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A Microsimulation Model for Belgian Indirect Taxes with a Carbon/Energy Tax Illustration for Belgium

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I. INTRODUCTION

During the last fifteen years there has been a rapid growth in the development and use of microsimulation models for public policy analysis (for an overview see Merz (1991) and Hancock and Sutherland (1992)). The key feature of these models is the calculation of the consequences of policy measures at the level of the individual household or firm by using a representative sample of the population. Until recently, Belgium had - to put it mildly - a bit missed the train[1]. This was a regrettable situation because an analysis at the level of the individual (be it the person or the household) allows an assessment of the distributional consequences of the policy. And the relevance of distributional considerations to determine the political acceptability of proposed measures cannot be overestimated.

The aim of this paper is twofold. First, we want to *present* the microsimulation model *ASTER*. We hope to convince policy makers that this model is a valuable tool in preparing policy measures. We do not want to reduce the political discussions to a purely technocratic level.

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But we think that quantitative information on the distributional consequences of policy orientations is among others one crucial input in the decision process. One of the key features of the recently developed microsimulation models is that the product is very user friendly. The threshold for the potential users is kept as low as possible. Also our product reflects this concern[2]. Of course it is impossible in this paper to illustrate all these menu-driven options graphically. We will confine the presentation here to illustrations of possible output of the model. For a detailed description and illustration of the practical use of the model we refer the interested reader to the Users' Guide (Decoster, Rober and Van Dongen (1994)).

The second objective of this paper follows from our view that the proof of the pudding is in the eating. The best way to see what the model does is to present it in the context of a relevant real world simulation. We have chosen the carbon/energy tax proposal of the EC-commission to illustrate the microsimulation methodology. The distributional consequences of this environmental tax proposal are of course interesting in themselves. Studies abroad have revealed the strongly regressive nature of energy taxes (see Johnson, McKay and Smith (1990), Pearson and Smith (1991) and Symons, Proops and Gay (1992)). It is interesting to know whether the structure of expenditure patterns in Belgium would lead to the same conclusion.

The family of microsimulation models is expanding rapidly and our model belongs to a small and specific subset. We have confined ourselves to a *static* model[3] which describes *household behaviour* for exogeneously given prices and total expenditures. The policy change which can be implemented consists of a change in the *indirect* tax structure[4]. Of course this is a partial approach. As will become clear in section IV we assume producer prices to be constant. In our example of the carbon/energy tax this implies that an increase of the excise on fuel has no influence on the price of say food or clothing. This means that we cannot study general equilibrium effects of policy reforms in indirect taxes[5]. Not only does this mean that we have to neglect the price changes of other commodities, induced by changed production costs, but also that we cannot assess the important distributional effects linked with changing employment opportunities in the different sectors of the economy. The limitation to implementation of indirect tax changes with fixed nominal expenditures distinguishes the model from the better known tax-benefit models. In an associate project carried out at the university of Namur a Belgian tax-benefit model has been developed[6]. This model allows to assess the distributional impact of a change in the parameters of the direct tax and transfer system. Many measures of reform of indirect taxes are part of a broader package of reform. Think of the decrease of the social security contributions to be paid by the employer that are compensated by the extra revenues collected from the introduction of an energy tax. Our model only allows to analyse the latter part of the reform in isolation. A major point of future research in the development of microsimulation methodology will be the integration of the direct tax-benefit model from Namur with the indirect tax model from Leuven.

The plan of the paper is as follows. In the next section we shortly describe the EC-Commission proposal to introduce a carbon/energy tax in the member countries. In section III we present the results of the use of the ASTER-model for this policy proposal. This section will show how suitable the approach is to identify the winners and the losers of this tax reform. In section IV the model itself is briefly explained. We present the demand system used to model consumer expenditure behaviour and discuss what the simulation does and does not. Section V and VI give an empirical answer to two prominent methodological questions. Section V investigates whether behavioural reactions from the part of the households are important in the evaluation of policy measures. In section VI we return to an evergreen in discussions about income or welfare distribution between households: the use of equivalence scales. Section VII concludes.

II. THE CARBON- AND ENERGY TAX PROPOSAL OF THE EC

In the context of the greenhouse problem the EC has committed itself to reduce the CO_2-emissions in the year 2000 to the level of 1990. The proposal by the Commission to introduce a mixed carbon- and energy tax dates from May 13th 1992. To reduce the emissions the commission has proposed to introduce an excise per unit of energy. If the excise is differentiated according to the carbon content of the energy holder, one speaks about a carbon tax. If there is no such differentiation one better uses the word energy tax. In the EC-proposal both options are combined. The reason is that one does not only want to discourage the emission of carbon dioxide, but also stimulate a more efficient use of energy.

The excise has been fixed at $3 per barrel of crude oil in 1993. It will increase with $1 a year to reach the level of $10 in the year 2000. The above mentioned option of a combination of carbon and energy tax means that the amount of the excise is related to the carbon content for 50% and to the energy content for also 50%. The energy content of a barrel of crude oil is well known and is expressed in gigajoule. By using the carbon content of other forms of energy relative to the one of crude oil one calculates the carbon/energy tax per gigajoule for these other forms of energy. These figures are then transformed into excises per unit of energy sold (e.g. kilo of coal, liter of fuel etc.). In the first two columns of Table 1 these excises are expressed in Bfr for 1993 and 2000.

TABLE 1

The European proposal for a carbon/energy tax and the Belgian energy tax in Bfr per unit

Form of energy	Unit	EC-proposal 1993 (1)	EC-proposal 2000 (2)	Belgium 1993 (3)
Gasoline	liter	0.564	1.881	0.550
Gasoil	liter	0.630	2.102	0.000
Lpg	liter	0.388	1.291	0.000
Natural gas	megajoule	0.015	0.051	0.014
Butane gas	kg	0.711	2.370	0.690
Propane gas	kg	0.717	2.391	0.700
Fuel	liter	0.630	2.102	0.340
Coal	kg	0.577	1.925	0.000
Electricity	kwh	0.089	0.297	0.055

At this moment the proposal of the commission has not been implemented yet. But in the meantime the Belgian government has decided to introduce an energy tax from August 1st 1993 on. It was embedded in a set of measures to improve the competitive position and employment of the Belgian economy. The figures of this tax increase for private households are in the third column of Table 1. It has been explicitly mentioned that these excises would be taken into account at the moment the European tax is introduced. In our simulation this Belgian energy tax is already included in the pre-reform situation. We have chosen to look at the distributional effects of the introduction of the complete EC-tax of the year 2000. We therefore increase the existing excises with the difference between column (3) and column (2) of Table 1.

