Redistribution Effects of International Environmental Agreement's Implementation by Poland on the Example of Sulphur Protocol

Olga Kiuila, Dr.
Economics Department Warsaw University

1. Introduction[1]

We have attempted, using the general equilibrium modelling, to estimate distribution effects for the Polish economy resulting from implementation of international environmental agreements. One of such agreements, signed by Poland in 1994, is so-called Sulphur Protocol (SP), which requires reduction of sulphur dioxide emissions until 2010 by 66% in comparison with the emission level of 1980.

Poland gets more and more actively involved in international agreements dealing with environmental protection. Fulfilment of the signed commitments by Poland is important for the European countries because it is in the forefront of the largest emitents of pollution. Poland is interested in controlling not only its own emissions, but also in cutting emissions generated by its neighbours. Joint implementation of agreements would allow improving the quality of the environment. However, not all signatories of such agreements proceed with their implementation. Poland is among such signatories. On the one hand the environmental policy gains more and more importance in the country, and on the other hand the emission limits imposed in the agreements raise concerns of negative impact on the economic situation. This deters the Polish authorities from implementation of the signed commitments.

The Polish government is so far postponing ratification of the Sulphur Protocol. However, it can be expected that Poland will decide to ratify this protocol because of the European Union requirement. All the EU members are obliged to ratify the Sulphur Protocol as European Parliament ratified it in 1998. Therefore, the question arises: what effects can this have on the Polish economy? The outcomes of research conducted so far indicate that the

[1] This work has been completed within the framework of the research project No 5H02 C05121 financed by KBN (the Polish Committee of Scientific Research).

sectors directly influenced by the Protocol requirements will not break down, however, the welfare level of households may decrease (Kiuila (2002)). Difficulties related to lack of the relevant data have not allowed checking the distribution effects of the Sulphur Protocol implementation. This work is devoted to exploring such effects based on unpublished data on households developed by *Polish Central Statistical Office* (GUS (1996)).

Classic economic models adopt one representative household. Such models are not suitable for simulation of the distribution effect. In order to assess impact of the governmental policy on income distribution in the society at least two representative households should be taken into account. Division can be made for example into the groups of rich and poor households. The main difference between these groups of households is the level of disposable income.

A key of division criterion for households in this analysis is the average monthly sum of incomes per capita, which constitutes the median of incomes in the analysed panel. Such a division is easy to make for the Polish economy because the necessary data are commonly accessible in GUS. However, setting up budget equations for both groups of households is difficult because this would require separating all income components. Thus, one would have to determine what part of income is generated from capital, work, and transfers in each type of household. The unpublished data of GUS allow answering this question and achieving the intended goal.

Distribution effects have been calculated for 2010 using the General Equilibrium Model. The year 1995 has been adopted as a benchmark. The selection was conditioned with accessibility of the national economy balance data presented in the form of input-output table. The second part of the paper presents the description of the model and the scenarios. This will be followed with the description of the method of calculating the distribution effects. The fourth part of the paper describes and summarises the outcomes of the simulation. Finally, conclusions part contains the remarks related to the outcomes of the calculations.

2. The method of the analysis

For checking distribution effect of SP implementation we have used Computable General Equilibrium Modelling (CGE). Economic analysis in case of environmental pollution problems requires taking into account long term. Achieving more stringent environmental protection standards, in addition to direct consequences for the regulated units, is connected with additional consequences. If the competitive firms in the market for the same product are not bearing these additional costs, this means that the competitiveness of the given sector will decrease. The sector will have to find a way to finance these additional costs. One of the possible solutions is to set higher prices for the products. This may bring various consequences. The first may be a drop of sales of the sector's products on the market and a shift of consumers' demand to substitutes. The second may be the situation where the consumers will still buy the products of this sector in spite of price increase. In this second case the consumers may decrease their demand for goods produced in other sectors. Only the model that takes into account functional connections among all the markets simultaneously can give accountable picture of such long, interconnected cause-effect strings.

The above reasoning depicts the principal advantage of the general equilibrium models. The approach of general equilibrium does not imply suggesting that the real world passes from one equilibrium to another, but it allows recognising the demand-supply mechanisms in these markets.

2.1. Model assumptions

In the model we have aggregated 58 industries into 17 sectors, and 8 of these industries are characterised with high sulphur dioxide emissions: iron industry, minerals industry, chemical industry, transport, municipal services, coal industry, oil refining industry, power and electricity production. To generate its own production each sector uses 7 production factors including 5 endogenous factors: coal, liquid and gaseous fuels, secondary fuels, electricity together with heating energy, and manual labour (*Lm*). The remaining production inputs are capital and non-manual labour (*Ln*). Demand has been set endogenously for all production factors. The model assumes lack of mobility of capital and labour.

