Review of the Recent CGE Applications in the Slovak Republic's Economy

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Abstract

Computable General Equilibrium (CGE) models have achieved a growing importance and more extensive usage in the recent years. The aim of this paper is to present a review of the recent results of several author teams dealing with applications of CGE approach to several phenomena within the Slovak Republic´s economy. First of all, recent entry of the Slovak Republic into the European Union brings a need to quantify the possible assets and costs of this process. Thus, this quantification has been performed by means of the CGE model. Another interesting and useful application of CGE model is simulation of impacts of tax parameter modifications on transforming economies. This approach is novel in the Slovak Republic´s economical environment due to an implementation of recently constructed Social Accounting Matrix with a focus on the key tools of tax policy and also owing to the automatic optimization procedures of several calculated scenarios used. Several other recent CGE applications in the Slovak Republic are also mentioned.

I. Introduction

Computable General Equilibrium models are widely used tool for quantitative economical analyses in the world. Capability of estimation of changes in production sectors and flexibility in the level of aggregation of economical subjects are their main advantages.

Usage of such approachs in the Slovak Republic is significantly poorer in comparison with the rest of the world. The models reviewed in this article belong among the first serious CGE applications used for real estimate of changes in the economy policy.

The entry of the Slovak Republic into the EU brings a natural need to evaluate and quantify the possible assets and costs of this process. It is also closely conected with several partial phenomena like, e.g., tax rate changes. CGE models are very suitable tool for such analyses and thus they were chosen to be applied for these purposes in the Slovac Republic's environment. This paper reviews the results of these simulations performed in the recent period [1].

Another important application of CGE models within Slovak Republic's economy was evoked by a need for evaluating and improving the influences of relevant tools of the Slovak Ministry of finance. These were the first usage of Social Accounting Matrix in the Slovak Republic with disaggregated government sector and deal with simulation of influence of tax parameter changes on economy [2]. The work was novel also due to new structure of CGE model used, with emphasis put on the key tax policy tools.

Agricultural, environmental and other CGE applications will also be mentioned [3, 4].

II. CGE Applications

Computable General Equilibrium models simulate the behavior and mutual interactions of individual economical subjects on the market. These macroeconomical models are based on microeconomical assumption of optimal subject behavior.

The starting point is construction of a database represented in the case of CGE models by a Social Accounting Matrix (SAM) which can be in a symplifying manner characterized as an table desribing the flows of comodities, services and money in the economy within a given period, usually during a year. CGE models are comparatively static ones. This principle is exploited to model the consequences of non-marginal exogenous shocks and policy changes in the medium-range and long-range horizon assuming ceteris paribus condition. The main areas of CGE applications and analyses of impacts of non-marginal changes in environmental, foreign trade and tax policies.

The Slovak Republic's Entry into the European Union

The database of the model applied was the SAM designed from the 1998 data. Three data sources were used to design SAM – *Branch-and-Comodity Tables for the Supplies and Usage, National accounts,* and *Foreign Trade of the Slovac Republic* [5, 6, 7].

The model used to estimate the impacts of the Slovac entry into the EU can be characterised by the following structure:

- *Production* is in the model allocated into eight commodities.
- *Household sector* is agregated and described as a "representative household".
- *Government sector* is described as one entity. Under the label Government it is understood the whole area of public finance.
- *Foreign countries* are disaggregated into the three regional groups – EU countries, candidate countries and the rest of the world.

The equations of the model were allocated into the following groups:

- To describe *production branches* one used Cobb-Douglas production functions.
- Armington function of imports *and exports* were of the CES type, where substitution elasticities were estimated by econometric methods.
- *Function of households usefulness* – Cobb-Douglas production function.
- *Function of government usefulness* – Leontieff's complementary function.
- *Function of investments production* – Cobb-Douglas function.