III. IDENTIFICATION OF WINNERS AND LOSERS

The impact of the tax reform is calculated for each household separately. This allows to calculate gains and losses for different subgroups of the population and hence to identify winners and losers of the reform. For this illustration we have defined the loss concept as the change in *net* expenditures (nominal expenditures minus total indirect taxes to be paid), which is equivalent to the difference in taxes to be paid after and before the reform. Other concepts can be chosen within ASTER.

Before investigating the variation of the loss across households, let us look at the average result for the whole population and some summary characteristics of the distribution. These are found in Table 2, one of the output tables of the ASTER program.

TABLE 2

Descriptive statistics for the distribution of net expenditures before and after the carbon/energy tax

Statistic	Pre-reform (Bfr/year)	Post-reform (Bfr/year)	Absolute change (Bfr/year)	Percentage change (%)
Mean	741 886	736 762	-5 123	-0.78
Minimum	116 786	111 965	-33 641	-5.01
Lower hinge	463 051	458 820	-6 762	-0.97
Median	675 358	671 178	-4 736	-0.67
Upper hinge	941 614	937 134	-2 933	-0.46
Maximum	3 884 643	3 876 484	234	0.03
Standard deviation	383 153	381 666	2 998	0.51
Coefficient of variation	0.5165	0.5180	-0.5852	-0.6536
Standard deviation of logs	0.5297	0.5319		
Gini coefficient	0.2748	0.2757		
Atkinson coefficient (ε=1.5)	0.1767	0.1779		

Above the horizontal line in the table, all figures are calculated as averages across households, also the third and fourth column. The third column gives the average absolute loss across all households, and hence is not equal to the difference in the averages of net expenditures in the first two columns. The same holds for the percentage loss in the final column. The first figure of -0.78% is the average of the percentage loss of all households.

Obviously, the carbon/energy tax causes a substantial increase in the indirect taxes to be paid by households. On average the increase is Bfr 5123 a year, with a standard deviation of Bfr 2998. There is one household in the sample which pays Bfr 33641 more indirect taxes. At least one household in the sample has a small gain: Bfr 234. The substantial impact of the EC-proposal is also reflected in the percentage loss: on average -0.78%. The table already reveals that there is substantial variation in the loss (and also in expenditures) between the households. It is this variation that can be investigated by the rest of the ASTER program.

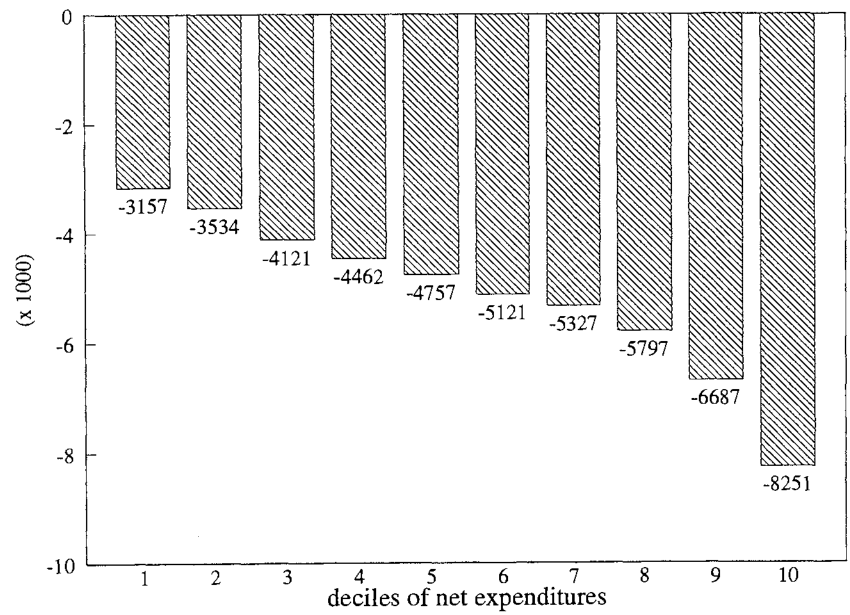
Figure 1 shows how the absolute loss in Bfr per year increases as total expenditures increase. The top decile pays nearly three times as much more indirect taxes than the bottom decile (Bfr 8251 and Bfr 3157 respectively). Of course most people will not adhere to this absolute loss concept to assess the distributional impact of the reform. The deciles are defined on total expenditures so that it is normal that the increase in indirect taxes is higher for the higher deciles.

If we calculate the percentage loss in net expenditures (relative to the net expenditures before the tax reform) we get Figure 2. The picture is reversed now. The carbon/energy tax proposal seems to be regressive in terms of total expenditure deciles. The average loss for all households is 0.78% of pre-reform net expenditures. But the poorest 40% of the households loose relatively more, the richer households incur smaller losses. The picture here confirms the results found abroad that energy and carbon taxes have a strongly regressive impact on the distribution. This is confirmed by the increase in sixteen commonly used inequality measures, calculated by ASTER (in Table 2 we only reproduced the Gini and Atkinson coefficient and the standard deviation of the logs). The figures show that there is an increase in the inequality measures, but that it is small: the Gini increases from 0.2748 to 0.2757, the Atkinson measure from 0.1767 to 0.1779 (for an inequality aversion parameter of 1.5).