In addition, each sector uses production of other sectors and its own, which altogether forms indirect demand. Total demand contains all the components of the domestic demand, such as indirect demand, consumption of the population, governmental demand. Consumers demand goods of all sectors except for crude oil and gas sector because this sector produces only indirect products that are not suitable for final consumption. Governmental sector does not demand goods generated by most of the sectors. Governmental demand is set only for production of the commercial services sector, non-commercial services sector, and chemical sector. This is implied by the data of input-output table (GUS (1999)).[2] A detailed description of the domestic demand can be found in the next chapter.

The model is looking for solutions in accordance to the neoclassic theory of general equilibrium: it calculates the prices and volumes of production which equalize demand with supply at all markets and make marginal profits equal to zero in all sectors. For each good with established positive price, aggregate demand is equal to aggregate supply. In the situation of excessive supply the equilibrium price is set at zero level. This does not apply, however, to labour market, where unemployment is allowable. Even if all the markets must be by definition equalized in CGE, it does not mean that unemployment cannot occur. It is possible that the labour market is "balanced" with a certain level of voluntary or involuntary unemployment in the base

[2] Governmental spending in chemical industry is due to medicine subsidising.

year. Then the calculation algorithm will find a solution where all the remaining markets are balanced.

In addition the model assumes that all the sectors can be to a certain extent price-generating. In such case, the level of supply is initially set by the production possibilities. The condition for reaching the balance, with a given demand curve, determines the price level at the domestic market. According to the Armington's condition, if the considered goods produced in the country are significantly different from the comparable goods produced at the World's market, or if they sell well, they can be sold at prices different than the prices of foreign surrogates. In case of lack of such foreign surrogates, the domestic producers are independent to such extent that they are not submitted to the limitations of the world price but only to the limitations of the consumers' budgets. Thus, each sector as a whole can be price-maker in the model, but the specific producers can only be price-takers. Decision which sectors will be price-maker depends exclusively on price elasticity of demand for exports.

All the prices in the model are described as relative and for the benchmark equilibrium they are normalized to unity. This means that there is no one selected price ("numeraire") which would be used to express all other prices. The year 1995 has been adopted as a base year. This choice was implied by availability of the national economy balance data in the format of an input-output table.

2.2. Analytical scenarios

The general equilibrium model has been solved for the year 2010 in which all the cumulated effects of implementing the Protocol are fully revealed. The model has been calibrated using the year 1995—all the changes in the economic indicators until 2010 are compared with this base year. Simulations have been made for two scenarios defined as following:

— scenario I does not impose the obligation to fulfil the emission limits + standard assumptions;

— scenario II imposes the obligation to reduce domestic emissions of SO_2 by 41% as compared to 1995 + standard assumptions.

Standard assumptions are the same for both scenarios and they deal with a number of parameters of the model. The assumptions are as follows: 2% increase of real prices in the world markets over 15 years (i.e. until 2010), stable Polish zloty (i.e. constant real exchange rate), annual trade balance increase by 1.5%, annual increase of autonomic export by 0.2%, annual increase of imports prices by 0.01%. Increase of price elasticity of demand for exports by 25% means more competitive foreign trade in the future. At the same time the scenarios assume that the excise tax for secondary fuels will increase by 2%, and pollution fees will remain at the level of 0.29 PLN[3]/kg of SO_2. One of the

[3] The annual average exchange rate of New Polish Zloty (PLN) for the US Dollar was 2.43 in 1995.

major factors of the economic increase in the model is the change of accessibility of the production factors: the annual increase of capital amounts to 0.02%, and the annual increase of non-manual labour also amounts to 0.02%. The remaining factors of production are set in the model endogenously and this is why the rate of increase of their resources is not assumed in exogenous way. The scenario assumes increase of active labour force (for non-manual labour—by 0.9% per year, for manual labour—by 0.7% per year). In this way the scenario introduces the assumption that the investments in human capital will stimulate productivity of labour and will induce increase of the original labour force resources in non-manual labour. On average productivity of all production factors taken together will increase annually by 0.1%. In addition mixed system towards labour force has been used: supply *Ln* has been set exogenously but its price—endogenously; supply *Lm*, in turn, has been set endogenously, and its price—exogenously. It has also been assumed that real wage for *Lm* will increase annually by 1%.

Calculations for the two scenarios described above gave the results that have been compared both regarding the direction and scale of deviation of endogenous variables. The first scenario is regarded to be the basic scenario, and the second scenario is compared with it. Deviation of a given variable from the basic scenario proves sensitivity of this variable to increase of the environmental protection costs related to reduction of SO_2 emissions. This means that presentation and interpretation of the outcomes will be carried out in the way of comparison with scenario I.

3. Households' specification in the model

In order to set the domestic demand, the consumption block in the model uses the data from input-output table and information on the production factors. Demand functions have been derived from Stone-Geary utility function:

$$U(x) = \sum_i \beta_i \ln(x_i - \gamma_i) \text{ for } \gamma_i < x_i$$

where $U(x)$ is a non-homogenous utility function describing consumers' preferences, β_i—marginal propensity to consume the good i, x_i—total demand of the consumer for the good i, γ_i—autonomic consumption of goods from the sector i. b_i parameter is always positive and fulfils the condition $\Sigma\beta_i = 1$.