Slovakias's entry into the EU was modelled by means of the following changes:

- *Change of VAT rate,*
- *Change of excise tax rate,*
- *Change of our import rates* in compliance with EU rates,
- Change *of custom tarifs for our exports in the countries of extended EU,*
- *Change of income* for legal entities and for natural persons,
- *Net incomes from the EU funds,*
- *Investment costs for approximation in the sphere of environment.*

From the results of model calculations the most important is the production development listed in Table I. The EU entry characterised by the described scenario will prove by its impacts differently on individual branches. A significant increase will occur in agricultural and foodstuff production and industry products. The increase in both branches will be caused by the increase of exports resulting from the custom duty elimination. Production increase will be observed also in the production of market services caused by the increase of domestic demand. Changes will be registered in the production of the sectors of mining and

intermediate products and chemical industry. On the other hand a mild increase will be observed in the building production, however, electricity, gas and water supply will significantly decrease as well as non-market services.

Table I. *Domestic production and domestic demand changes caused by the entry into the EU.*

Production sector	Domestic production		Domestic demand	
	Production change [%]	Price change [%]	Volume change [%]	Price change [%]
Agriculture and foodstuff	+1.3	-0.4	+0.8	-0.7
Mining and intermediate products	-2.1	+1.4	+0.3	-0.5
Chemical industry	-2.1	+2.7	-1.9	+1.5
Other industrial products	+4.7	-1.9	+2.8	-1.6
Electricity, gas and water supply	-5.2	-0.4	-5.2	-0.4
Building industry	+0.9	-1.1	+0.9	-1.1
Market services	+1.5	-1.5	+1.6	-1.4
Non-market services	-2.1	+3.4	-2.1	+3.1
Total	+0.3	-0.4	+0.5	-0.5

The changes in the foreign trade – structure and allocation of our imports and exports - will come into being and are listed in Table II. Our trade exchange with the EU countries will increase more significantly, whereas with non-member countries there will be only slight increase.

Table II. *Market changes with enlarged EU and with non-members of the enlarged EU.*

Comodity group	With the enlarged EU		With non-members of the enlarged Eu	
	Export volume change [%]	Import volume change [%]	Export volume change [%]	Import volume change [%]
Agriculture and foodstuff	+10.0	+2.3	+0.1	+0.4
Mining and intermediate products	-2.6	+1.9	-2.5	+1.3
Chemical industry	-2.2	-1.9	-2.3	-1.9
Other industrial products	+5.0	+2.9	+5.1	+2.2
Electricity, gas and water supply	-5.2	-5.2	0	-5.2
Building industry	+0.9	+0.9	+0.9	+0.9
Market services	+1.5	+1.6	+1.5	+1.6
Non-market services	-2.1	-2.1	-2.1	-2.1
Total	+1.7	+1.8	+1.2	+0.4

On the side of generation and use of the gross domestic product the overall effect of complex processes will result in its shift. Positive effects will prevail negative ones and the entry of the Slovac Republic into the EU will bring to Slovakia an additional GDP growth of 0.8 per cent (see Table III).

From the DGP components on the expenditure side the biggest increase will be registered in investment demand, caused mainly by the inevitability of environmental investments. Household consumption will increase and farourable impact will be witnessed at direct tax reduction. The consumption of the state will slightly increase. Slovak Republic's economy will became more open - exports and imports will increase which will lead in higher GDP growth in comparison with domestic demand.

Model results suggest that even if the entry of the Slovak Republic into the EU brings not an immediate enormous growth of the economy and living standards, the gains of the process will prevail over its costs.

Table III. Change of GDP and its components.

	Volume change [%]	Price change [%]	Note
Household consumption	+0.3	+1.4	
Government consumption	+0.2	+2.6	
Investitions	+1.0	-1.5	
Domestic demand	+0.5	+1.2	
Import	+1.5	-1.7	
Export	+1.7	-0.6	
GDP	+0.8	+1.1	
Labour price	.	1.0	*numeraire*
Capital Price	.	-3.1	
Exchange rate	.	-1.0	

The competitiveness of the economy will be influenced by various contradictory influences. Elimination of our import taxes for the imports from the EU countries will decrease the competitiveness of domestic production. Inevitability of environmental investments will act unfavourably too. On the other hand, elimination of custom tarrifs for our exports will act favourably for the competitiveness of the economy. The development of the exchange rate also proves that positive effects will prevail over the negative ones, the result will be slight appreciation or revaluation of the Slovak crown exchange.

Simulation of Tax Rate Changes

The second work [2] deals with studying the influence of tax parameter changes on the Slovak Republic's economy.