Of course one can criticise the construction of deciles on the basis of nominal expenditures, which are a too crude measure of welfare of the household. This is true, and ASTER therefore allows to choose

FIGURE 1

Absolute change in net expeditures (in Bfr) by expenditure deciles

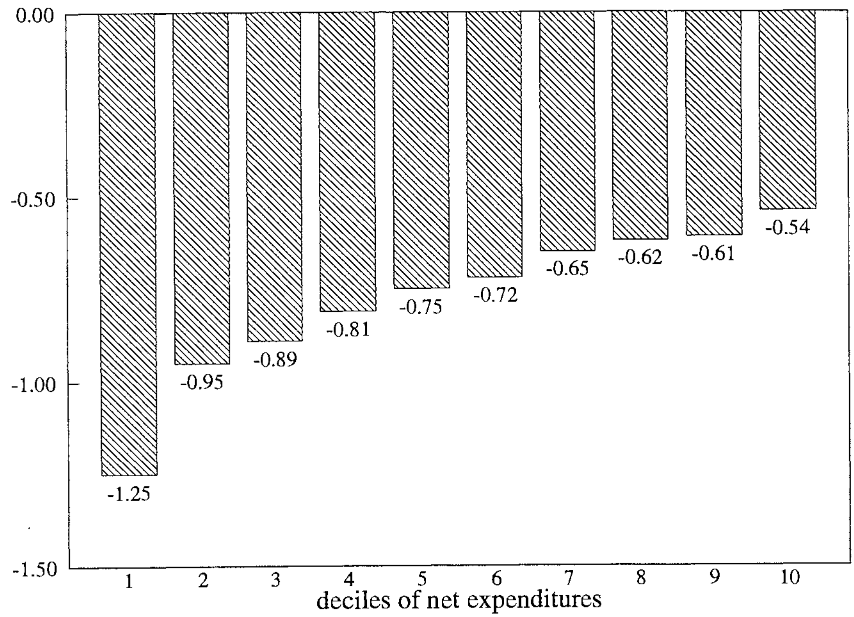


other variables to define welfare. One of the main options in this context is the correction with equivalence scales to adjust for household size. We will discuss this topic in section VI.

Undoubtedly, the distribution of gains and losses over poor and rich households is one of the main items to be discussed in the evaluation of a reform. But the analysis above can be repeated for other divisions of the population as well. ASTER offers a choice of 62 available characteristics to define subsets in the population (e.g. whether the household lives in a rural or an urban area, whether the household has a home computer or not, whether there is telephone, refrigerator etc.). Needless to say that it depends on the simulation chosen whether a characteristic is relevant or not. In Figure 3 and 4 we give the percentage losses for different age classes of the head of the household, and for subgroups defined on the type of energy used to heat the house.

FIGURE 2

Percentage change in net expenditures (in%)
by expenditure deciles

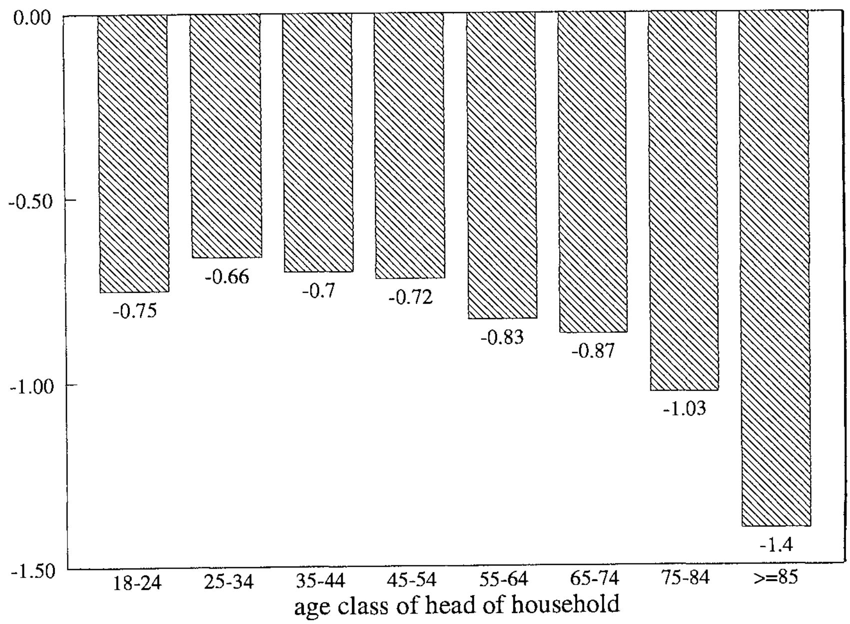


Obviously the households in the age classes of 55 and above incur a loss above the average. Partly this is explained by the lower net expenditures of these groups (the denominator for the percentage loss). For the households in the class 25-34 e.g. net expenditures amount to Bfr 807105, whereas for those in the class 75-84 this is only Bfr 452001. On the other hand expenditure patterns themselves might explain the differences between age groups. It is possible that older households consume more of the highly taxed goods (e.g. coal) than the younger ones (who heat more with e.g. electricity). Given the aim of the paper set out above, it is beyond its scope to *explain* the differential burden of the carbon/energy tax.

Figure 4 proves that there is indeed substantial differentiation in the burden of the carbon/energy tax depending on the type of energy used to heat the house. With an average loss of 0.78%, the relative winners are the households who use electricity and natural gas, the relative losers those who heat with coal and to a lesser extent fuel.

FIGURE 3

Percentage change in net expenditures (in%)
by age class

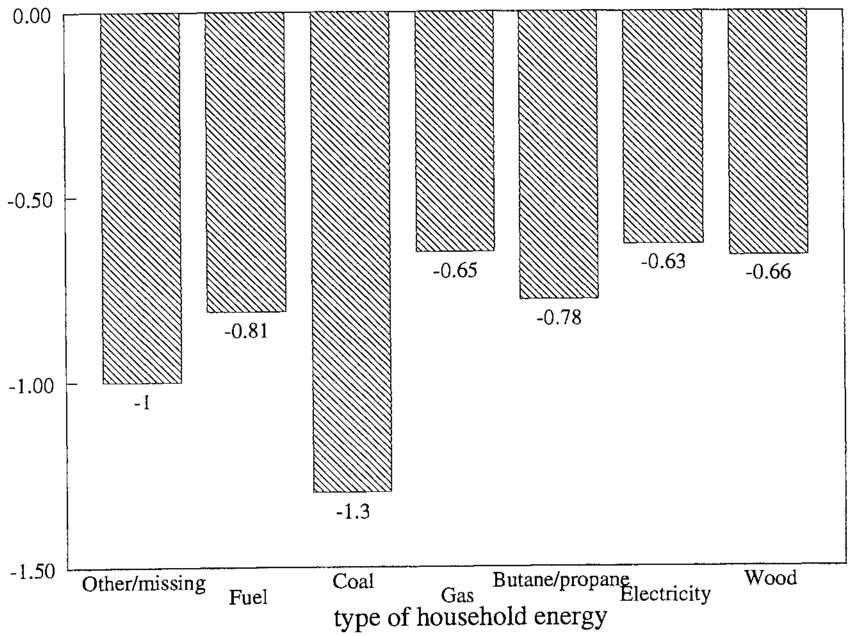


Note the importance here of taking into account the shares in the population, made up by the different subgroups. Households using coal make up only 9% of the households, and electricity is used as main source of energy by only 6% of the population. The main sources are fuel (41.6%) and natural gas (38%).

