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Efficiency and Equity Aspects of Energy Taxation

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Efficiency and Equity Aspects of Energy Taxation[1]

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Abstract

We analyse the distributional effects of increased oil excises in Belgium by combining a Computable General Equilibrium (CGE) model with the EUROMOD microsimulation framework that exploits the rich detail of household-level data. The link between the CGE model and the micro level is top-down, feeding changes in commodity prices, factor returns and employment by sector into a non-behavioural microsimulation. The results suggest that policymakers face an equity-efficiency trade-off driven by the choice of revenue recycling options. Distributional effects of the environmental tax reform appear to depend strongly on changes in factor prices and welfare payments.

JEL Classification: C68, D31, D58, H22, H23, Q43

Keywords: Energy policy, income distribution, CGE, microsimulation

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[1] The results presented here are based on EUROMOD version 6.0. EUROMOD is continually being improved and updated and the results presented here represent the best available at the time of writing. Any remaining errors, results produced, interpretations or views presented are the author's responsibility. This paper uses data from the EU-SILC 2006 provided by Eurostat The author is indebted to all past and current members of the EUROMOD consortium for the construction and development of EUROMOD. Valuable comments of Nicolas Bouckaert, Rembert De Blander, André Decoster, Guyonne Kalb, Kevin Spiritus and Pieter Vanleenhove are gratefully acknowledged. We thank IWT-SBO for financial support of the Flemosi-project (www.Flemosi.be).

1. Introduction

Policies to reduce carbon emission have become ubiquitous in both academic discussions and popular debates. Besides the differential impact of climate change across countries around the globe, one might wonder how energy and emission reduction policies affect inequality within countries. Environmentally related taxes can be argued to be regressive for various reasons. First of all, indirect taxation on the carbon or energy intensity of goods can raise the prices for certain commodities (e.g. oil fuel and petrol). Possibly, the consumption of these goods takes up a larger share of the budget for low-income households, who would therefore be affected disproportionately. Second, carbon taxes or tradable permit schemes can have a significant impact on factor incomes. The extent to which households depend on labour and capital income typically varies along the income distribution. The first argument depends on relative product prices and affects households on the uses side, whereas the second one is driven by relative factor prices and is referred to as an effect on the sources side (Musgrave, 1959). Other factors that may influence the incidence of environmental taxes are differences in endowments and sector composition across regions (Rausch, Metcalf, & Reilly, 2011), the distribution of benefits in environmental quality, and the extent to which all these effects capitalize into land prices (Fullerton, 2011)

Research reports usually find that environmental taxes are slightly regressive in developed countries (see OECD (1995), Speck (1999) or Zhang and Baranzini (2004)). Studies that apply microsimulation techniques using household-level data tend to confirm these findings. For instance, Johnson et al. (1990) simulate expenditure responses to changes in consumption prices of energy, petrol and food. The results suggest that particularly price changes of energy products caused by e.g. value-added taxes or carbon taxes are likely to raise inequality. Decoster (1995) performs a similar analysis for the effects of a carbon tax in Belgium. His analysis identifies initial expenditure patterns as important drivers of redistributive effects of indirect tax reforms. The heterogeneity in consumption responses to price changes seems to play a subordinate role for the distributional impact. A third illustration of a study into the regressive nature of green taxes using household-level data is provided by Metcalf (1999). He emphasizes the potential of using the additional revenue to alleviate the burden of the tax reform for households at the lower end of the income distribution. In general, microsimulation is well-suited to address distributional implications of tax reforms because it allows incorporating the heterogeneity in characteristics and behaviour across individuals or households. However, analyses in partial equilibrium have common limitations, such as exogenous incidence of taxes and the absence of sectoral linkages that may be useful in assessing the economy-wide impact of policy reforms. For a more elaborate discussion on the use of microsimulation for inequality analyses, we refer to Bourguignon and Spadaro (2006).