- *Production sector* was disaggregated into eleven branches and was described using Cobb-Douglas production functions.
  (However, the cost and demand functions are entering the model, being derived from the zero-profit condition and trade equilibrium condition, respectively.)
- *Household sector* is similarly as in the previous work aggregated and described as a representative household. Function of households usefulness is also represented by Cobb-Douglas function.
- *Government sector* is aggregared into one whole described by function with zero elasticity of substitution.
- *Investment production* function has a from of the Cobb-Douglas type.
- *Foreign trade* is modeled using the Armington's concept.

The model is enriched also by allowing the involuntary unemployment, where equation of labour demand was approximated by econometrical methods. The price of the labour was set as the numeraire value.

The presented CGE model enables to simulate alternative scenarios of tax policy, based on the information of Statistical Office of the Slovak Republic [8]. The author collective focused on indirect tax changes: the first scenario is convergence of basic (23 %) and reduced (10 %) VAT to the value of 20 % and 14 %, respectively; the second scenario deals with unifying of both types of VAT (with the assumption of constant real income of the government) and the third one models changes in excise tax for tobacco commodities.

Additionally, more advanced features of CGE models were employed – in spite of pure evaluation of the effects of predetermined steps and modifications in the SAM matrix, optimization procedures automatically find suitable scenarios fulfilling the aim required. The purpose function, optimization parameters, and constraints of these parameters have to be formulated. Two optimization scenarios were constructed by the authors: maximalization of

GDP with respect on change of tax structure, and evaluation of marginal loss from the tax charge.

Results of these scenarios are listed in Tables IV – VIII. The first scenario – decrease of the basic VAT rate from 23 % to 20 % and increase of the reduced VAT rate from 10 % to 14 % - influences production sector as it is shown in Table IV. This process is caused mainly by relative price changes. Generally, sectors charged by reduced VAT rate (agriculture; electricity, gas and water supplies; standard market services) will naturally feel decrease of production and domestic demand, only with exception of mining. However, in the sectors charged by the basic VAT rate an increase of production will occur. This mostly applies to chemical industry where also domestic demand will increase similarly, indicating that foreign as well as domestic producents will profit similarly from to VAT convergence. Other situation will occur in heavy industry where domestic demand will increase almost two times in comparison with production, thus being more profitable for foreign producents.

Nevertheless, several sectors are charged by combination of both VAT rates and their influence will partially be compensated. Those branches (manufaturing, building industry, market financial services and non-market services) encounter only slight changes or stagnation.

Table IV. *Sector indexes for the scenario of VAT rate convergence.*

Production sector	Production change [%]	Domestic demand change [%]	Domestic Demand Price Change [%]
Agriculture	-1.07	-1.06	-0.24
Mining	-0.74	-0.68	-0.27
Food industry	-2.72	-2.71	-0.23
Heavy industry	+0.47	+0.70	-0.24
Chemical industry	+0.58	+0.55	-0.26
Manufacturing	+0.16	+0.28	-0.26
Elextricity, gas and water supply	-2.09	-2.1	-0.21
Building industry	+0.16	+0.16	-0.27
Standard market services	-0.28	-0.3	-0.2
Financial market services	+0.16	+0.16	-0.32
Non-market service	+0.05	+0.09	-0.14

Results of the first scenario for GDP and other important indexes are shown in the relevant column of Table V. We can see that negative effects of increase of reduced VAT rate will cause lowering of household consumption with increased consumer prices. On the other hand, enriched public income together with lower government consumption prices will lead to an increase of government consumption. Exchange rate will slightly appreciate, however, negative impacts will prevail the positive ones and GDP will slightly decrease.

The second scenario (unifying the both VAT rates) was based on the assumption of the Slovak Republic's entry into the EU. The aim of authors was to find such value of the unified VAT rate which will not affect public income. Effects of this scenario on production are listed in Table VI. Similarly as in the previous case production of branches charged by reduced VAT will decrease whereas sectors charged by basic VAT will profit. Production and domestic demand will have similar behavior, advantaging neither domestic nor foreign producents considerably. The only expception is sector of standard market services where export of these services will increase but import will decrease. As one can see from results for GDP and other indexes in the relevant column of Table V, unification of VAT rates will not have significant impact on economy. Total positive and negative influences will lead to very mild increase of GDP, being in concordance with decreased deformation in economy with stable level of redistribution. Resulting VAT rate is approximately 17 % with the assumption

of constant public income (decrease of VAT income will be compensated by increase of other taxes).