A final illustration of the possibilities of the program is offered in Table 3. Until now we first defined subgroups of the population based on a given characteristic like total expenditure, age class, occupation etc. We then calculated the average loss for these subgroups and compared. But ASTER also allows to reverse the procedure. Given a loss concept defined by the user (e.g. absolute or percentage loss), the program orders the household from greatest loser to greatest winner and then partitions this ordered population in quantiles. With quintiles e.g. we then get five subgroups. The first group consists of the 20% greatest losers, the fifth group of the 20% greatest winners (or in this example, the smallest losers). For each subgroup the program calcu-

FIGURE 4

Percentage change in net expenditures (in%)
by source of energy



lates the average value of a selected list of characteristics. Table 3 illustrates this procedure for the carbon/energy tax.

The first three lines provide information of the ordering process by ASTER and the partitioning in quintiles. Reading the table from left to right for a selected characteristic, one finds the correlation of the characteristic with the position in the loser-winner ordering. Reading the table vertically for a selected column, e.g. the first one, one finds the characteristics of e.g. the greatest losers. This approach is attractive since it gives a clear answer to the prominent political question: who are the winners, who are the losers? It also allows to make use of characteristics defined as continuous variables. In contrast, for the approach illustrated earlier to be operational, the characteristic had to be defined in discrete classes.

The Table reveals that in the 20% greatest losers group we find households with low expenditures, elder people, in smaller and more non

TABLE 3

Average value of characteristics for gainers and losers

Characteristic	Quintile 1 (greatest losers)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (smallest losers)
Lower bound quintile (%)	-5.01	-1.06	-0.77	-0.59	-0.41
Upper bound quintile (%)	-1.06	-0.77	-0.59	-0.41	0.03
Average loss (%)	-1.55	-0.90	-0.67	-0.50	-0.27
Net expenditures (Bfr)	504 961	691 255	803 199	911 122	798 865
Age head of household (year)	56.71	52.11	47.31	46.15	50.98
Number of persons in househ.	2.03	2.55	2.73	2.89	2.21
Number of active persons	0.58	0.93	1.13	1.23	0.94
Dummy for white collar	0.15	0.28	0.35	0.42	0.35
Dummy for higher education	0.26	0.36	0.50	0.50	0.52
Dummy for car ownership	0.59	0.77	0.79	0.83	0.69

active (probably retired) households, with a smaller proportion of white collar and higher educated head of households, and less car owners[7].

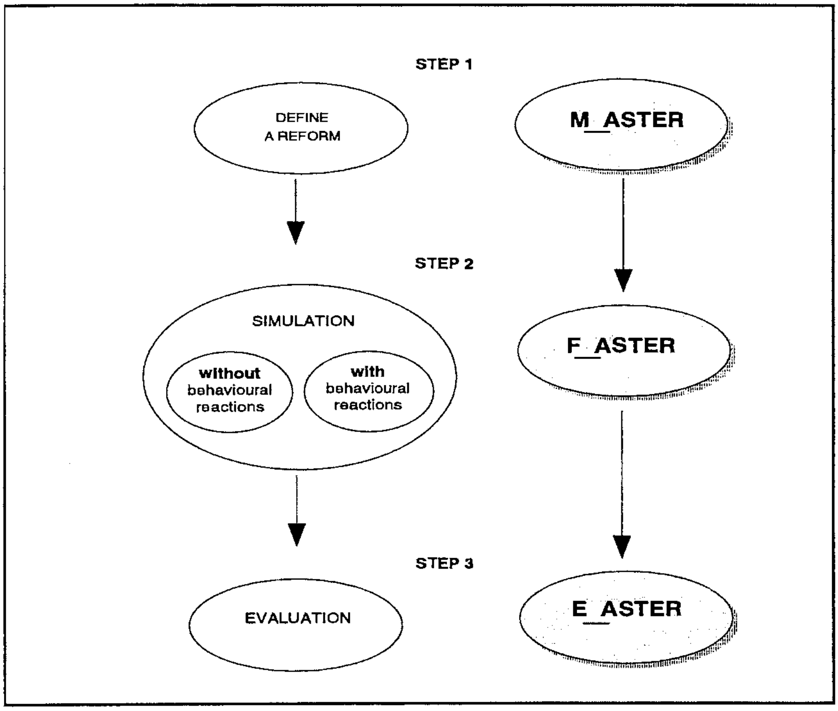
Of course, we have not exhausted the possibilities of the program to evaluate the carbon/energy tax proposal. For Table 3 e.g. the user can choose from a list of 67 characteristics. Before investigating two important user options in detail in sections V and VI, we will briefly explain in the next section how the simulations take place.

IV. STRUCTURE AND WORKING OF THE SIMULATION PROGRAM

Figure 5 illustrates the basic structure of the ASTER model. It consists of three separate modules. In the first step, called M_ASTER, the user defines the reform. We describe this part in section IV.A. The second part, F_ASTER, carries out the simulation for each household. The underlying demand system is briefly discussed in section IV.B. The results of this simulation are then used in the third step, E_ASTER, to assess the distributional impact of the reform. The results presented above for the carbon/energy tax all come from the output of the E_ASTER module. The E_ASTER module has many more options for the user than shown in the above illustration. But in this paper we will not discuss it further. From a policy point of view, the first and third part of the program are the most interesting ones. From an academic point of view, the F_ASTER part is the crucial one.

