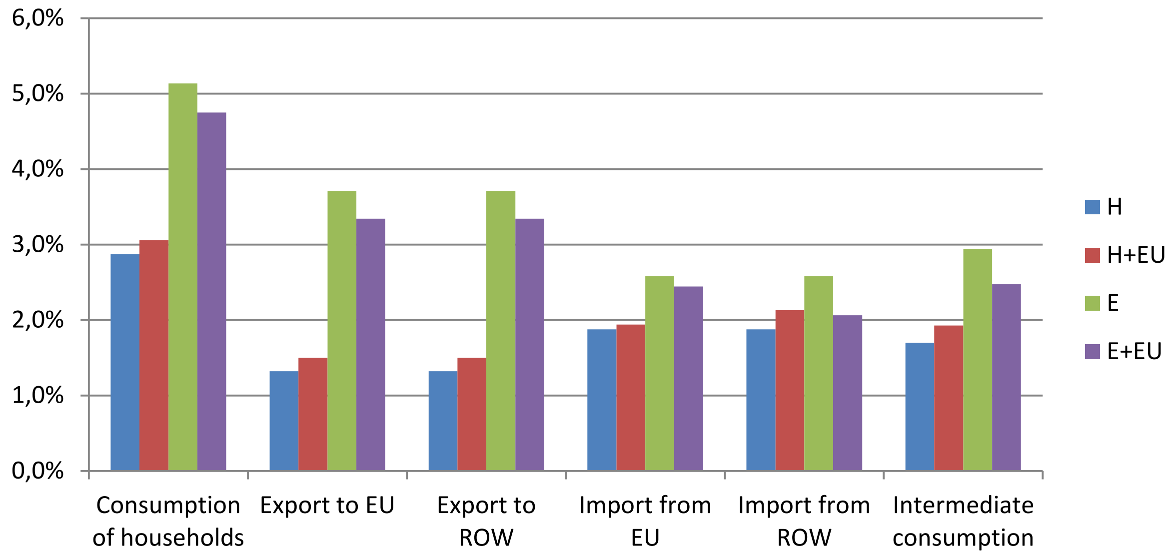
Source: Calculations of authors.

While analysing scenario E we have to look at a simultaneous introduction of the environmental tax and decreasing of labour tax. At the same time, a salary level is decreased by enterprises what makes disposable income of households unchanged. Results visible in the table 4 and the picture 4 show a positive influence of scenario E. Additional growth of GDP is 3.9 % and household consumption is 5.1 %. Negative effect of the environmental tax on economy comes in the form of the raise of consumer price level. Reduction of salary expenses is reflected in the area of production prices that will improve the competitiveness of Slovak producers on domestic and foreign market. This will subsequently result in the raise of export (by 13.1 %), the production, the demand for labour and higher employment (by 6.5 %) and salaries growth. Finally, disposable incomes of households will go up as well. In comparison with the scenario H, positive effects in results of CGE simulation would strongly prevail over negative ones.

The difference between scenario E+EU and the scenario E is that the simultaneous introduction of the environmental tax and the decreasing of labour tax would take place not only in Slovakia, but in the rest of EU so it would enter the category of own resources. Slovak producers would lose a better competitive position and would have to share the benefit of decreased salary expenses with all EU producers. Despite the fact that the scenario E+EU is understandably less advantageous for the Slovak economy than the scenario E, the difference between scenarios is according to the results of CGE simulation quite small. In case of GDP it is only 0.2 percentage point and for the household consumption it presents 0.4 percentage point.

Picture 5

Results of modelled simulations, relative changes against the baseline scenario



Source: Calculations of authors.

4 Discussion

Let start the discussion to interpret results of all four simulated alternative scenarios against one basic scenario. Applied model is static, aggregated and considers one representative producer, household and government. Only foreign is disaggregated into the rest of EU and the rest of the world. Despite of this applied model, like all the other CGE models, is quite complex to interpret, with various feedbacks that make the results not very explicit.

Scenarios H and E were designed to quantify two opposite cases (most benefit for household and enterprises) that would present limits for market forces, but we could consider them as a space for collective negotiation as well.