The importance of initial tax distortions (Bovenberg & De Mooij, 1994) and revenue recycling options (Parry, 1995) in the analysis of environmental tax reforms calls for a general equilibrium framework in which consumption prices and wages are determined endogenously. Aggregate models in a general equilibrium setting, contrary to microsimulation, usually lack a sufficient degree of detail to adequately analyse welfare impacts for different groups of society. These studies therefore tend to focus on efficiency aspects and often present aggregate results in terms of economy-wide or sectoral production and pollution. One notable exception, however, is presented by Proost and Van Regemorter

(1995). They apply a general equilibrium model that deviates from the assumption of one representative household by introducing four types of consumers, differing in employment status and sources of income (labour, capital and welfare payments). The dynamic simulations for an increase in excises on energy products compare two ways of recycling the additional tax revenue: raising the welfare payments or reducing employers' social security contributions. Whereas most studies that ignore equity aspects confirm the weak double dividend hypothesis[2] (Goulder, 1995), the authors argue that this hypothesis need not hold when equity concerns are taken into account. The results under a flexible wage regime show that an inequality averse policymaker may prefer to raise the welfare benefits instead of lowering social security contributions. The reason is that welfare payments accrue more to the poor, whereas a reduction in labour taxes would mostly benefit the higher income groups.

A more recent strand of literature attempts to reconcile aggregate and disaggregate perspectives by linking CGE models with microsimulation. The advantage of this approach is that it includes general equilibrium feedbacks but nevertheless exploits the full detail captured by household-level data. Several variants of this approach can be distinguished[3]. Chen and Ravallion (2004) illustrate a straightforward top-down link, transmitting CGE changes in prices and wages to household survey data to analyse the distributional impact of China's accession to the World Trade Organization. Their analysis assumes quantities are fixed, which comes down to unchanged labour and consumption behaviour of households. A second type of linkage strives for some consistency by reweighting the microdata in accordance with the CGE aggregates. Buddelmeyer et al. (2012) apply this approach to study the effects of climate change policies on income distribution in Australia. Employment and population changes are accounted for by adapting the sample weights of the households in the microdata. Since our work builds largely on methods presented by Buddelmeyer et al., this procedure for linking the CGE model with microsimulation will be discussed in more detail in section 3. The authors analyse two scenarios (80 and 90 per cent CO_2 reduction below the level in the year 2000 by 2050) of an Emissions Trading Scheme for Australia. The revenue generated by this program is redistributed lump sum to the households. In the aggregate, real net incomes seem to drop after the reform. For the lowest income quintile, however, the income loss is overcompensated by the lump sum transfer, such that overall income inequality as measured by the Gini index is reduced. Top-down links with explicit modelling of household behaviour at the microlevel can be found in Labandeira et al. (2009), who use a demand system on microdata, or in Robilliard et al. (2008), who employ a micromodule with endogenous occupational choices. Third, some studies develop an iterative procedure between aggregate and disaggregate models, referred to as a top-down / bottom-up method, which may be useful when the reform under study causes important microlevel changes that have effects on a macro scale (Savard, 2003). Finally, for a fully integrated CGE model based on household-level data we refer to the ambitious work of Rausch et al. (2011), who apply algorithms developed by Rutherford and Tarr (2008). Over 15000 households are incorporated as individual agents in a general equilibrium setting in order to analyse carbon taxes in the US. One of the conclusions claims that a progressive impact of carbon pricing on the sources side

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[2] The 'weak double dividend' hypothesis states that recycling the additional revenue of increased environmental taxes by lowering pre-existing distortionary (e.g. labour) taxes is less costly than redistributing the extra tax income as lump sum transfers.

[3] An overview (of applications in international trade literature) is given by Hertel and Reimer (2005).

can offset regressivity on the uses side. Interestingly, the authors point out impact variation across racial and ethnic groups.

This paper uses a top-down link between a regional computable general equilibrium model and a non-behavioural microsimulation framework. We analyse the distributional effects of an increase in excises on mineral oil in Belgium, taking into account employment, consumption price and income changes. In addition to describing the results in terms of household's characteristics, we break down the impact of the energy tax reform in employment, income and price effects. The next section briefly describes the most important features of the CGE model. Section 3 provides details on how we build the bridge between the CGE model and microsimulation. Results are presented in section 0. The final section concludes.

2. CGE model

In this section we set out the most important features of the regional CGE we have developed for this exercise. It is largely based on the GEM-E3 model. For a full description, we refer to the model manual[4]. For each of the three regions in Belgium, we model a representative household and eighteen industry sectors. This way we take into account important differences in sectoral composition between the regions. One federal and three regional governments are included, as well as trade with the rest of the world.

