The Impacts of Natural Gas Prices on the Lithuanian Economy: a CGE Analysis

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Abstract: Currently, natural gas is one of the most important energy resources for Lithuania. Regrettably, natural gas is currently being imported from only one source. The lack of own resources and absence of competition makes the country strongly dependent on imports and vulnerable to the changes of natural gas price. Therefore, natural gas price plays very important role in energy planning in Lithuania. The aim of this research is to evaluate economic consequences of natural gas price changes in the Lithuanian case. For this, a special computable general equilibrium (CGE) model has been created and simulations with different natural gas price levels have been performed. The tentative results of simulations show that the increase of natural gas prices leads to the significant increase of consumers' prices for energy, chemical, and agricultural products. However, only moderate decrease in natural gas consumption has been observed.

Key-Words: Computable general equilibrium model, energy planning, optimal integration of energy technologies, energy-economy relationships.

1 Introduction

Because of the current increase of prices for energy resources, the issue of energy-economy relationships is becoming fateful. Inasmuch as energy products are essential inputs in many contemporary production processes, energy price changes make significant influence on the macroeconomic indicators such as inflation, value added etc. Moreover, energy-economy nexus plays crucial role in energy planning as price changes of energy products are strongly related to the demand. Therefore, an integrated analysis is necessary prerequisite for elaboration of adequate and realistic recommendations regarding to the rational development of energy sector and the optimal integration of future energy technologies.

Natural gas is one of the most important energy resources for Lithuania. Its significance has especially increased after the closure of Ignalina nuclear power plant, which was the largest electricity generation source in Lithuania. In 2010, natural gas accounted for about 35 per cent of the gross inland consumption. Regrettably, natural gas is currently being imported from only one source. The lack of own resources and absence of competition makes the country strongly dependent on imports and vulnerable to the changes of natural gas price. In this context, research focused on economic consequences of changes in natural gas price is highly relevant.

The aim of the present research is to evaluate impacts of natural gas price change on the Lithuanian economy. For this, a computable general equilibrium model has been created and simulations with different natural gas price levels have been performed. In this paper the first preliminary results are presented that have been obtained from this model.

2 Methods and data sources

For this analysis, a computable general equilibrium model has been created and scenarios with gas price increase by 10% and 30% have been analyzed.

2.1 Description of the model

The structure of the present CGE model allows analysis of changes in natural gas price taking into account assumptions about behavior of corporations, government, and households, as well as foreign trade possibilities.

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The production structure described in the model is shown in Fig. 1.

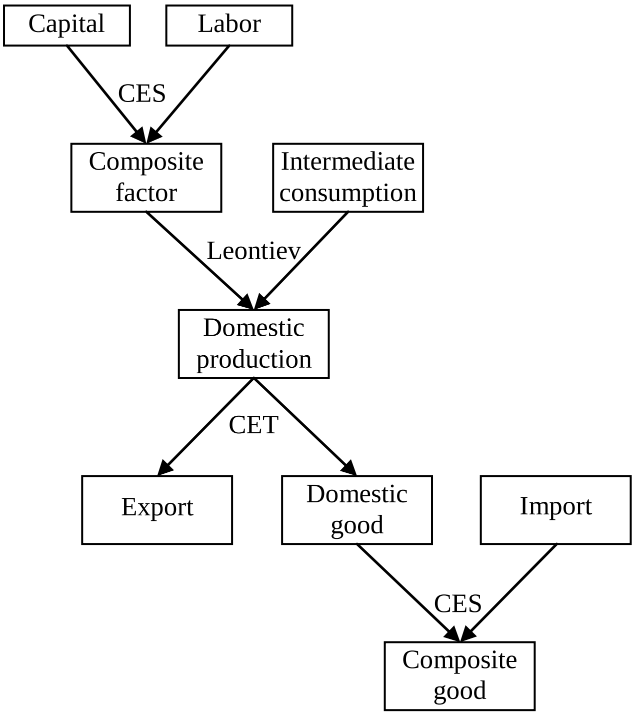

Fig.1. Formation of the composite good in the model

Every producer (represented by an activity) is assumed to maximize the profit. As it can be seen from Fig. 1, the relationship between usage of production factors (labor and capital) has been modeled applying constant elasticity of substitution (CES) functional form, which reflects imperfect substitutability between labor and capital.