Consumers, according to the standard assumption of neo-classical theory, maximise utility derived from consumption subject to constraints imposed by budget equation. We can depict these assumptions in the Lagrange function:

$$l = U(x) + \lambda\left[m - \sum_i p_i x_i\right]$$

where L—Lagrangean, λ—Lagrange multiplier, m—total disposable income, p_i—price of the purchased good x_i. The first-order conditions are as follows:

$$\frac{\partial L}{\partial x_i} = \frac{\beta_i}{x_i - \gamma_i} - \lambda p_i = 0 \text{ and } \frac{\partial L}{\partial \lambda} = m - \sum_i p_i x_i = 0$$

Solving this set of equations with respect to x_i we will receive the Marshall-type demand function:

$$x_i(p_i, m) = \gamma_i + \left(\frac{\beta_i}{p_i}\right)\left(m - \sum_j p_j \gamma_j\right)$$

Such demand functions are referred to as Linear Expenditure System (LES). Like any other demand function, according to the consumer theory, this function is homogenous at zero level, thus it does not induce the effect of money illusion. Characteristic for the LES function is that it enables substitution among goods only to a limited extent. A certain component of total expenditures ($\Sigma p\gamma$) is constant and does not allow any substitution among goods. Such a function excludes inferior goods because $\beta_i = \frac{\partial(p_i x_i)}{\partial m}$, so income elasticity has to be always positive.

The LES system is used in the model for distribution of global income (understood as the sum of value added) among the selected economic actors expressing global domestic demand. LES is a function of disposable income, prices of products in the specific sectors, and relative share of expenditures in total demand of the base year, expressed with the b_i parameter. Parameters of the LES function are derived from the input-output table.

In order to assess the impact of environmental policy on income distribution in the society the model has been adjusted to simulation of the distribution effect. Households have been divided into two groups: rich and poor. These households differ with the amount of disposable income. A division criterion is the average monthly disposable income per capita. Based on the statistical data on household spending in various income groups, a difference among household expenditures on the specific groups of goods has been calculated. Calculations have been conducted using weighted average. The outcomes are presented in Table 1.

Table 1.

Share of household expenditures on the specific goods (%)

Sectors symbol	Commodities specification	Households			
		poor		rich	
T1	metal products	41	*0.00*	59	*0.00*
T4	quarry, building materials, ceramic, glass	41	*1*	59	*1*
T5	timbered and paper products, other prod120 ucts	40	*2*	60	*2*
M1	electro-machinery products	41	*5*	59	*6*
M2	textile and leather products	47	*4*	53	*4*
M3	food and cigarettes	55	*36*	45	*25*

Sectors symbol	Commodities specification	Households			
		poor		rich	
M4	chemical products	49	*4*	51	*4*
M5	construction	35	*1*	65	*2*
M6	agricultural products	54	*11*	46	*8*
M7	transportation	39	*2*	61	*3*
M8	commer. service (hotels, restaurants, architecture, etc.)	36	*23*	64	*34*
N	health care, social service, education, etc.	32	*3*	68	*5*
Ne	municipal service	42	*0.2*	58	*0.2*
E1	coal	51	*1*	49	*1*
E2	oil and natural gas	0	*0.00*	0	*0.00*
E2e	fuel and greases	36	*2*	64	*3*
E3	electricity, heating, warm water, gas	53	*4*	47	*3*
			100		*100*

Source: own calculations based on GUS (1993, 1996).

Italic columns show the structure of expenditures of the households. Non-shaded columns show the share of household expenditures on the specific goods. The consumers do not express demand on goods of *E2* sector because this sector contains only indirect goods that are not suitable for final consumption.

For the sake of this analysis welfare functions have been introduced into the model. Direct comparison of the household welfare functions leads to error in calculations because the measure of the unit of utility is not the same for different groups of consumers. Therefore, we have to express these units of welfare using a monetary measure of utility.

Consumer surplus is a classic measure of welfare change. However, we can use this measure only in the specific case, for quasi-linear preferences where income effect does not exist. More general measure of welfare change is equivalent variation (EV) or compensating variation (CV). In the model these two measures have been defined using the following formulas:

$$EV = \mu\left(q^0, p^1, m^1\right) - \mu\left(q^0, p^0, m^0\right)$$

$$CV = \mu\left(q^1, p^1, m^1\right) - \mu\left(q^1, p^0, m^0\right)$$

where $\mu(.)$—money metric indirect utility function that shows how much money the consumer will need at the price q so as to be equally satisfied as with the price p and the limited income m. In order to formulate this function for the preferences of Stone-Geary type, first we have to know what the expenditure function looks like, namely:

$$\min_{x_i} \sum_i p_i x_i \text{ s.t. } \sum_i \beta_i \ln\left(x_i - \gamma_i\right) \text{ dla } x_i \geq 0$$