Households maximise an intertemporal Stone-Geary utility function by choosing the desired amounts of leisure and consumption goods. Expenditure on commodities is further allocated between non-durables (11 categories) and a stock of durable goods ('Heating' and 'Transport equipment'). The use of a durable involves the consumption of fuels, a non-durable. Excises are levied on this linked consumption. The diagram in Figure 5 in appendix A visualises the structure of the household side. Note that this modelling approach abstracts from differences in skill levels between households and assumes all unemployment is voluntary.

Firms maximise profits subject to a Constant Elasticity of Substitution (CES) production technology with constant returns to scale. A nested structure, shown in Figure 6 in appendix A, allows for more complex substitution patterns. On the first level, firms can substitute a stock of capital against a bundle of labour, energy and materials. The model is dynamic through accumulation of capital over time. Each industry branch makes an investment decision (based on exogenous growth expectations) in order to obtain the desired capital stock in the next period. This investment demand is converted (using an investment matrix) into a demand for the outputs of the different sectors. Energy inputs in the production process are subdivided into electricity, oil, gas and coal. On the firm side, excises on oil are levied on the volume of oil inputs in the production process.

Governments' behaviour is exogenous. Several government instruments are included, such as direct, indirect and energy taxes, welfare payments, subsidies and import duties. Federal and regional government budgets are interlinked via mechanisms that organise the

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[4] An extensive manual can be found on http://www.ecmodels.eu/index_files/Manual_of_GEM-E3.pdf or http://ipts.jrc.ec.europa.eu/activities/energy-and-transport/gem-e3/.

sharing of revenues of federal taxes. International trade is modelled according to the standard Armington (1969) assumption, which states that domestically produced goods and imports are imperfect substitutes. Exports are based on exogenous world demand, following the same reasoning. For Belgium, the assumption of a small open economy seems obvious, so we take world prices as exogenous and uninfluenced by the import demand. Interregional trade is not explicitly modelled.

Labour, goods and capital markets are simultaneously in equilibrium. First, labour supply matches labour demand in a countrywide, perfectly competitive labour market. This implicitly assumes perfect labour mobility. As a result, wages will evolve in the same direction. Second, household, government, investment and export demand for each consumption category is transformed (by means of a consumption matrix) into demands for the outputs of each industry branch. The commodity market is in equilibrium at the country level, such that consumption prices are the same across the country (aside from small differences in regional taxation). We neglect cross-border shopping. Third, within a five-year period, the capital stock is fixed per region and per industry sector. Capital supply therefore comes down to the existing stock of capital in one period. The capital market equilibrium, where capital demand is determined by investment choices, determines the price of capital. Part of the return on capital is paid out to the households, which can be interpreted as return on investment for the self-employed. Another part is retained within the firm, of which a fraction is paid out to the households as a dividend. The model is implicitly closed by imposing the zero profit condition, complete use of income, the equilibrium on the goods market and the government budget constraint.

The model's parameters are fixed in the calibration, which uses 2005 as the base year. Input-output tables, regional and national government accounts, household accounts and employment data (made available to us by the Federal Planning Bureau) are combined in a consistent way to construct the social accounting matrices for the three regions. Population projections are provided by Eurostat.

Finally, carbon emissions of firms are based on regional energy balance sheets, which contain information on the energy sources used in each sector, combined with default emission coefficients from IPCC (2006). Together with energy tax rates from the International Energy Agency (IEA), the energy balance sheets additionally serve to calibrate the initial level of energy taxes. In calculating the CO_2 emissions by households, we distinguish between the use of fuels for heating and transport purposes.

3. Link with microsimulation

The approach to combine the CGE model with microsimulation followed here is a top-down method, inspired by the work of Buddelmeyer et al. (2012). Our microsimulation framework is non-behavioural, which means that household behaviour is not modelled explicitly at the microlevel. Herault (2010) compares the link of a CGE model with two types of microsimulation: a behavioural module with endogenous occupational choices and a non-behavioural framework with a reweighting procedure to account for employment and population changes. The behavioural approach can take heterogeneity of preferences into account and may better capture employment changes both at the intensive and the extensive margin. The reweighting approach may introduce a small bias, since household characteristics or preferences that may affect the probability of labour market responses are not considered. Nevertheless, Herault (2010) suggests this approach seems to give a good approximation of distributional effects and is simpler to apply. Also note that we do not use the output of the microsimulation as further input into the CGE model; the link is uni-directional.