FIGURE 5

Structure of the ASTER model



A. *M_ASTER: from tax change to consumer price change*

The first part of the model performs two tasks. First, it allows the user to change VAT rates, excise duties and ad valorem rates on a detailed list of 746 commodities. Second, since it is impossible to model household behaviour for more than 700 commodities, the model calculates new consumer prices for 32 aggregates. This is the number of commodities for which the demand system has been estimated.

The relation between indirect tax components and consumer prices for commodity i is given by:

$$p_i = (1 + t_i) \cdot (q_i + a_i + v_i \cdot p_i) \qquad (1)$$

with:
- p_i consumer price for commodity i
- q_i producer price for commodity i
- t_i VAT rate for commodity i
- a_i excise duty for commodity i
- v_i ad valorem rate for commodity i

The windows of the M_ASTER model provide the pre reform tax information for all commodities. The producer price is assumed constant. In very user friendly windows the user can pick out any commodity to change t_i, a_i or v_i. It is also possible to define global changes (e.g. increase the VAT-rate of 6% to a rate of 10%). The post reform consumer price is then calculated for the 32 aggregates.

In Table 4 we list the pre and post reform consumer price for the 32 aggregates, using a normalisation of the producer price equal to unity. The commodities changing in price are typed in bold face. Of course *all* relative prices change. The price changes are important: the coal price goes up with 20.8%, the fuel price with 27.1%, gasoline becomes 4.7% more expensive and gasoil 10.1%.

B. *F_ASTER: price and total expenditure elasticities*

The choice of the functional form of the demand system is highly inspired by the SPIT-model of IFS-London. The model specifies budget shares and is an extension of the widely used AID-model of Deaton and Muellbauer (1980) (see Blundell, Pashardes and Weber (1989) and Baker, McKay and Symons (1990)).

TABEL 4

Prices, price elasticities and total expenditures elasticities for the 32 aggregates

	Commodity	pre reform price	post reform price	own price elasticity	total exp elasticity
1	Bread	1.0600	1.0600	-0.4519	0.4543
2	Meat	1.0600	1.0600	-1.1864	0.5314
3	Fish	1.0989	1.0989	-0.4309	0.8039
4	Dairy products	1.0600	1.0600	-0.1125	0.4717
5	Oils and fats	1.0788	1.0788	-0.2009	0.2134
6	Potatoes, vegetables, fruit	1.0681	1.0681	-0.7275	0.5715
7	Coffee and tea	1.1051	1.1051	-0.2137	0.3825
8	Sugar and jam	1.0600	1.0600	-0.6468	0.6891
9	Other food	1.0600	1.0600	-0.7272	0.5757
10	Soft drink	1.3513	1.3513	-0.1481	0.6564
11	Beer	1.3978	1.3978	-0.8802	0.6892
12	Alcohol	1.9636	1.9636	-1.0055	0.8674
13	Wine	1.3322	1.3322	-0.5597	1.1589
14	Tobacco	3.0063	3.0063	-0.8072	0.1439
15	Clothing	1.2050	1.2050	-0.7994	1.0621
16	Rent, tax, water	1.0146	1.0146	-0.0382	1.1830
17	**Coal**	1.1200	**1.3535**	-0.1220	-0.0503
18	**Natural gas**	1.2653	**1.4283**	-0.1461	0.5335
19	**Electric heating**	1.2409	**1.3989**	-0.0482	1.3088
20	**Fuel**	1.3163	**1.6727**	-0.7037	0.4419
21	**Electric lighting**	1.2177	**1.2735**	-0.1472	0.4742
22	Durables	1.2037	1.2037	-0.7395	1.8031
23	Maintenance of the house	1.1227	1.1227	-0.9388	1.1453
24	Hygienics	1.0753	1.0753	-0.1581	1.0825
25	Use of private transport	1.0893	1.0893	-0.6992	1.1321
26	**Gasoline**	3.8466	**4.0266**	-0.6291	0.6587
27	**Gasoil**	2.7353	**3.0102**	-0.7786	0.9006
28	**LPG**	1.2050	**1.3963**	-0.5474	0.8723
29	Public transport	1.0566	1.0566	-0.4319	0.7965
30	Other transport	1.0283	1.0283	-0.7266	1.2364
31	Leisure goods	1.1255	1.1255	-0.3499	1.0051
32	Services	1.0845	1.0845	-0.2254	1.0573

The functional form to be estimated for each budget share reads as:

$$w_{ih} = \alpha_i + \beta_i \log\left(\frac{y_h}{P}\right) + \lambda_i\left[\log\left(\frac{y_h}{P}\right)\right]^2 + \sum_j \gamma_{ij} \log p_j + \varepsilon_{ih} \qquad (2)$$

with: $\log P = \sum_j w_{jh} \log p_j$ (the Stone price-index)

and: $w_{ih}=\frac{y_{ih}}{y_h}$ the share of expenditures on good i in the total expenditures of household h or

- y_h total expenditures of household h
- y_{ih} expenditures of household h on good i
- p^j consumer price for good j
- β_i, λ_I total expenditure effects (to be estimated)
- λ_{ij} price effect of price j on good i (to be estimated)
- ϵ_{ih} disturbance term

In the SPIT-model the same database (the Family Expenditure Survey) is used both for estimation of the behavioural parameters and for the simulation of the tax reform. In Belgium we do not have a time series of expenditures at the level of the household. The most recently available budget survey files the expenditure behaviour of 3235 Belgian households on a very detailed list of commodities during one year (1987-88). Presumably there is too little relative price variation in this survey too estimate the price parameters in (2).

Therefore we have estimated the γ_{ij}'s on the National Accounts time series. These are yearly data starting in 1953. Because we have chosen for a rather disaggregated demand system of 32 acommodities, we have estimated the demand system under the restriction of weakly separable preferences. This assumption implies that the household takes the decision how to allocate the budget over the different commodities in two steps (called *two stage budgeting*). First, one decides how much to spend on broad categories (e.g. food, clothing, transport, etc.). This allocation is determined by real income and relative prices of these aggregate commodities. Second, the budget for e.g. food is allocated to individual commodities (bread, fish, vegetables etc.). This allocation is determined by the budget allocated to food in the first step and the relative prices of the individual commodities in this group. The assumption of weakly separable preferences is therefore not only attractive from a theoretical but also from a statistical point of view. It imposes a structure on the matrix of price coefficients to be estimated, which reduces the size of the estimation problem considerably.