Solving this problem we will get the Stone-Geary expenditure function $e(p, U)$:

$$e(p,U) = \exp\left\{U - \sum_i \beta_i \ln \frac{\beta_i}{p_i}\right\} + \sum_i p_i \gamma_i$$

Substituting the utility function into the expenditure function equation we will get the Stone-Geary compensating function $m(p, x)$:

$$m(p,x) = \exp\left\{\sum_i \ln\left[\frac{p_i(x_i - \gamma_i)}{\beta_i}\right]^{\beta_i}\right\} + \sum_i p_i \gamma_i \equiv e(p,U(x))$$

In order to get the money metric indirect utility function we have to know additionally the formula of indirect utility function, i.e.

$$\max_{x_i} \sum_i \beta_i \ln(x_i - \gamma_i) \text{ s.t. } m = \sum_i p_i x_i$$

Solving this problem we will get the indirect Stone-Geary utility function $V(p, m)$:

$$V(p,m) = \sum_i \beta_i \ln \frac{\beta_i}{p_i}\left(m - \sum_i p_i \gamma_i\right)$$

Substituting the indirect utility function into the expenditure function equation we will get the indirect Stone-Geary compensating function $\mu(q, p, m)$:

$$\mu(q,p,m) = \exp\left\{\sum_i \ln\left(\frac{q_i}{p_i}\right)^{\beta_i}\right\}\left(m - \sum_i p_i \gamma_i\right) + \sum_i q_i \gamma_i \equiv e(q,V(p,m))$$

One can easily notice that when the prices are identical, so $p_i = q_i$, money metric indirect utility function equals income m. This is a property of each indirect compensating function. This allows reducing the equations that describe EV and CV to the following form:

$$EV = \mu(q^0, p^1, m^1) - m^0 \text{ and } CV = m^1 - \mu(q^1, p^0, m^0)$$

At this point the general equilibrium model is prepared to simulation of the distribution effect and to welfare analysis of different household groups. Household incomes in the model can originate from four different sources:
— manual labour income;
— non-manual labour income;
— capital income;
— dividends.

These sources have been divided among the specific households based on the unpublished GUS data (GUS (1996)) in the following way. The group of poor households holds 70% of incomes from manual labour jobs (30% belongs to rich households), 50% of incomes from non-manual labour jobs, 40% of incomes on capital, and no dividends. The remaining part of household incomes is retained by the group of rich households.

The next section of the paper presents the outcomes of calculations conducted using the described model.

4. Simulation results

The Sulphur Protocol implementation directly means that the production costs in the sectors being the main source of SO_2 generation will increase. Its natural consequences in these sectors should be the following: price increase, consumption decrease, pollution emission decrease, and improvement of the state of environment. We present possible distribution of the consequences after implementation of this international agreement in the whole economy with special attention to the consumers. The prices and costs are expressed in relative units, and the unit level has been set for the base year.

General equilibrium models often produce the results that are apparently contradictory to common sense reasoning. This can happen because such models take into account not only direct impacts in single markets but also the effects and counter-effects caused by long cause-effect chains that happen simultaneously in all markets—like in real world, where the energy producers are more or less dependent on the activities of all other producers and consumers in Poland and abroad. CGE model results have to be interpreted carefully and with a large dose of economic intuition. In interpreting the outcomes of such a model this is not the specific level of the variables that is the most important but the direction and mutual relations of changes in the levels of endogenous variables.

It should be stressed that the model used in this analysis disregards economic benefits for various sectors and for households resulting from decreasing damages due to pollution (i.e. reduction of external costs). Therefore, the presented outcomes should not be interpreted as the efficiency analysis of SP implementation but first of all as a contribution to understanding general long-term adjustment processes in the scale of the whole economy and to grasping the idea about the scale of these changes.

4.1. Demand of households

Figure 1 shows how the demand of all households for the specific goods will change. The picture presents the amounts in billions of 1995 Polish zloty. The first (the lightest in colour) bar to the left of each sector shows the situation for the base year. The second bar shows the situation for scenario I (without taking into account emission limits). All further comparisons will be made relative to this scenario. The next bar shows the situation for scenario II (fulfilling the requirements of the Sulphur Protocol).

The outcomes show that the aggregate demand expressed by all households will not change as a result of implementing more strict SO_2 emission limits but the contents of the consumption bundles will change. The consumers will give up the goods related to high pollution emissions because of increase of their prices (figure 2). This relates mainly to the coal sector, but also to the metallurgy, refining sector, and municipal services sector.