The microdata we use draws from the European Union Statistics on Income and Living Conditions (EU-SILC), survey data that contains information on labour supply status (and industry sector, if the person is employed), education levels, age, region of residence, factor incomes, household composition and other characteristics of over 14000 Belgian individuals. Expenditure data from the Household Budget Survey (HBS) is used as described below (in the fifth step).

The methodology can be summarized in five steps. The first step is concerned with consistency between aggregate and disaggregate data sources. Adding up the employment figures from the household survey does not reproduce the employment totals that can be found in regional accounts. We align the employment figures by changing the sample weights of the microdata, with as little deviation (measured by a chi-square function) from the original sample weights as possible, such that the labour supply in each region matches the aggregate numbers (keeping total population constant). In doing so, we generate the baseline pre-reform dataset. The reweighting procedure follows the methods described in Cai et al. (2006).

In a second step, we use the same reweighting method to translate employment changes, induced by the policy reform, to the microlevel. Since both the aggregate and the household data contain information on industry sector, variations in employment can be taken into account by industry sector (again with the additional constraint on the population size). After matching both data sources, seven industry sectors remain, as shown in Table 5 in appendix 0. This is a simple way to achieve consistency between aggregate and household level employment changes. A more advanced method to incorporate these variations at the microlevel would be to model behavioural reactions, for instance by means of a discrete choice labour supply model.

Furthermore, a policy reform can affect factor incomes (sources side). The third step brings the real changes in welfare payments (e.g. pensions and unemployment benefits), wages, self-employment income and capital (e.g. shares and bonds) income, as predicted by the CGE, to the microdata by uprating households' income by source. Note we transmit the real percentage changes. By using 'real' changes, there is no need to adapt the tax-benefit system to new price levels in the next step. The choice for percentage changes rather than absolute differences is driven by differences in absolute numbers between aggregate and microlevel data. Table 1 compares the components of household disposable income in both data sources in 2005 (EU-SILC 2006). The frequently encountered problem of under-reporting of capital income in household surveys is apparent from this comparison.

Table 1: Comparison of household income in aggregate data and microdata

Household income *Million €, 2005*	***CGE***	***MSM***	***Relative Difference (%)***
Employment income	116805	131819	-11.39
Self-employment income	30496	19534	56.12
Capital income (dividends etc.)	25731	5209	393.96
Benefits received	56041	51524	8.77
Income taxes	40863	40682	0.44
Social contributions	19290	20558	-6.17
Disposable income	168920	146845	15.03

When households' incomes alter, some families may no longer be entitled to certain means-tested benefits, such as income support. Others start receiving benefits they were not eligible for in the pre-reform situation. A tax-benefit calculator is designed to take these effects into account. The fourth step therefore uses EUROMOD to generate net disposable incomes. EUROMOD is an arithmetic microsimulation model that contains a detailed modelling of the legislative framework concerning taxes and benefits for the countries of the EU27, including Belgium. For more details on EUROMOD, see Sutherland (2001).

Finally, varying levels of excise taxes will result in different consumption prices (uses side). The extent to which a household is affected by these price changes depends on expenditure patterns. The final step aims at incorporating this source of impact variation by constructing household-specific consumption price indices (CPI_i). Based on expenditures from the HBS and price changes derived from the CGE simulations, we compute this index for household i as

$$CPI_i = \frac{\sum_c \left(\frac{p_{1,c} - p_{0,c}}{p_{0,c}} + 1\right) e_{c,i}}{\sum_c e_{c,i}},$$

where $p_{0,c}$ and $p_{1,c}$ are the prices of consumption category c ($c = 1,...,13$) before and after the reform respectively and $e_{c,i}$ is the expenditure by household i on commodity c. This household-specific price index, used to deflate incomes, will be higher for households who spend a large share of their budget on goods that experience a strong price increase. The thirteen expenditure categories are displayed in Table 6 in appendix C. We do not include second order welfare effects caused by changes in consumption. A demand system could be estimated to model consumption behaviour. We refer to Labandeira et al. (2009) for an application on energy taxes.

4. Results

This section first describes the two budget neutral policy reforms we analyse. Before going into the distributional implications, we highlight the impact on aggregate economic and environmental indicators. Next, we decompose the effects on income distribution. The fifth and final subsection studies characteristics of winners and losers.