The assumption of weak separability is easily imposed within a Rotterdam specification of the demand system, not in an AID specification. Hence we first have estimated a Rotterdam system, both for the first stage and for the subsystems. Since there is a one to one relationship between the parameters of a Rotterdam and an AID specification (see Barten et al. (1992)), we could then derive the corresponding AID-parameters of (2).

The results are summarised in the third column of Table 4. For ease of interpretation we have transformed the original parameters into elasticities[8]. The limitation to *own price elasticities* follows from obvious space limitations. Most of the commodities ar rather price inelastic (only two have an elasticity exceeding unity). The elasticities for the different motor fuels are rather similar (around -0.6). But within the household energy sources there is a remarkable difference between fuel (-0.7) and the much less inelastic demands for coal (-0.12), natural gas (-0.15) and electricity (-0.05). We will investigate the impact of these coefficients on the results in section V.

For the estimation of the total expenditure effects (the β_i's and λ_i's) we can of course make use of the budget survey. Since the real expenditure effect seems to be correlated with being a smoker or not and having a car or not, we have estimated the Engel curves of (2) for four different subgroups of households: car owners/smokers, car owners/non smokers, non car owners/smokers and non car owners/non smokers. We also included a white collar dummy, a dummy for higher education, the number of actives and the number of children in the household, the age of the head of the household and a dummy for the household living in a rural area.

In the simulation program we use the set of coefficients, appropriate for one of the four subgroups to which a household belongs. But in the fourth column of Table 4 we have for the sake of brevity calculated a weighted average of the total expenditure elasticities for the four subgroups. Coal is the only inferior good, and durables is the most clear luxury good.

V. DO BEHAVIOURAL REACTIONS MATTER?

It would not be wise to present the price and total expenditure effects presented in the previous section as the final answer to the question how Belgian households adjust expenditures to changing relative prices and real income. More research is needed to compare them with previous estimates or with results based on other - on certain aspects better - theoretical specifications (e.g. for durables and for zero expenditures). Yet, at first sight the estimates seem reasonable.

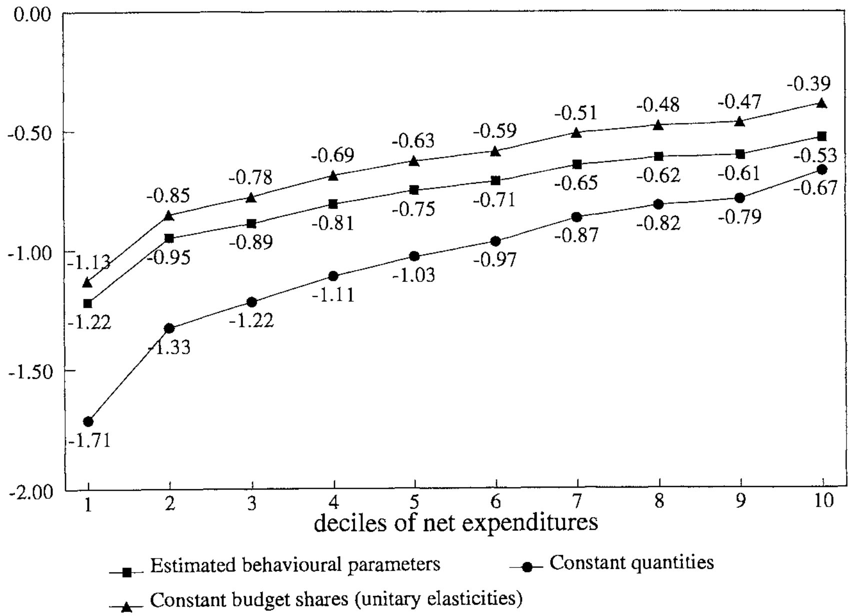
To investigate the sensitivity of the results with respect to these parameters, we have done two other simulations. The first option offered by ASTER is to forget about behavioural effects. Households simply buy the same quantities after the tax reform as before. This is the assumption often implicitly made in many "simulations" carried out by government officials. The second possibility built in the simulation program is to assume constant budget shares. This implies that all total expenditure elasticities are equal to one, that all own price elasticities are equal to minus one and that all cross price elasticities are equal to zero. We will refer to the simulation with the estimated parameters as *Est*, the simulation with constant quantities as *CtQ* and the simulation with constant budget shares as *CtS*.

On average the absolute increase in total indirect taxes to be paid goes down from Bfr 6858 in CtQ to Bfr 5123 in Est and even Bfr 4162 in CtS. This implies that taking into account the behavioural reactions of the households on the carbon/energy tax is indeed important. People succeed in avoiding part of the increased taxes by adjusting their consumption behaviour. This also implies that the frequently used assumption of constant quantities leads to a substantial overestimation of the revenue effects (on average Bfr 1735 or 34% too high)[9]. The assumption of unitary elasticities is more optimistic about the substitution possibilities and leads to the smallest loss.

Figure 6 illustrates the percentage change in net expenditures for the ten deciles of pre reform net expenditures[10]. The change in the level of the loss depending on the assumption made about the behavioural parameters is clear. But the regressive nature of the tax is not affected at all. The shift away from the higher taxed commodities seems to be independent of the welfare level. The same holds for the other characteristics analysed above. Hence the answer to the question in the title of this section is: yes for the level of the loss, but no for distributional effects.

FIGURE 6

Percentage change in net expenditures (in%)
for different assumptions on behavioural parameters



VI. DO EQUIVALENCE SCALES MATTER?

It is nice to observe how the concept of equivalence scales survives time after time more or less deep theoretical criticisms and empirical difficulties in calculating or estimating them. The reason is simple: no theoretical or empirical weakness can ever expel the urgent practical need to adjust nominal variables (e.g. income or expenditures) to account for differences in needs. And this is what equivalence scales try to do.