Table V. *Other indexes for the VAT-convergence scenario (Scenario I)*
VAT-unifying scenario (Scenario II)
scenario of increased tobacco excise tax rate (Scenario III)
scenario of GDP maximalization (Scenario IV).

Index	Scenario I	Scenario II	Scenario III	Scenario IV
	Change [%]			
GDP	-0.20	+0.04	-0.12	+0.01
Household consumption	-0.65	-0.03	-0.25	0
Government consumption	+0.44	+0.03	+0.1	-0.5
Investitions	+0.14	+0.14	-0.01	+0.5
Net export	0.0	0	0	0
Consumer prices	+0.46	+0.09	+0.14	+0.7
Government consumption prices	-0.17	+0.03	-0.07	0
Investment prices	-0.39	-0.10	-0.1	-0.1
Labour price	*numeraire*	*numeraire*	*numeraire*	*numeraire*
Capital price	-0.5	+0.06	-0.23	1
Income from VAT	+3.75	-0.28	+5.23	
National budget income	+0.44	0	+0.17	0
Exchange rate	+0.4	0	0	0
Unified VAT rate		17.5		
Change of legal person income tax rate				-7.5
Change of natural person income tax rate				0

Table VI. *Sector indexes for the scenario of unifying both VAT rates.*

Production sector	Production change [%]	Domestic demand change [%]	Domestic Demand Price Change [%]
Agriculture	-0.45	-0.45	+0.03
Mining	-0.28	-0.24	+0.02
Food industry	-1.08	-1.05	+0.04
Heavy industry	+0.86	+0.93	+0.04
Chemical industry	+0.62	+0.68	+0.03
Manufacturing	+0.39	+0.41	+0.02
Elextricity, gas and water supply	-1.34	-1.34	+0.09
Building industry	+0.2	+0.2	0.0
Standard market services	+0.08	-0.04	+0.04
Financial market services	+0.25	+0.25	+0.04
Non-market service	-0.17	-0.17	+0.03

Excise tax rate modifications are a current topic in policy of the Slovak Republic. Thus, the third scenario deal with modification of tobacco tax rates, modeling its increase by 15 %. Results are listed in Table VII and in relevant column of Table V. The most intensively affected production sector will be food industry, followed by decrease of domestic demand for food products, as it can be expected. Increased excise rate will cause additional deformation and increased level of redistribitution in economy, thus leading to GDP decrease.

The aim of the fourth scenario was finding appropriate direct tax rates in order to maximize GDP with predetermined change of VAT and stable public income. VAT rate was used as a purpose function, constraints consist of real government income, intervals of tax rates, trade balance deficit, VAT rate; and natural and legal person income tax rates were the optimization parameters. The results in Table VIII and relevant column of Table V represent change in

Table VII. *Sector indexes for the scenario of increased tobacco excise tax rate.*

Production sector	Production change [%]	Domestic demand change [%]	Domestic Demand Price Change [%]
Agriculture	-0.4	-0.38	-0.02
Mining	-0.08	-0.08	-0.09
Food industry	-1.05	-0.91	+0.65
Heavy industry	-0.18	-0.11	-0.08
Chemical industry	-0.03	-0.07	-0.09
Manufacturing	-0.1	-0.05	-0.09
Elextricity, gas and water supply	-0.07	-0.08	-0.11
Building industry	0.0	-0.02	-0.01
Standard market services	-0.18	-0.12	-0.09
Financial market services	-0.05	-0.05	-0.1
Non-market service	0	0	-0.06

comparison with situation of original 10 % (reduced) and 23 % (basic) VAT rates. Reduction of legal person income tax rate and unchanged natural person income tax rate is the appropriate solution of the problem, indicating higher usefulness of reduction of legal person tax rates than natural person ones. Reduction of direct taxes for legal persons stimulates increase of investments whereas reduction of direct taxes for natural persons stimulates only an increase of household consumption.