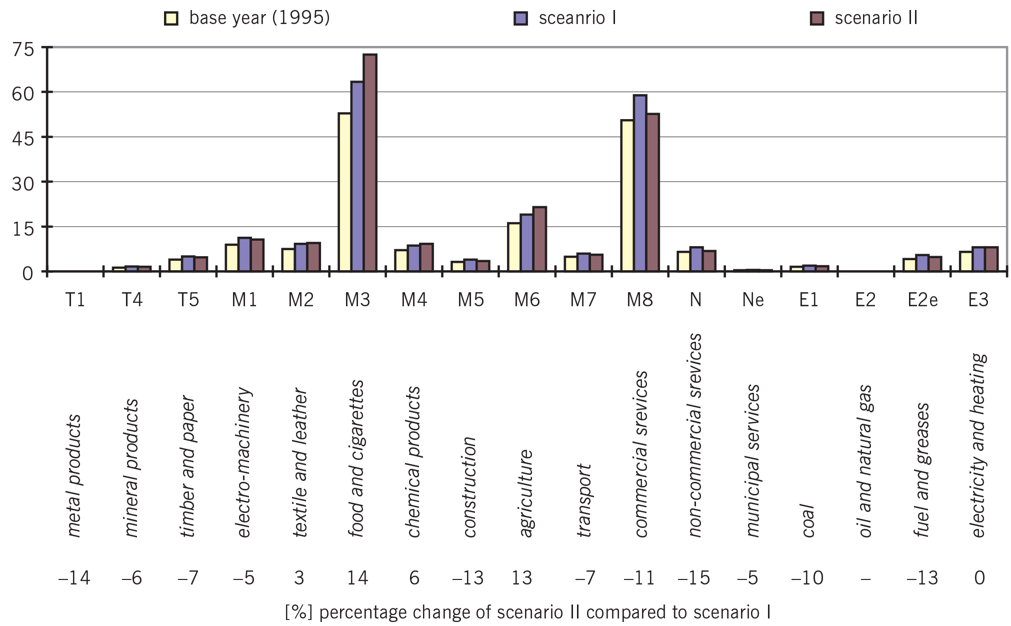

Fig. 1.

Change of the household demand [billions of 1995 zloty]

Source: own calculations.

In some sectors demand of households can undergo significant and not easily predictable changes because changes in consumption of the specific goods do not exclusively depend on prices of these goods but also on price changes of other goods—complementary or substitution goods in relation to a directly observable product. Change of consumers' prices as shown in figure 2 is the starting point to analyse demand changes. The figure is shown in relative units. The consumers, being the ultimate receivers of the goods and services, bear the costs of VAT, so all the prices have been increased by the rate of this tax.

As a result of the SP policy, the changes in production costs induced price changes. The direction and scope of these changes is similar to the changes in production costs. Coal sector is an exception, because the prices increase significantly in spite of just 1% increase in the production costs. Consumption of the sector *E1* products is directly related to sulphur dioxide emission. Reduction of this emission requires bearing additional costs. In the model it is assumed that the reduction costs will directly be included in the price of goods the use of which causes pollution, and proportionally to their use. As a consequence, the prices for products of the coal sector will significantly increase.

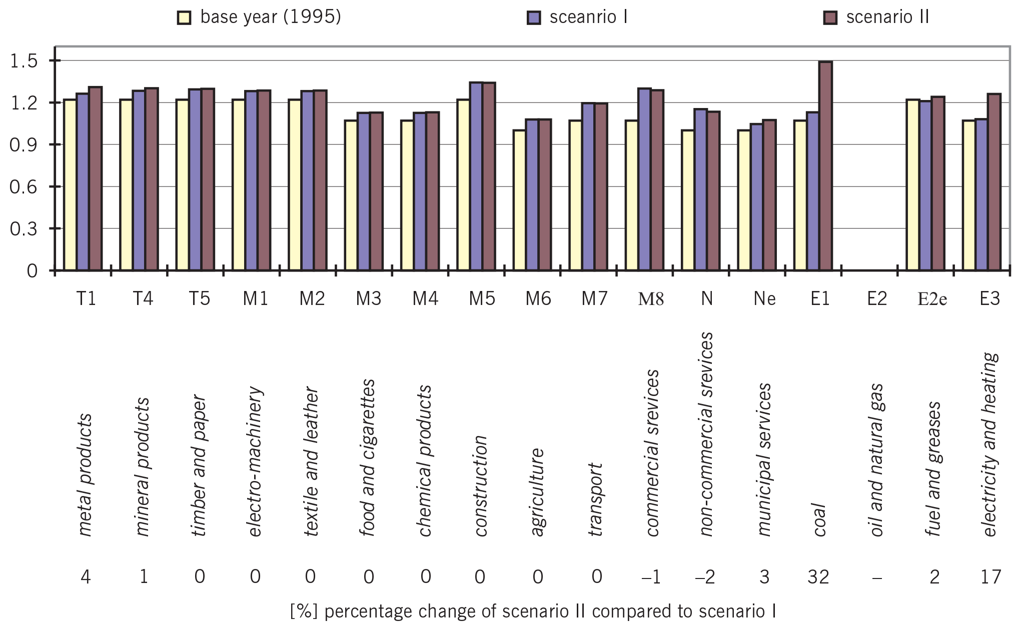

Fig. 2.