Although the field of application is much broader, most scales that have been estimated are numbers which deflate household incomes for differences in household size. The number of estimated scales is impressive (for an overview see Decoster (1988)). We will not add another set of figures to the list. Neither will we investigate which scale is the better one. But we will repeat the analysis of the previous section with one set of scales: the ones used by the Belgian National Statistical Institute itself. This is the old scale of the League of Nations, introduced in the thirties and used in the N.I.S since the surveys of 1961[11].

Figure 7 plots the losses in net expenditures (in Bfr) for the deciles. There are three lines in the graph. The line with the squares, which goes down from left to right, is a recapitulation of Figure 1. The deciles are defined here with uncorrected net expenditures and also the loss concept on the vertical axis is uncorrected. If one agrees that this is a good proxy for household welfare, then households who are better off, have to pay more. But most people feel that increasing nominal expenditures also have to do with increasing family size. This seriously troubles the link between nominal expenditures and welfare. If we correct for this by dividing nominal expenditures by the equivalence scale and then construct the decile distribution, we get the flat line denoted by the bullets[12]. We did not correct the variable on the vertical axis, the loss in net expenditures, which is now nearly constant across the deciles. Even in nominal terms the carbon/energy tax has lost its progressivity. Of course one might argue that this approach is a bit inconsistent. If we use a deflated concept on the horizontal axis, we also have to divide the loss concept by the equivalence scale. This leads to the upper line with the triangles. Again there appears some progressivity throughout the deciles. *If* we are prepared to accept nominal net expenditures divided by the equivalence scale as a good proxy for welfare, this figure reveals that the loss in welfare increases as welfare goes up.

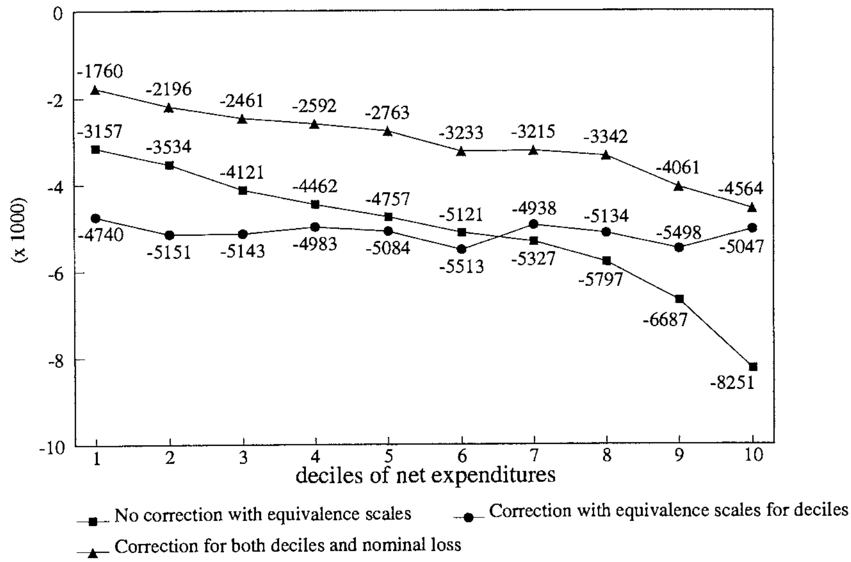
In section IV we observed that the step from nominal to percentage losses turned the tax into a very regressive one. Note however that it is quite useless to repeat this analysis after one has corrected for equivalence scales. If we choose for the consistent approach of either correcting both the variable on the horizontal and the vertical axis, or neither of the two, we simply get the same result in terms of percentage losses (i.e. Figure 2)[13].

In Figure 7, the correction with an equivalence scale of the variable on which the deciles are constructed, reallocates the households between the deciles. Therefore a sharper picture is obtained in Figure 8, where we use the characteristic *type of household* to subdivide the population.

The equivalence scale now only affects the loss concept on the vertical axis. As could be expected the impact is considerable. Without equivalence scales, larger family size means larger loss. But after cor-

FIGURE 7

Impact of equivalence scales on the decile distribution of nominal losses in net expenditures (Bfr)



rection, the singles come out as the greatest losers. Per equivalent person in the family, the loss is smaller the larger is the family. The picture of gainers and losers is completely reversed. Probably one will criticise the practice of dividing the nominal loss by the equivalence scale. Yet, I think most people would agree to use equivalence scales for *increases* in nominal income. I don't see why to leave this approach for decreases in income.

Moreover we have already pointed out that one can get rid of the equivalence scales problem by looking at percentage losses. Assume we define welfare as net expenditure divided by the equivalence scale. Figure 9 then shows the percentage loss of both uncorrected net expenditure and welfare, since the percentage changes of these variables are the same.

The loss picture which emerges ressembles very much the corrected line of Figure 8. Older singles are the great losers. Couples with one child are the relative winners.

FIGURE 8

Impact of equivalence scales on the distribution of nominal losses in net expenditures (Bfr) by type of household