Scenario H is the case of very strong unions which don't allow enterprises to lower salary expenses when there is a decrease of tax burden. Scenario E presents a situation, when companies take a maximal advantage to decrease their salary expenses and unions are not able to prevent a drop in gross salary. It is clear enough that the first situation, scenario H, is advantageous for employees and the second situation, scenario E, is for a benefit of enterprises. CGE simulation results proved that the scenario E is in accordance with expectations and is advantageous for enterprises. But on top of that, it is beneficial for households as well, even more than the scenario H. Incomes of households grow by 2.9 % in the scenario H, but in the scenario E by 5.1 %. The trend is even more obvious in the area of employment. It rises by 1.5 % in the scenario H, but in the scenario E by as much as 6.5 %. There is no such a situation applicable in a reality but we generate arguments for a public discussion and a collective negotiation about recipients of labour tax decrease. We can get closer to the real situation by a specific change in CGE model construction.

Scenarios H+EU and E+EU could be considered as the introduction of EU own resources. Differences against H and E scenarios are quite small and are corresponding to an economic intuition. Commodity desegregation would be necessary in future studies with different rates of environmental taxes for particular groups of products and services.[8] To bring the own resources reform into reality; it would be valuable to simulate effects not only for EU as a unit, but for individual member states. Simulations like this are technically possible, but require consistent SAM matrices and those are unfortunately not available at the moment.

5 Conclusions

In this working paper we calculated and discussed concept of EU own resources reform through the introduction of environmental tax in the amount of 1 % of the gross domestic product with a parallel decreasing of the tax burden by the same amount. We aimed only for case of Slovakia. We constructed one base scenario and another four alternative scenarios where simulated changes in tax burden. In the first two scenarios we assumed with the case of most benefit from tax changes for households. In the last two scenarios we assumed with the case of most benefit for enterprises.

Calculations of macroeconomic effects were executed with the help of CGE model with the focus on Slovakia and proved positive macroeconomic effects. The extent of those effects depends on reaction of enterprises and their employees to decreasing of labour tax in those ranges (medium term effect):

- Positive aspects on GDP (between 1.2 % to 3.9 %) and the income of households (between 2.9 % to 5.1 %).
- Number of employees increases from between 30 thousand (1.5 % negative scenario) to 150 thousand (6.5 % positive scenario).

Macroeconomic effects of scenarios with the profit of enterprises from decrease of labour tax are significantly higher than the influence of scenarios with profiting households. Differences among scenarios introducing reforms in Slovakia only and introducing reforms in whole EU are quite small.

The results of the simulations with CGE model show that concept of the environmental tax as new own resources of EU have potential and change to be successful. With the reduction of

[8] Calculation using the input-output model is the publication (Luptáčik, Luptáčik 2016).

labour costs the European economy would be more competitive and star the new growth base on environmental aspect.

SUMMARY

This study continues in the previous work of authors that describes the concept of EU own sources reform through the introduction of environmental tax in the amount of 1 % of the gross domestic product with a parallel decreasing of the tax burden by the same amount. Calculations of macroeconomic effects were executed with the help of CGE model with the focus on Slovakia.

CGE model of the Institute of Economic Research SAS was modified and applied in this study. Entry database for the model is the social accounting matrix for 2010 created by authors and to be found in the annex.

We constructed a market balance assuming a rational behaviour of all subjects. In this situation would a total supply equal to a total demand.

Other formulas create a budget limitation of households that maximized their effectiveness while using only their income. There was no profit since any positive results would create a potential for establishing a new company and a market wouldn't be ideally competitive. Foreign countries were for the purpose of environmental tax simulation divided into two groups. The first group represents European Union and the second group represents the rest of the world. All relations among domestic institutions and foreign countries were subsequently transformed to express this division.

One of the main conditions is the fact, that there is no labour movement between domestic and foreign. Then, we chose the aggregation of production commodities and production activities. It means that Slovakia is represented by one production sector producing just one commodity (product). Despite the CGE model created in IER SAS is being recursive dynamic, only its static feature was used for each simulation (all exogenous shocks were applied in the same time).

We created five scenarios while modelling inputs of introducing the environmental tax in Slovakia. The first one, a basic scenario (B), presents an economic balance of Slovakia based on data from a social accounting matrix for 2010.

The second scenario represents the introduction of the environmental tax in Slovakia in the amount of 1 % of the gross domestic product. Transfers to EU budget were decreased by the same amount, but on the other hand, by this volume was increased the tax burden of the final consumption. The government compensated smaller transfers to EU budget by decreasing an income tax burden for households in the amount of 1 % of GDP. Expenses for enterprises stay unchanged, but the disposable income of households goes up.