Change of consumer prices

Source: own calculations.

Behaviour of the consumers after the price change, as already mentioned, can be difficult to predict. As can be seen in figures 1 and 2, not only the power of the effect, but first of all its direction seems to be surprising. In spite of increase of the electricity prices, demand of households will not change. On the other hand, the demand for the products of the construction sector, as well as for commercial and non-commercial services will significantly decrease when prices are stable.

The outcomes of other calculations have not confirmed such demand changes. Each time the behaviour of consumers was a little bit different, although total demand did not change. However, a certain rule has been discovered: with small parameter changes (like in the presented scenario I) the consumers intensely react to the new economic situation after implementing emission limits (scenario II) and vice versa. Such behaviour means that the shock due to serious reduction of pollution emissions has high significance for the consumers as compared with small economic changes. On the other hand, if the same shock is accompanied with more significant changes in the economy, the consumers' reactions are less intense because the economic changes have then a larger significance than the shock.

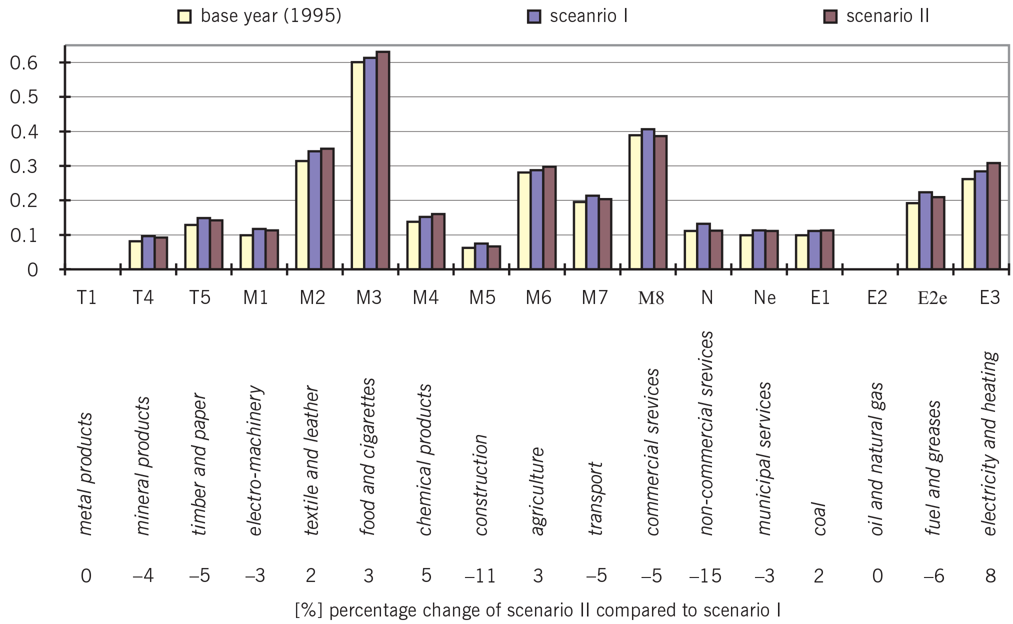

Fig. 3.

Change of the share of household expenditures in total expenditures in the economy [%]
Source: own calculations.

Overall situation of all consumers will not change (table 2); in spite of differences in their behaviour, the initial indifference curve (scenario I) will still be available after implementation of the SP limits (scenario II). The reason of this is a relative stability of the total demand expressed by the consumers and their incomes. Total sum of the expenditures and incomes of households will rather not change. Therefore, the share of household expenditures in total expenditures in the economy will be similar for both scenarios. However, the distribution of expenditures for the specific goods will change (figure 3). Comparing the figure 3 with the figure 1, one can note that the change of the share of household expenditures for most of the goods is in accordance with the direction of demand shifts for these goods and services. Exceptions are the goods and services from metallurgy and coal sectors (where the share of expenditures is not changing in spite of significant drop in demand) and electricity (where price increase implies that the consumers must devote a larger share of their budget to these expenditures than before).

4.2. Income distribution in the society

Disaggregation of households into the groups of rich and poor households allow conducting the impact analysis of new emission standards on the level of welfare of these two social tiers. We can both compare changes in demand of the specific groups and analyse the changes in their welfare level using the general indicators of welfare change.