Inasmuch as this functional form has been used at various stages of composite good formation, it is worth to provide more detailed description on CES function and demand functions related to it.

Let's assume that for the production of quantity *Q* (in this case, it is capital-labor bundle or composite factor) two production factors: F_1 and F_2 (in this case, labor and capital) are used. Then production function is as following:

$$Q = A\left(a_1 F_1^{\left(\frac{\sigma-1}{\sigma}\right)} + a_2 F_2^{\left(\frac{\sigma-1}{\sigma}\right)}\right)^{\frac{\sigma}{\sigma-1}}, \qquad (1)$$

where *A* is a scaling coefficient, a_1 and a_2 are input share coefficients in the production function, and σ is elasticity of substitution between F_1 and F_2.

By solving profit maximization problem, demand function for the factor F_1 can be expressed:

$$F_1 = Q pq^{\sigma} A^{\sigma-1}\left(\frac{a_1}{pf_1}\right)^{\sigma}, \qquad (2)$$

where *pq* is the price of *Q*, and pf_1 is the price of F_1. The demand function for F_2 is analogous.

As a result of coupling labor and capital, a composite factor is obtained. This factor is coupled with the intermediate consumption (material inputs) at the next stage of production process. This stage has been modeled with Leontief-type production function with zero-profit condition that allows ensuring of market equilibrium. In other words, it has been assumed that labor and capital are substitutable at some level, while material inputs are used in fixed proportions

Natural gas has been treated as one of material inputs in intermediate consumption. This approach does not allow production technology changes determined by fluctuations of natural gas prices. However, there are certain grounds for supposing that technological changes in production sectors can be long-run issue.

In contrary to some other CGE models (SUST-RUS [1] or Standard CGE model [2] are good cases in point), each activity in the developed model is able to produce more than one type of product, however, proportions between amounts of products are fixed similarly to the case of AIM/CGE 2.0 model [3]. This gives an opportunity for reflection of real life conditions when firms or activities along with the main type of product are able to produce various by-products.

The bundle of domestically produced products is then transformed to exports and domestic goods. This transformation is also run by profit maximization as producers deciding whether to sell their production on the domestic market or to export determine the optimal mix between exports and domestic sales. To describe this transformation, a constant elasticity of transformation (CET) function has been applied. This function is mathematical equivalent of CES function, but in this case, CET function allows description of imperfect transformation between exports and supply of the domestic goods.

In the last stage of composite good formation, domestic goods are coupled with imports, employing CES functional form again. Similarly to the export case, well-known Armington's assumption of imperfect substitution between imports and domestic goods has been used.

Composite goods, obtained as a result of the formation process described above, are consumed by government, households, invested by savings and investment agent, and used to cover trade and transport margins. Consumers' demand is based on utility maximization. In this model, it has been

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assumed that the utility functions are Cobb-Douglas type:

$$Utility = \prod_p X_p^{\alpha_p} , \quad (3)$$

where X_p is the quantity of product p, and α_p is share parameter in the utility function. By solving utility maximization problem including budget constraint, demand function for X_p can be expressed as follows:

$$X_p = \frac{\alpha_p B}{px_p} , \quad (4)$$

where B is budget constraint, and px_p is price of the product X_p.

Monetary flows in the model start form compensation for employees and payments for capital, and goes through various stages such as collection of taxes on income, production, products, and imports; collection of social security contributions and transfer payments etc. Virtual agents are employed to allocate each type of these monetary flows, but the main principle is to keep existing proportions among receivers. A good illustration is compensation for employees (cost of labor). In the base year entire compensation is allocated between the domestic households and the rest of the world. If this compensation increases, the increase will be apportioned for the same agents in the same proportions as in base year.