4.1 Scenario description

We study two scenarios that double the federal excises on mineral oil. In terms of tax revenue, the excises on mineral oil are the most important environmental tax in Belgium. Generating slightly over 3.7 billion € in 2005 (around 1.2% of GDP), this tax represents more than half of all environmental taxes (Eurostat, 2005). Almost 45% is paid by households; the remaining revenue is collected from firms. Note that important exemptions hold for agriculture, air and water transport sectors. How the additional tax revenue of the reform is recycled can have important macroeconomic and distributional consequences. The choice of revenue recycling option distinguishes the two scenarios.

- In the 'transfer scenario', the additional revenue is used to increase welfare payments by around 5% (there is a small regional variation because initial benefit levels differ by region). These payments include pensions, unemployment benefits, child allowances, health benefits and various smaller transfers (family, education, housing, social assistance, disability).
- In the 'social security scenario', employers' social security contributions are reduced by approximately 2 percentage points (from 26% to 24%).

Note that both scenarios are budget neutral for the federal government. For clarification, we state the relation between the wage w, the labour cost faced by firms p_L and the wage received by the worker I_L as

$$p_L = \frac{w}{1-\tau_{SS,F}}$$

$$I_L = (1-\tau_{SS,H})(1-\tau_{DT})w,$$

where $\tau_{SS,F}$ and $\tau_{SS,H}$ are the social security contributions on firm and household side respectively. Direct taxes are represented by τ_{DT}.

4.2 Aggregate results

The energy tax increase we study is substantial, affects both producer and consumer side and can be expected to have a significant economy-wide impact. The macro-level impact predicted by the CGE model is displayed in Table 2. We present the results as percentage differences from the baseline in the year 2050.

In the transfer scenario, the tax increase influences the country's Gross Domestic Product (GDP, in volume) negatively. Although production seems to decrease in all three regions, Wallonia appears to be affected more strongly, whereas Brussels experiences only a small drop in output. The reason is the importance of energy-intensive industries in Wallonia, which are particularly affected by an increase in oil excises. Brussels, on the contrary, mainly hosts headquarters and financial services. The regional variation becomes more apparent when looking at the evolution of employment. The decrease in employment in Flanders and Wallonia causes a downward pressure on the real wage, as shown in the lower part of Table 2.. Together with an increase in costs for oil as an input in production, this lowers the relative cost of labour, which leads to an increase in employment in Brussels. Despite the reduction in real wage, household consumption rises, driven by the strong increase in welfare payments. The reduction in investment is lower than the overall output reduction, indicating a shift towards capital (for Brussels investment even increases). In terms of environmental impact, the results suggest that carbon emissions decrease in all regions, most significantly in Wallonia, where CO_2 emissions are 3.58% lower than in the baseline. The emission reduction is induced by both a reduction in output, overall and of energy intensive industries, and a shift in the input structure in production[5]. As a result of higher input costs, the overall price level rises, causing a decrease in exports. Imports drop less than production, which indicates a substitution away from domestically produced goods.

Table 2: Aggregate results

Difference (%) with reference (2050)	***Transfer scenario***				***Social Security scenario***			
	Brussels	***Flanders***	***Wallonia***	***Belgium***	***Brussels***	***Flanders***	***Wallonia***	***Belgium***
GDP	-0.14	-0.31	-0.85	-0.40	0.59	0.05	-0.51	0.03
Employment	1.93	-0.29	-1.99	-0.31	3.38	0.30	-1.36	0.46
Household cons.	0.34	0.22	0.20	0.22	2.40	0.22	0.00	0.31
Investment	0.11	-0.18	-0.78	-0.26	0.45	-0.01	-0.59	-0.05
CO2 Emissions	-1.13	-2.55	-3.58	-2.63	-0.25	-2.61	-3.77	-2.59
Price Index	1.03				0.69			
Real Wage	-0.34				1.17			
Exports	-0.73				-0.22			
Imports	-0.35				-0.14			

In the case where the additional tax revenue is used to reduce labour taxes (social security contributions), a different picture appears. The right half of Table 2 shows that replacing labour for energy taxes results in a small increase the country's GDP, although production in Wallonia also decreases in this scenario. Lowering labour taxes leads to a small rise in employment, despite the job loss in Wallonia, and an increase in real wages of 1.17%. This

[5] Note that the employment increase in Brussels may intensify commuting flows towards Belgium's capital. The additional congestion and pollution this may cause is not taken into account.

consequently raises disposable incomes and household consumption. A reduction in carbon intensity brings about a countrywide reduction in carbon emissions of 2.59%. Note that lowering pre-existing distortionary (labour) taxes seems to be less of an economic burden than recycling the revenue by means of a transfer to households, thereby confirming weak double dividend claims. Furthermore, the results indicate the potential for a strong double dividend, a scenario in which both economic (in our case, an increase in GDP and employment) and ecological gains (a reduction in CO_2 emissions) can be obtained from an environmental tax reform.