Table VIII. *Sector indexes for the scenario of GDP maximalization.*

Production sector	Production change [%]	Domestic demand change [%]	Domestic Demand Price Change [%]
Agriculture	-0.6	-0.6	0
Mining	-0.4	-0.4	-0.01
Food industry	-2.3	-2.3	-0.01
Heavy industry	+0.1	+0.11	+0.01
Chemical industry	+0.7	+0.6	-0.01
Manufacturing	+0.6	+0.7	-0.01
Elextricity, gas and water supply	-0.17	-0.17	0
Building industry	+0.4	+0.4	0
Standard market services	0	-0.01	0
Financial market services	+0.4	+0.3	0
Non-market service	-0.3	-0.3	+0.01

Microeconomical theory suggests that every tax change causes a deadwight loss as a loss of consumer's and producer's surplus. CGE models offer a marginal excess burden (MEB) concept for evaluation of such losses. This represents an amount of substances which are inevitable for consumers to reach the same level of usefulness as they had before public income increase. Results of endogenous partial increase of public income and ceteris paribus endogenous change of VAT, product tax, import tax and natural and legal person income tax rates are shown in Table IX.

We can see that the direct taxes cause the least deformation which is in concordance with microeconomical theory, similarly as higher level of uneffectivity for comodity taxes. An extreme case is the excise tax loss, resulting from the microeconomical fact that the level of deadweight loss is the higher the larger differences among each comodity tax rate are.

Table IX. *Marginal charge.*

Income change [%]	VAT MEB [%]	Import taxes MEB [%]	Excise tax MEB [%]	Natural person income tax MEB [%]	Legal person income tax MEB [%]
1	18.33	13.63	66.74	1.13	1.12
2	18.80	18.11	74.36	1.16	1.14
3	19.27	23.39	83.17	1.18	1.17

Simulation of Agriculture Subsidiary Policy

The third main CGE model was applied to study the agriculture sector [3]. Dual or Mathiesen complementary formulation of the problem was employed, thus the functions of demand and supply of goods were derived from production functions. The equations naturally fulfill the market equilibrium conditions, zero firm profit and budget constraint of consumers.

- *Production sector* was disaggregated into twelfe branches described by Cobb-Douglas and CES production functions. Production functions were designed to have more complicated structure specifically for this model and they have several nesting levels, thus modeling the fact that some comodities are natural and primary substitutes whereas other are not. Shape of the production function for each sector depends on authors‘ assumption of substitution possibilities between inputs of the relevant sectors. In this case the production function has two nesting levels – the lower level employs aggregate of an intermediate consumption, where the elasticity of substitution can be chosen arbitrarly. Similarly, the second lower level aggregate consists of work and capital components with arbitrary elasticity of substitution. These two aggregates are at the higher level completed by the soil component employing CES function.
- *Household sector* is disaggregated into two groups – rural and urban households, each with different primary factors, transfer relations with government, and consumption behaviour. Cobb- Douglas function of usefulness is assumed.
- *Government sector* is aggregared into one whole described by function with zero elasticity of substitution.
- *Investment production* function has a from of the Cobb-Douglas type.
- *Foreign trade* is modeled as a whole using the Armington’s concept with CET function. Authors have partially modified this concept by addition of transport and trade margins. Two level production function consists of lower aggregate (imports and domestic comodities) with arbitrary elasticity of substitution combined with the transport and trade margins with zero elasticity of substitution at the higher level.

In order to evaluate this model a test scenario was constructed and quantified. Its aim was to explore the influence of changes in ariculture subsidiary policy on economical development of the Slovak Republic after its entry into the EU. This model is now under further development and utilization in cooperation of the Slovak Academy of Sciences and the Research Institute of Agriculture Economy and Food Processing, Slovakia.

Other Applications

Also other experimental works have been draught. In the Ref. [4] author has constructed CGE model of the Slovak economy. As an illustration of the capabilities of the model an increase of import prices of agricultural products and in heavy industry was simulated. Relative prices of these commodities absorbed approximately one third of the import price increase. Structure of the production and consumption changed for behoove of the light industry and non-market services.