Total amount of monetary inflows are used as consumers' budget constraints. An additional assumption has been taken with respect to current account status. It is widely acknowledged that changes in price for imports make influence on the balance of payments as increase of expenses for imports must be compensated by exports, borrowing or increase of foreign investment. Nevertheless, such actions are not directly related to the prices for energy resources (e. g. the level of state debt depends at large extent on the political factors). Therefore, current account balance has been fixed in the model. However, depending on the purposes of the analysis and availability of the information, this assumption could be changed. Hence, the circles of monetary and commodity flows are closed in the model and general equilibrium among the markets can be found by solving the system of nonlinear equations.

The model described above has been developed in the GAMS [4] mathematical programming language using Gtree interface. From the methodological point of view, the main shortage of the approach used in the presented model is the fact that it fails to cover long-run issues, such as changes in energy transformation technologies. To deal with this issue, this model could be coupled with the bottom-up energy system model. In order to make this CGE model more sensitive to natural gas prices, substitution possibilities between natural gas and other energy products at the stage of intermediate consumption should be assumed in the further research.

2.2 Data sources

The social accounting matrix (SAM) has been created especially for this modeling exercise. Currently, 2008 is the first and the only year for that it is possible to get coordinated information required for creation of SAM. Since 2008 Lithuanian statistical office started to compile supply and use tables according to NACE rev. 2 classification system.

Most of the data required for compiling of the SAM have been collected from the databases of Lithuanian statistical office [5] and EUROSTAT [6], but they have been made more precise using various information sources, including reports of the State Tax Inspectorate and the Customs of the Republic of Lithuania. An aggregated version of this SAM is presented in Table 1.

In the model, there is used a version of this SAM which consists of 9 activities that use significant amounts of natural gas and 10 kinds of products (the 10th product is natural gas that is unable to be produced by domestic activities).

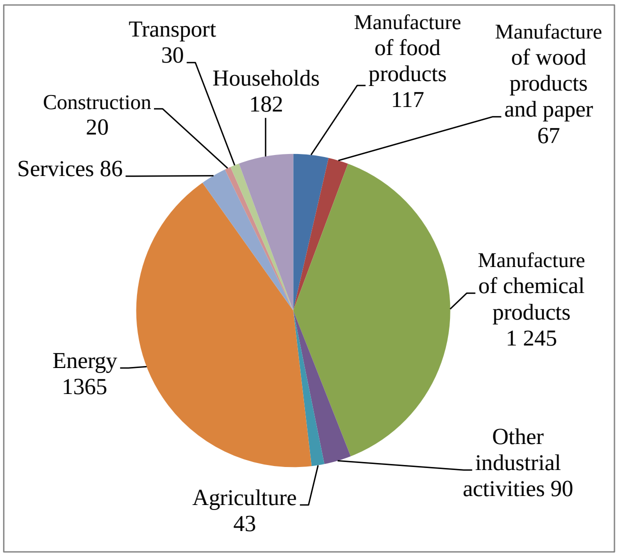
An additional explanation is required regarding to the manipulations that have been made in order to include natural gas as a product to the SAM. The most detailed supply and use tables available consist of 64 product types (with the reference to 64 activities covered). Unfortunately, natural gas is aggregated with other fuels. In order to describe natural gas as a separate product in the social accounting matrix, additional calculations have been done.

Data about consumption of natural gas in Lithuania in energy units have been collected from Lithuanian Energy balance [7]. The information about natural gas consumption in various branches of the Lithuanian economy is presented in Fig. 2.

Table 1. Social accounting matrix for Lithuania in 2008, billion LTL (1 EUR is equal to 3,4528 LTL)

		ACT	PROD	LAB	CAP	TTF	CORP	GOV	HOH	ROW	SIA	**Total**
Activities	ACT		205.76			0.25						**206.01**
Products	PROD	103.44				32.64		21.50	73.68	66.75	30.13	**328.14**
Labor	LAB	49.57								0.71		**50.28**
Capital	CAP	50.71										**50.71**
Margins, taxes, subsidies, and transfer payments	TTF	2.29	42.41				30.47	15.21	21.63	7.11		**119.12**
Corporations	CORP				36.60	10.38						**46.98**
Government	GOV				2.68	35.23						**37.91**
Households	HOH			50.01	11.44	31.74						**93.18**
Rest of the world	ROW		79.98	0.27		8.87						**89.12**
Saving-Investment account	SIA						16.50	1.19	-2.12	14.55		**30.13**
	Total	**206.01**	**328.14**	**50.28**	**50.71**	**119.12**	**46.98**	**37.91**	**93.18**	**89.12**	**30.13**	

Source: own calculations



Source: Statistics Lithuania [7]

Fig.2. Natural gas consumption in Lithuania in 2008 (mill. m^3)

It is obvious that sectors of energy and chemical products are the largest natural gas consumers in Lithuania. Nevertheless, some other sectors use significant amounts of natural gas as well. In addition, natural gas is being used directly by households as this fuel seems to be attractive for individual heating [8].