4.3 Distributional impact

Next, we turn to the impact of the reform on income distribution. Figure 1 presents differences between monthly disposable income per income decile before and after the reform. Absolute differences $D_{A,d}$ (displayed in panel A of Figure 1, € per month) and relative differences $D_{B,d}$ (panel B) per income decile d are calculated as

$$D_{A,d} = \frac{\sum_{i\in d} s_{0,i} y_{0,i}}{\sum_{i\in d} s_{0,i}} - \frac{\sum_{i\in d} s_{1,i} y_{1,i}}{\sum_{i\in d} s_{1,i}}$$

$$D_{B,d} = D_{A,d} / \left(\frac{\sum_{i\in d} s_{0,i} y_{0,i}}{\sum_{i\in d} s_{0,i}} \right)$$

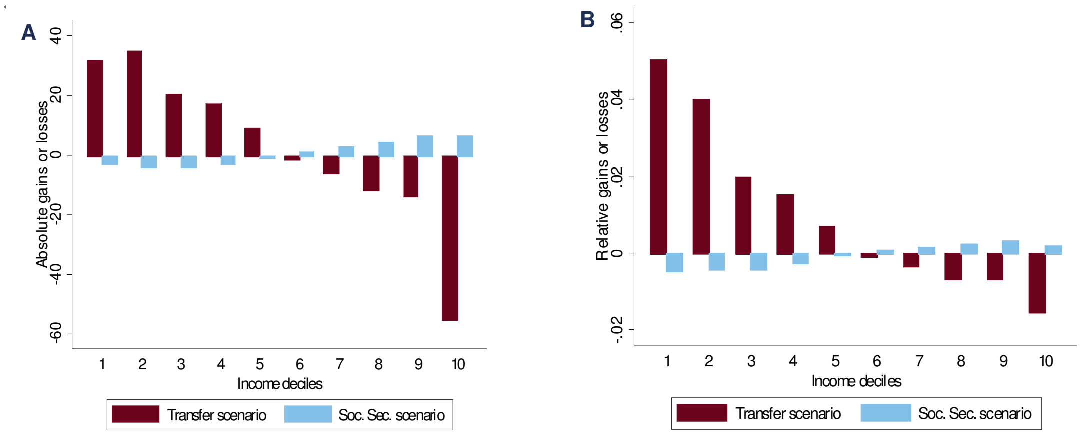
where $s_{0,i}$ and $s_{1,i}$ are the weights of household i before and after the reform, $y_{0,i}$ and $y_{1,i}$ their disposable incomes respectively. Note that income deciles before and after the policy change may differ in composition, because income deciles after the reform are constructed on the basis of altered weights and post-reform incomes.

Figure 1 shows that the distributional effects vary strongly according to the way the additional revenue is recycled. Increased welfare payments (Transfer Scenario) seem to benefit mostly the lower income deciles. This is not surprising, since the share of pensioners and unemployed is higher in these income groups. However, higher excise levies impose a burden

on the industry sectors. The increased production costs lead to higher consumption prices. Furthermore, the transfer scenario entails reductions in real wages (-0.34%), capital (-1.20%) and self-employment income (-1.12%), which mostly harm higher income groups

The shift from labour to energy taxation (Social Security Scenario), on the other hand, appears to be slightly regressive. Reduced labour taxes lead to an increase of overall employment and the real wage rises. However, the lower income deciles hardly gain from the moderate real wage increase of 1.17% because labour incomes and employment rates in these income groups are lower. They are worse off because the overall price level rises as a consequence of higher production costs and more excises paid by consumers. The gains of households at the higher end of the income distribution are limited by a decrease in capital (-0.76%) and self-employment income (-0.64%).

Figure 1: Absolute (A) and relative (B) changes in monthly disposable household income



Panel B of Figure 1, displaying gains and losses relative to disposable income, leads to the same conclusion: redistributing the additional energy tax revenue through welfare transfers is beneficial for lower income households, while social security reductions may give rise to increasing inequality.