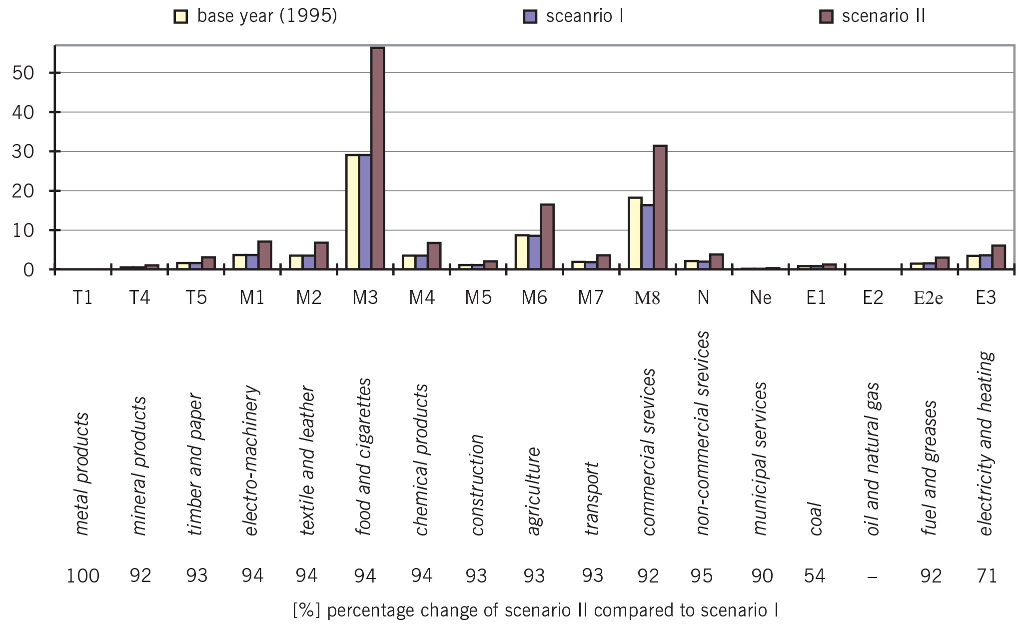

Fig. 4.

Change in demand of the poorer households [billions of 1995 zloty]
Source: own calculations.

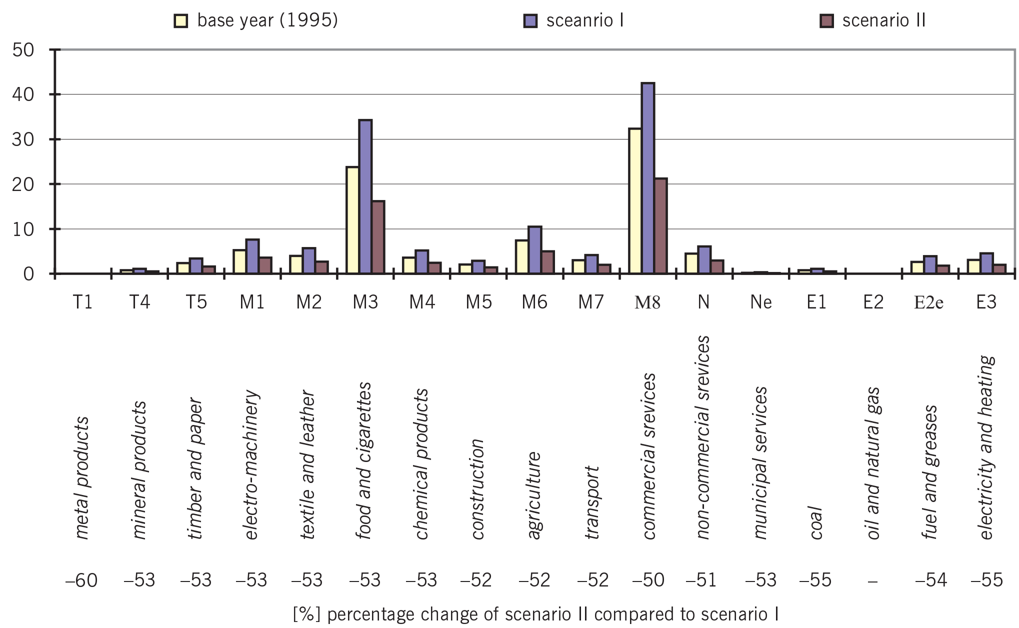

Fig. 5.

Change in demand of the richer households [billions of 1995 zloty]
Source: own calculations.

According to the calculations made using the CGE model, the poor households (figure 4) react more intensively to any changes in the economy than the rich households (figure 5). In addition, the demand expressed by the poor consumers in the new conditions increases, and the demand of the rich consumers decreases. Such behaviour has been confirmed in various simulations.

Large changes in the consumers' behaviour should not be interpreted literally. The CGE model must find balance in all the markets simultaneously (the vectors of prices, production and consumption). In reality it is obvious that the consumers do not react as intensively to the economic changes as can be suggested in the simulation. Cautious interpretation of the outcomes suggests that imposing emission limits implied by the SP on the economy will have slightly stronger impact on the poor households than on the rich ones. The richer households may even loose unlike the poor ones. Such a conclusion is supported with the values of economic welfare indicators.

Tab. 2.

Welfare change values (measured with CV and EV) for the specific households' groups

Households	[billions zloty]	[percentage of income]	
		previous	new
rich	–83	–52	–107
poor	80	46	88
total	0.8	0.3	0.3

Source: own calculations.