For general equilibrium analysis, data in monetary units have been used. Therefore, natural gas consumption in energy units has been recalculated to the monetary units according to the import price of natural gas (919 LTL (266.16 EUR) for thousand m^3 in 2008) [9]. Then, these values have been subtracted from the uses of imported mining and quarrying production in the particular branches of the economy.

During compilation of the SAM and first runs of the model, additional restrictions have been noticed. In 2008, export of industrial products was 20.44 billion LTL, whereas domestic production was only 16.38 billion LTL. It seems reasonable to suppose that a large part of industrial products was re-exported. As it has been mentioned before, CES and CET functions have been used for the modeling of international trade, but this structure of the model has nothing to do with re-export. In order to provide a realistic description of the situation and to avoid computational problems, it has been assumed that 50 percent of export of industrial products is re-exported. As this process is not directly related to the natural gas prices, import of that amount of industrial products has also been set exogenously.

Most of the parameters used in the model have been calculated directly from the SAM (e. g. proportions for allocation of income, tax and margin rates, share parameters in utility and production functions etc.), while elasticity parameters could be taken from the scientific literature. Nevertheless, the literature provides various values of elasticity of substitution between production factors or between domestic and imported goods [10, 11]. As differences are significant, for the present model average values have been chosen, but in the further research, elasticity parameters should be re-estimated taking into account the structure of the model (as it has been done for GEM-E3 model [12]) and national peculiarities.

3 Results

Results of the simulations include changes in relative prices, consumption of production factors, quantities of products at various stages of production process etc.

The most questionable issue related to the changes of natural gas prices is their impact on prices for other products. Simulated changes in consumers' prices are shown in Fig. 3.