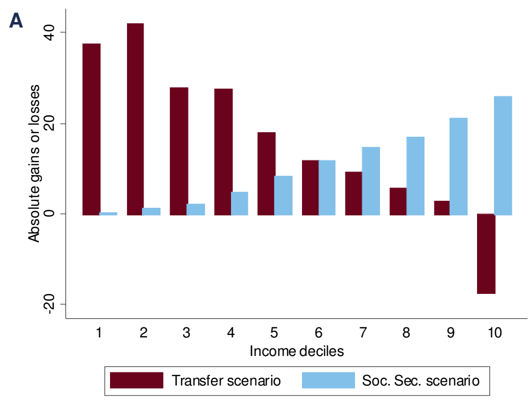
4.4 Decomposition

In this section, we zoom in on the distributional effects of employment, factor income and consumption price changes. Figure 2 decomposes the overall impact by displaying intermediate results (panel D shows the final result, as in panel A of Figure 1).

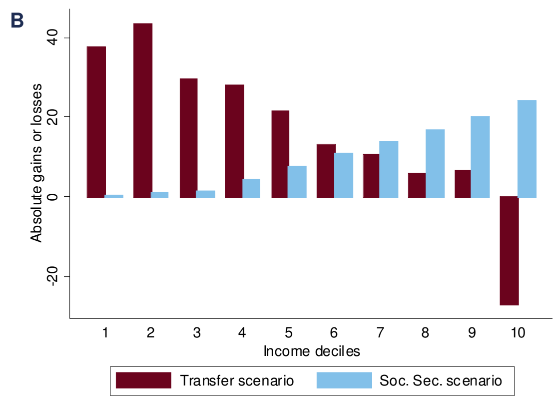
Panel A shows absolute differences in disposable income after taking into account factor income changes and variations in benefit entitlements (in EUROMOD). The sources side seems to be crucial in determining the impact variation across income deciles. More details on the initial distribution of factor incomes can be found in Figure 7 in appendix D.

Panel B illustrates the impact of employment changes, included by changing sample weights. This figure largely shows the same structure as in panel A. Although the changes in weight differ by disposable income (as is shown in Figure 3, with $s_{1,i} - s_{0,i}$ on the vertical axes), the relatively small changes in employment do not seem to change the conclusions that could be drawn from panel A. Possibly, an explicit modelling of labour supply reactions at the intensive and extensive margin, as is done in discrete labour supply models, is more suitable to address distributional concerns of employment changes.

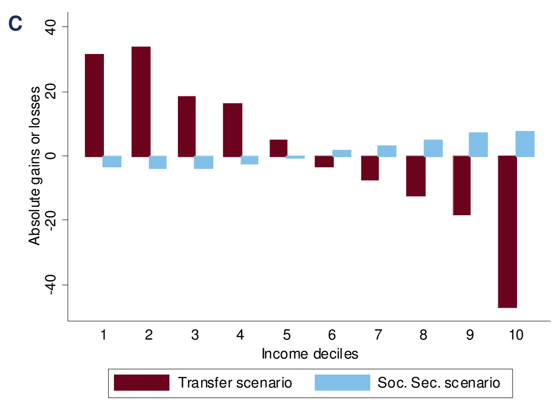
Figure 2: Decomposition of the effects on income distribution