To our knowledge the last CGE application in Slovak Republic economy was launched in 2000 by Ministry of Environment of the Slovak Republic within the *Project to Assist the Slovak Republic in the Preparation of an Integrated EU Approximation Strategy in the Environment Sector* and sponsored by Danish DEPA-DANCEE environmental agency. This work dealt with investment costs of adoption of the EU environment protection guidelines and its total impacts on the Slovak economy. Further development of this model was enabled by the *Economic Support Project* (2001 – 2003) – updated estimates of the previous investment costs were obtained as well as application of CGE model to analysis of introduction of environmental taxes and impacts of Kyoto protocol on the Slovak economy.

III. Summary and Conclusion

Naturaly, as all pilot works, these models have several topics which require further research in the near future. This applies especially to improving the description of the production sectors, where econometrics research in order to estimate the production functions is inevitable. Further econometrics research is required also for estimates of the consumer behaviour functions. A big challenge for future development is also dynamization of the CGE model.

On the other hand, the government sector is described detaily. All the tax and non-tax revenues are endogenously described in the models. The expenditure side of public finance is also described relatively closely.

In spite of the objective limitations mentioned the models have estimate the trends for the economical progress. The relevant input conditions are in an opinion of the author collectives realistic and offer usefull information for policy makers in the near periods.

The results indicate that the entry of the Slovak Republic into the EU will not bring an immediate boost of the economy and living standards, however, the total benefits of this proces will prevail its costs. The competitiveness of the economy will be affected by several oppositely acting influences. Removal of the import rates for imports from the EU will reduce the competitive ability of domestic production, similarly will act also required environmental investitions. On the other hand, removal of customs tarrifs for our exports will affect positively the competitiveness of our economy. The exchange rate fluctuation indicates that the positive effects will prevail the negative ones, in other words an appreciation or revalvation of the Slovak crown will occur.

Environmental investitions are likely to have the most important impact on the power and competitiveness of Slovak economy. The dynamics of the economy growth will depend primarily on their concrete amount as well as on a fraction of foreign subventions. The majority of industrial branches, agriculture and non-market services will be considerably affected by inevitability of the environmental investitions. Market services and building industry sectors will be influences to a lesser ammount. Foreign trade will also be negatively affected due to a probable need for importing the majority of new required technologies. Implementation of possible environmental taxes (energy tax, CO_2 tax) into the Slovak tax system without relevant compensation tools may negatively influence competition ability of Slovak producents.

Results of the simulations of different tax rate scenarios have shown, that changes of indirect tax rates can have variety of influence on economical production of different branches and also on performance of national economy as a whole.

Simulated converegence of VAT rates increases public income and consequently also a level of redistribution which will lead in increased deformations followed by a decrease of econonomy performance and GDP. However, convergence of VAT rates with unchanged

public income will result in deformation decrease in economy with stable level of redistribution followed by GDP growth.

Increased tobacco excise tax rate will introduce an additional increase of deformations and together with an enforced redistribution level will lead to lower GDP.

Calculation of optimization scenario indicates a possibility of higher level modeling of tax policy, enabling to automatically explore much wider spectrum of scenarios as in the case of an intuitive choice. The more parameters enter the calculation the stronger this advantage is. Simulations also show that the narrower group of commodities is affected the stronger are economy deformations. Foreign producents profit (lose) from an increase (decrease) of domestic demand more than the domestic ones.

Investigation in the field of agriculture subsidiary policy in order to study its impact on economical development of the Slovak Republic after its entry into the EU has also been initiated. Testing scenario has successfully documented the predictive capabilities of the model and can serve as a groundwork for further analyses and investigation in the field of agricultural policy modeling.

Also other works dealing with CGE analyses of Slovak economy have been performed applied to agriculture and heavy industry import price increase (National Bank of Slovakia) and analyses of environmental policy (environmental taxes, Kyoto protocol impacts).

CGE models, starting to be used by the World Bank and the International Monetary Fund in order to calculate alternative steps of economy policy mainly in the developing countries, are constantly enhancing their utilization in the recent period – for example, OECD, Australian government (ORANI model), Danish Statistical Office (DREAM model), Ireland (IMAGE), Norwegian Ministry of finance (MSG) are using CGE approach for solution of current economical questions and tasks. We can conclude that even Slovak Republic does not lag behind this trend and that there exists an adequate structure for appropriate data acquisition and also qualified author teams capable to construct and apply CGE models to actual topics of Slovak Republic's economical progress.

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