The third scenario represents a simplified reaction of EU economy to similar exogenous shocks introduced in all EU. Prices of imported goods from EU are expected to grow by the

same amount as in the second scenario. Finally, this scenario shows the introduction of the environmental tax in EU and subjects that profit the most are households not only in Slovakia, but in whole EU.

The fourth scenario (E) represents the introduction of the environmental tax in the amount of 1 % of the gross domestic product. Transfers to EU budget were decreased by the same amount. On the other hand, this volume increased the final consumption. The government compensated smaller transfers to EU budget by decreasing an income tax burden for enterprises in the amount of 1 % of GDP. Subjects that profit the most are enterprises that decrease their expenses, but disposable income of households stays unchanged. The tax burden of the final consumption increases. Enterprises become more competitive due to decreasing of expenses and are able to increase their production.

The last, the fifth scenario (E + EU) features a simplified reaction of EU economy to a flat introduction of exogenous shocks in the whole EU. With the alternative scenario E+EU, we expect the change of import prices from EU by the same percentage level that occurred in Slovakia in the scenario E.

We can conclude that all alternatives would positively influence economy. The influence of scenarios E and E+EU is significantly higher than scenarios H and H+EU. On the contrary, the difference between scenarios H and H+EU and scenarios E and E+EU is rather small.

The scenario H affects tax changes in Slovakia only. Households would be sole recipient of a profit from decreased tax burden since salary would remain unchanged in used CGE shock. Based on results of CGE simulation, there would be a positive influence of decreased labour tax over a negative impact of introducing the environmental tax with the GDP growth by 1.2 % and household consumption rise by 2.9 %. This also leads to employment increase (by 1.5 %), GDP growth and living standards of households measured by their income.

While analysing scenario E we have to look at a simultaneous introduction of the environmental tax and decreasing of labour tax. At the same time, a salary level is decreased by enterprises what makes disposable income of households unchanged. Additional growth of GDP is 3.9 % and household consumption is 5.1 %. In comparison with the scenario H, positive effects in results of CGE simulation would strongly prevail over negative ones. Reduction of salary expenses is reflected in the area of production prices that will improve the competitiveness of Slovak producers on domestic and foreign market. This will subsequently result in the raise of export (by 13.1 %), the production, the demand for labour and higher employment (by 6.5 %) and salaries growth. Finally, disposable incomes of households will go up as well.

The difference between scenario E+EU and the scenario E is that the simultaneous introduction of the environmental tax and the decreasing of labour tax would take place not only in Slovakia, but in the rest of EU so it would enter the category of own resources. Slovak producers would lose a better competitive position and would have to share the benefit of decreased salary expenses with all EU producers. Despite the fact that the scenario E+EU is understandably less advantageous for the Slovak economy than the scenario E, the difference between scenarios is according to the results of CGE simulation quite small. In case of GDP it is only 0.2 percentage point and for the household consumption it presents 0.4 percentage point.

Scenarios H+EU and E+EU could be considered as the introduction of EU own resources. Differences against H and E scenarios are quite small and are corresponding to an economic intuition. Commodity desegregation would be necessary to count through CGE model in future studies with different rates of environmental taxes for particular groups of products and services. We could benefit from the already mentioned study which calculated those tax rates through input-output model. To bring the own resources reform into reality, it would be valuable to simulate effects not only for EU as a unit, but for individual member states. Simulations like this are technically possible, but require consistent SAM matrices and those are unfortunately not available at the moment.

LITERATURE

ARROW, K. – DEBREU, G. (1954): Existence of an Equilibrium for a Competitive Economy. Econometrica, 22, p. 265 – 329.

ARROW, K. – CHEBERY, H. B. – MINHAS, B. S. – SOLOW, R. (1961): Capital-Labour Substitution and Economic Efficiency. Review of Economics and Statistics, vol.43(3), p. 225 – 250.

BARRIOS, S. – PYCRIFT, J. – SAVEYN, B. (2013): The marginal cost of public funds in the EU: the case of labour versus green taxes. European Commission, Brussels, Taxation Paper, working paper n. 35, 48 p.

BRUNOVSKÝ, P. – PÁLENÍK, V. – KOTOV, M. – MRÁZ, M. (2002): Simulácie vplyvov zmien vybratých daňových parametrov s využitím CGE modelov. Bratislava: Združenie pre ekonomické modelovanie, prognózy a analýzy.