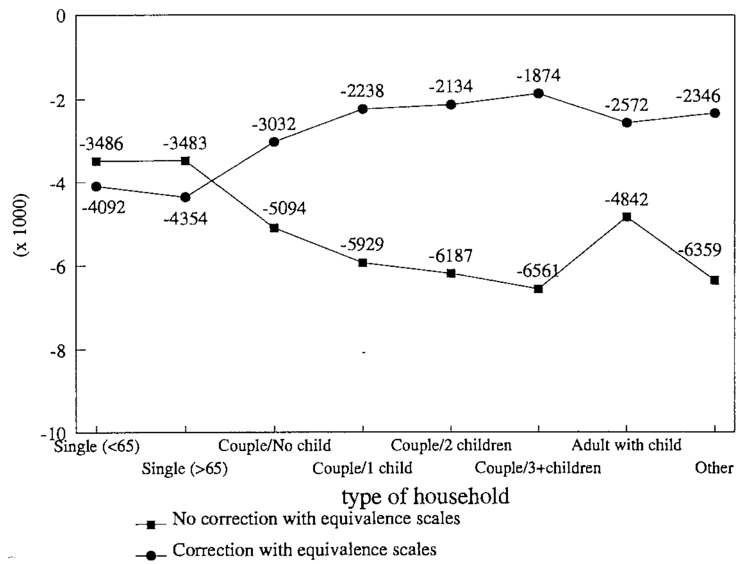
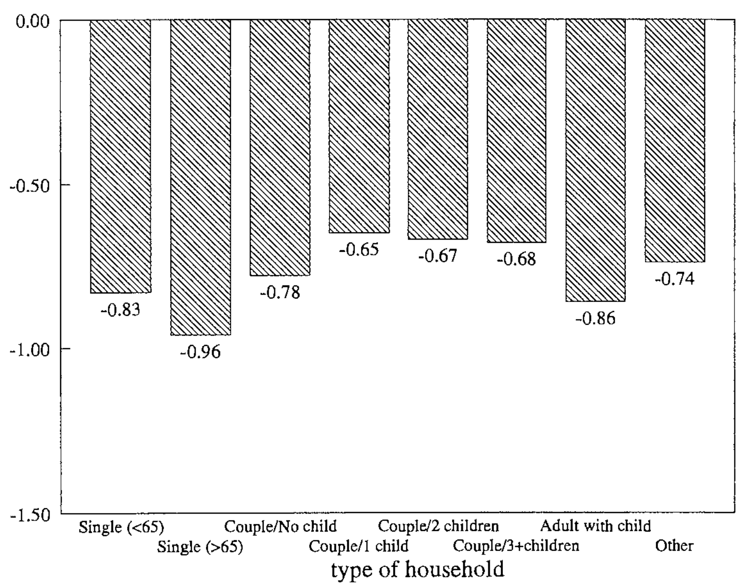


FIGURE 9

The distribution of percentage losses in net expenditures (%) by type of household



Hence the conclusion is clear and could be expected: the use of equivalence scales certainly changes the picture of the distributional effects of tax changes. In the future we hope to enrich the microsimulation model with other specifications of equivalence scales.

VII. CONCLUSION

This paper does not give the final answer to the question about the distributional impact of carbon and energy taxes. But it has proposed a methodology and an instrument that allows at least partial insight in the assessment of the distributional effects of changes in indirect taxes. Although the carbon/energy tax example has only been introduced for illustrative purposes, it is interesting to see that results found abroad also hold in the Belgian case. Environmental taxes are regressive in terms of net expenditures and are more heavily felt by older households.

The possibility to model expenditure behaviour at the level of the household is one of the main advantages of the microsimulation methodology. Our model fully exploits this possibility. We have shown that these behavioural reactions are important to calculate the average loss. But at least in the context of the carbon/energy tax, the regressivity is not affected by the use of the estimated price and total expenditure parameters. This implies that the variation in the expenditure patterns themselves accounts for the major part of the regressivity.

The simulation results with and without equivalence scales have once more highlighted the importance of this topic. They are but one expression of the everlasting question which variable to use to measure welfare or burden of a tax. The microsimulation model is not developed to solve this problem. But we hope to enrich ASTER in the near future with other and more sophisticated scales than those available now.

The ASTER model is ready for use by interested civil servants or government officials. But further research could improve it substantially. It would be interesting to distinguish short run and long run reactions of the consumers. We have to improve the specification for durable expenditures. And the fairly disaggregated level of our demand system, which has of course advantages on its own, also produces many zero expenditures. This is an interesting theoretical problem for which we have to find an appropriate solution. And finally, from a policy point of view, the most interesting challenge is to try to integrate the model with microsimulation models for social security and direct tax benefits.

NOTES

1. An important exception being the simulations carried out at the CSB (Centrum voor Sociaal Beleid) of the University of Antwerp. The model developed there covers social security and is described in Cantillon et al. (1993a). For applications, see Cantillon et al. (1993b) and De Lathouwer (1993).
2. The model runs in a Windows environment which allows the user to choose from the many different options in a very straightforward way.
3. For recent progress in building dynamic models see Harding (1993).
4. The model is highly inspired by the SPIT-model (Simulation Program for Indirect Taxes) of the Institute for Fiscal Studies in London. Thanks are due to Paul Baker and Liz Symons of IFS for valuable help in transposing the SPIT-experience to the Belgian situation.
5. For recent research in this field, see Proost and Van Regemorter (1992) and Proost and Van Regemorter (1994).
6. The work by the authors Dehaspe et al. is still in progress.
7. Especially the use of dummies is interesting in this approach. With the dummy switching from 0 to 1 if the household has a given characteristic, the value in the table gives the percentage of the subgroup who meets the characteristic. In Table 3 e.g. there are only 15% of the households belonging to the greatest losers group who have an occupation classified as white collar. In the greatest winners group this percentage is 35%.
8. The elasticities ar not constant, but vary with the budget shares. They have been evaluated for the average share in the budget survey.
9. In principle the microsimulation model should also be able to predict aggregate revenue effects. Because of our concentration on distributional effects, ASTER has not been validated yet on this point. But apart from the level of the aggregate variables, the percentage changes might already give some indication. In CtQ total indirect tax revenue goes up with 7.2%, in Est with 5.4% and in CtS with 4.4%.
10. In this figure we make an exception to the rule that all averages are calculated at the level of the household. The problem arises from the fact that under the assumption of constant quantities, the budget constraint no longer holds. In the simulation program total nominal expenditure is adjusted to meet the changed tax payments. Hence net expenditure will be unchanged and becomes useless as a variable to analyse. We therefore have chosen another variable to analyse: total indirect taxes paid by the household. After we got this average figure for the ten deciles, we have divided it by the average pre reform net expenditure level for the deciles.
11. The scale assigns a weight of 1.0 to a male between 14 and 60, a weight of 0.8 for females and for males older than 60, and weights going from 0.2 to 0.8 for children (increasing linearly with 0.1 for every 2 years starting at the age of 2).
12. The average of net expenditures equals Bfr 741886, the average of net expenditures deflated with the equivalence scale equals Bfr 423931. The latter distribution is also more equal. The gini goes down from 0.2748 to 0.2591, the Atkinson measure from 0.1767 to 0.1483.
13. Denote net expenditures by x, then the percentage loss equals dx/x. With an equivalence scale s, the percentage loss in corrected net expenditures equals $(dx/s)/(x/s)$, which is of course the same as dx/x

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