Table 2 presents comparison of the welfare changes of households. The outcomes measured with CV and EV are the same, which proves that the calculations are correct. Because large differences in demand relate to the new shock in the economy, EV and CV values are also relatively large. For other scenarios, where the changes in parameters are much higher than the ones in the currently analysed scenario (i.e. contained in the original scenarios), the values of EV and CV are proportionally lower. All the scenarios, however, have confirmed the direction of EV and CV changes.

According to the theory, relation between these two welfare measures is the following: for normal goods EV>CV when prices decrease (CV cannot exceed the income level, and EV is not limited at the top) and vice versa [Johansson 1991]. In our model the direction of price changes is not uniform—prices of some goods decreased, others increased, and the rest did not change (figure 2). In such a situation there is no simple relation between EV and CV. However, this does not mean that we cannot interpret the outcomes. As can be seen in the table 2, more strict emission standards lead to decrease in welfare of the rich households and to increase in welfare of the poor ones.

Another welfare measure that allows to compare costs and benefits of both groups of the society is Kaldor-Hicks (*KH*) criterion. This criterion says that the policy is acceptable if it leads to such changes in prices and incomes that those who have benefited are able to reimburse the losses to the others and still be better off than before the changes. This is the necessary and sufficient condition for Pareto improvement. The outcomes of our model suggest that if the poor compensated the losses to the rich and we would still get positive EV and CV values, the SP policy should be implemented. Thus the overall effect, for both groups of the society, depends on which effect will prevail: decrease in welfare of the rich or increase in welfare of the poor. Outcomes of the calculations (table 2) indicate that the power of these two effects will be comparable and that one should not expect the change in overall welfare level of the society. So we can suspect that the SP policy is acceptable according to the KH criterion.[4]

5. Conclusions

Impact of the SP policy on income distribution, analysed using the CGE model, has been assessed using the general welfare measures. The outcomes indicate that the aggregated demand of all households will not change as a result of implementation of more strict SO_2 emission limits but the contents of the consumers' bundles will change. The consumers will give up the goods related to high pollution emissions because of increase of their prices. In some sectors demand of households can undergo significant and not easily predictable changes, because changes in consumption of the specific goods do not depend exclusively on prices of these goods but also on price changes of other goods that are complementary or substitution goods in relation to the directly observed products.

The scale of consumption reduction depends, to a high degree, on the assumptions of the original scenarios. However, independently on the adopted assumptions, welfare of the rich households decreases, and welfare of the poor ones may increase. Therefore, one can suspect that for the whole economy the required sulphur dioxide emissions abatement should not be more unfavourable towards the poor than towards the rich.

As a result of the SP policy the change in production costs induced price changes. Behaviour of the consumers after price changes will also change. According to the calculations conducted using the CGE model, the poor households react more intensively to any changes in the economy than the rich ones. In addition, demand of the poor consumers in new conditions increases, and the demand of the rich consumers decreases. The overall situation of all consumers will not change; in spite of their different behaviour the

[4] One should keep a certain distance regarding validity of the KH criterion because we assume equal distribution weights for all the goods (in our case the number of goods is 17) and for both household groups.

initial indifference curve (scenario I) will still be available after implementation of the SP limits (scenario II).

Big changes in behaviour of the consumers should not be interpreted literally. The CGE model must find equilibrium in all markets simultaneously. In reality it is obvious that the consumers do not react as intensively to the economic changes as is implied in the simulation. Cautious interpretation of the outcomes suggests that more strict sulphur dioxide emission standards in Poland will lead to decrease in welfare of the rich households and increase in welfare of the poor households.

In an attempt to generalise the outcomes of all the conducted simulations and taking into account weak points of our model, one can speculate that even the radical programmes of environmental protection, such as SP implementation, should not have strong negative impact on the economic objectives in Poland. Global production might decrease a little, so might the value added. This would undoubtedly be the negative effect of the new policy. However, so far the Ministry of Environment has not noted any complaints from the interest groups being against implementation of the SP.

The Polish government still afraid the negative results for the economy of the SP implementation and postpone its ratification. The sulphur dioxide emission in 2003 (1375 kt) was already below the Protocol requirements (1397 kt). It will be, however, difficult to keep this emission level as industrial output goes up every year.

References

GUS (1993): *Budgets of households for the 1992*, Warsaw: Central Statistical Office.

GUS (1996): *Detailed data of households' budgets for the 1995*, Warsaw: Central Statistical Office, unpublished data

GUS (1999): *The Input-Output Tables for the 1995*, Warsaw: Central Statistical Office

Johansson, Per-Olov (1991): *An introduction to modern welfare economics*, Cambridge University Press

Kiuila, Olga (2002): "The costs of Poland's adjustment to ecological requirements of the international sulphur protocol", *Polish Economist*, Number 1, first quarter, pp. 41–60