DERVIS, K. – DE MELO, J. – ROBINSON, S. (1982): General Equilibrium Models for Development Policy. New York: Cambridge University Press.

HERTEL, T. – HUMMELS, D. – IVANIC, M. – KEENEY, R. (2004): How Confident Can We Be in CGE Based Assessments of Free Trade Agreements? GTAP Working Paper No. 26, Center for Global Trade Analysis, West Lafayette, Indiana.

JOMINI, P. – ZEITSCH, J. – MCDOUGALL, R. – WELSH, A. – BROWN, S. – HAMBLEY, J. (1991): SALTER: A General Equilibrium Model of the World Economy, Vol. 1. Model Structure, Data Base, and Parameters. Canberra, Australia: Industry Commission.

LICHNER, I. (2013): Model všeobecnej vypočítateľnej rovnováhy Slovenskej republiky (modelovanie trhu práce). Bratislava: Ekonomická univerzita.

LICHNER, I. – MIKLOŠOVIČ, T. (2011): Odhad elasticcity substitúcie CES produkčnej funkcie. Forum Statisticum Slovacum 3/2011, p. 50 – 54.

LUPTÁČIK, M. – LUPTÁČIK, P. (2016): Analysis and quantification of a new fiscally neutral European tax. European Economic and Social Committee, Bruxelles/Brussel, Study, 48 p. Available on the Internet: <http://www.eesc.europa.eu/resources/docs/qe-01-16-118-en-n.pdf>.

MCDONALD, S. – ROBINSON, S. – THIERFELDER, K. (2005): A SAM Based Global CGE Model using GTAP Data. Sheffield Economics Research Paper 2005:001.: The University of Sheffield.

MIKLOŠOVIČ, T. (2014): CGE model a možnosti jeho aplikácie na vybrané zmeny v slovenskej ekonomike. Bratislava: Univerzita Komenského. Fakulta matematiky, fyziky a informatiky.

NZIER (2011): Review of export elasticities. Wellington: Rbiedermann.

PÁLENÍK, V. – MIKLOŠOVIČ, T. (2015): Environmental Tax as the Possible Pillar of EU Own Resources. Bratislava, Intitute of Economic Research SAS, WP 72, 14 p. Available on the Internet: <http://www.ekonom.sav.sk/sk/publikacie/-p316>.

REIMER, J. – HERTEL, T. W. (2004): International Cross Section Estimates of Demand for Use in the GTAP Model. GTAP Technical paper No. 23, Center for Global Trade Analysis, West Lafayette, Indiana.

ROBINSON, S. – KILKENNY, M. – HANSON, K. (1990): USDA/ERS Computable General Equilibrium Model of the United States. Economic Research Service, USDA, Staff Report AGES 9049.

ANNEX

Annex 1
The social accounting matrix for 2010, in mil. Eur

	Commoditiy	Business span	Transport span	Activity	Human capital	Operating surplus	Physical capital	Household	VAT	Import tax EU
Commodity		12650	956	91099				38456		
Business span	12650									
Transport span	956									
Activity	151016									
Human capital				24901						
Operating surplus				23702						
Physical capital				11736						
Household					26231	14704	1613			
VAT	4182									
Import tax EU	14									
Import tax – the rest of the world	129									
Consumption tax	2078									
Other taxes	-422									
Production tax				-422						
Government							1760	704	4182	14
Enterprise						8999	8363			
Capital								4402		
Stock										
EU	39951				166			362		
ROW	13162									
Total	223716	12650	956	151016	26397	23702	11736	43924	4182	14

The social accounting matrix for 2010, in mil. Eur, continue

	Import tax – the rest of the world	Consump-tion tax	Other taxes	Production tax	Government	Enterprise	Capital	Stock	EU	ROW	Total
Commodity					12727		13851	1017	44804	8155	223716
Business span											12650
Transport span											956
Activity											151016
Human capital										1496	26397
Operating surplus											23702
Physical capital											11736
Household						1373				5	43924
VAT											4182
Import tax EU											14
Import tax – the rest of the world											129
Consumption tax											2078
Other taxes											-422
Production tax											-422
Government	129	2078	-422	-422		2218				284	10524
Enterprise										753	18115
Capital					-3061	11058				2469	14868
Stock							1017				1017
EU					858	3466					44804
ROW				0							13162
Total	129	2078	-422	-422	10524	18115	14868	1017	44804	13162	

Source: ŠÚ SR and calculations of authors.