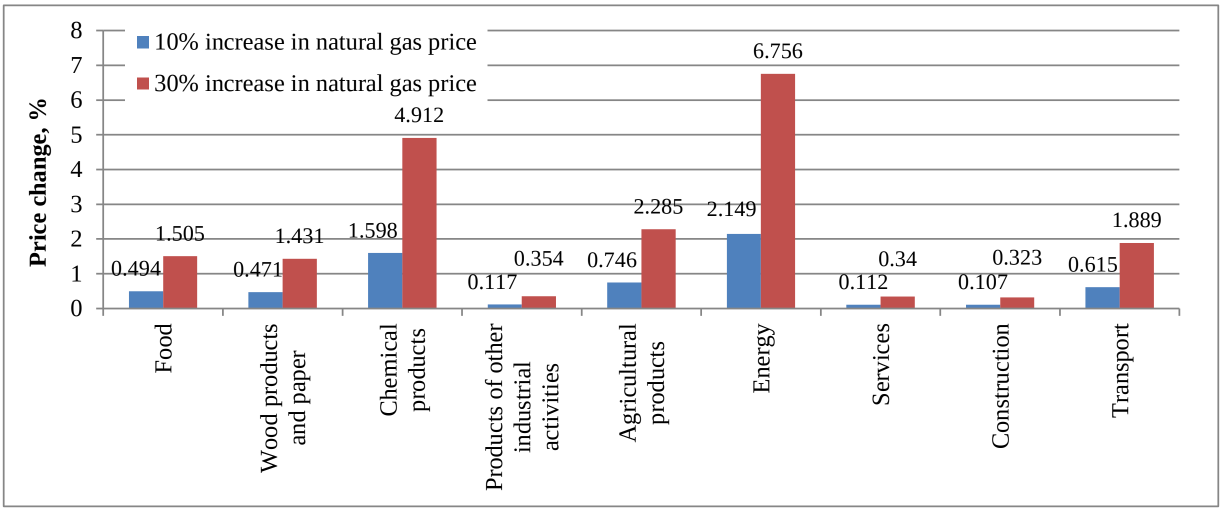


Fig.3. Impact of natural gas price change on consumers' prices for products

Simulation of the two scenarios has shown that increase of natural gas price would have largest impact on consumers' prices for energy and chemical products. In the case of energy, this result is not surprising, as natural gas makes a large share (about 18.9% in 2008) in the cost structure of this activity. Increase of consumers' prices for chemical products is related not only to the cost, but also to the assumption about stability of the current account deficit. Taking into account this restriction, the economy tries to increase exports and decrease imports when it is possible. As a result of these perturbations, the price for chemical products in the domestic market increases so strong. The increase of prices for agricultural products can also be explained by the increase of prices for fertilizers and other chemical products.

Price increase makes strong influence on the domestic consumption. Fig.4 shows percentage changes in the consumption of various products.

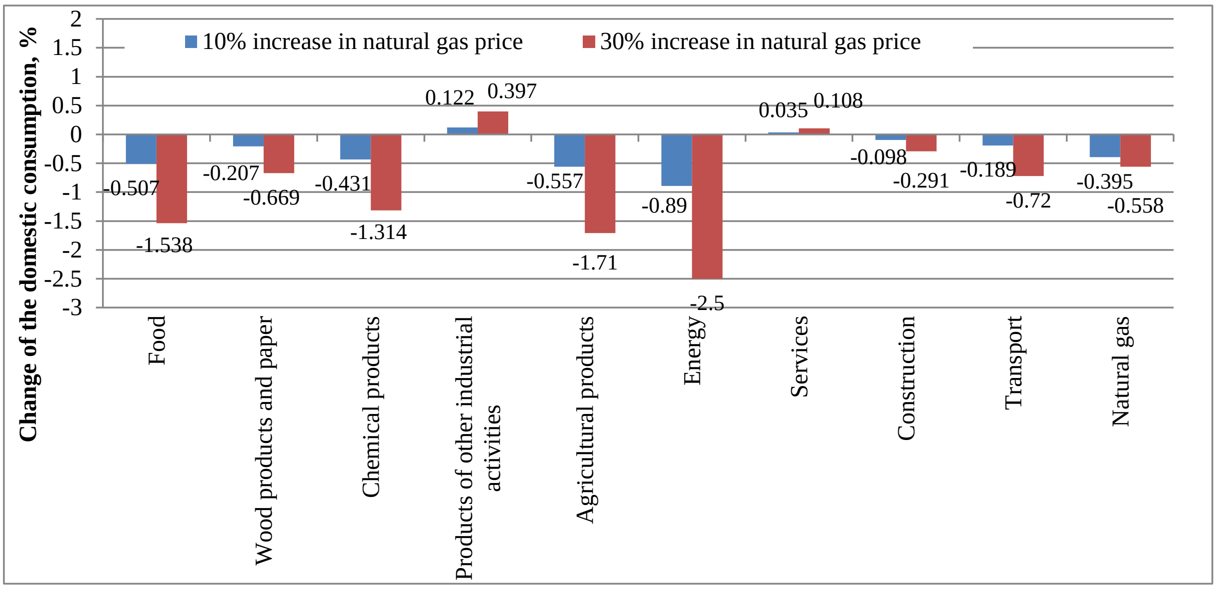


Fig.4. Impact of natural gas price change on domestic consumption

As it can be seen form Fig.4, domestic consumption of natural gas decreases less than consumption of many other products. This result is mostly related to the fact that only a small part of imported gas is consumed directly. Largest decrease is observed in energy consumption as the economy tries to produce less energy-intensive production, and in consumption of agricultural products.

4 Conclusion

The developed CGE model covers composite good formation processes as well as monetary flows within the Lithuanian economy and allows evaluation of economic consequences of natural gas price changes.

The results of simulations with different natural gas price levels show that the increase of natural gas prices leads to the significant increase of consumers' prices for energy, chemical, and agricultural products.

However, only moderate decrease in natural gas consumption has been observed, while consumption of energy and agricultural products decreases considerably.

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