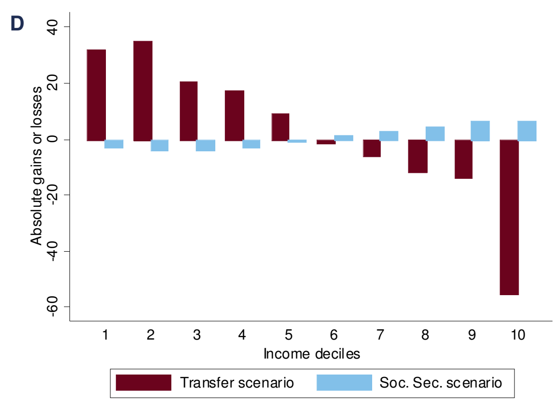
Before reweighting and price change



After reweighting, before price change

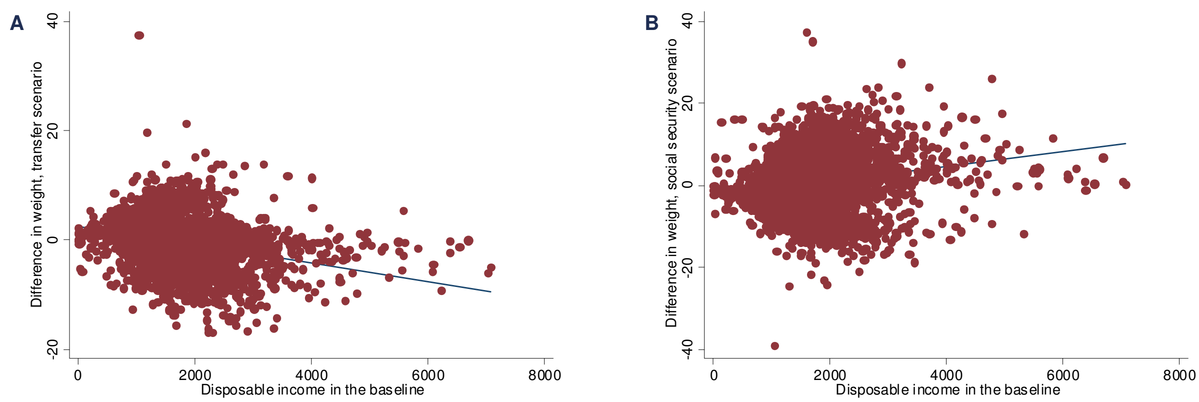


Before reweighting, after price change



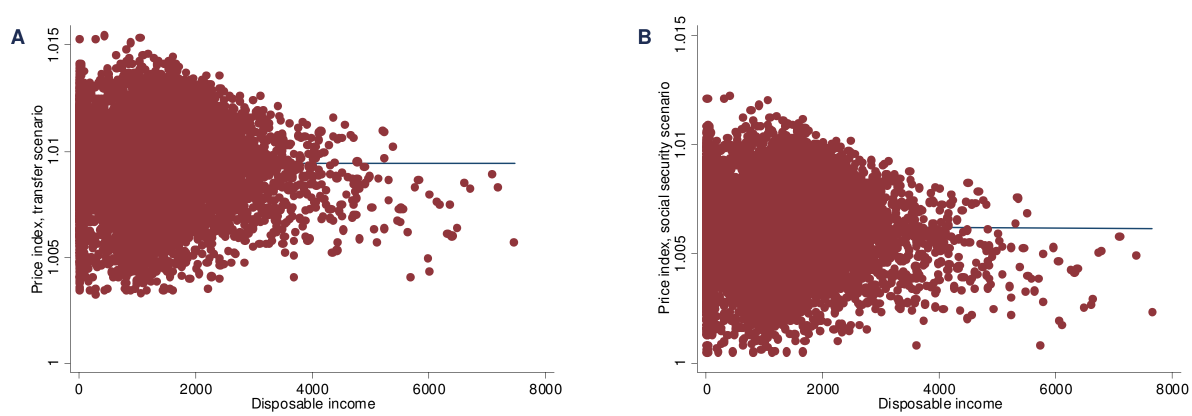
After reweighting and price change

Figure 3: Difference between new and old weights in the transfer (A) and social security scenario (B)



We move from panels A to C in Figure 2 by incorporating consumption price changes based on household specific expenditure patterns. The increase in price level shifts the picture of panel A in Figure 2 downwards. Higher energy taxes raise production costs, which leads to higher consumer prices. Lowering labour taxes partially offsets this effect. Therefore, the price increase in the transfer scenario is more substantial. This is illustrated by the slightly larger downward shift in the case of revenue recycling via welfare payments. However, the contribution of the household specific price changes to the impact variation across deciles appears to play a minor role. A first explanation can be found in Figure 4. This figure plots the household specific price indices against disposable incomes. For the transfer scenario, the value of the price index ranges from 1.003 to 1.15. In the social security scenario, price changes vary from nearly 0% (price index equal to 1) to 1.2% ($CPI_i = 1.012$). A clear increasing or decreasing trend is absent in both scenarios, indicating that the impact of the prices changes is not particularly concentrated in specific ranges of the income distribution.

Figure 4: Household specific price indices by disposable income



A clearer picture can be drawn when we use the information captured in Table 3. The table consists of three parts. First of all, budget shares are shown for thirteen expenditure categories (that are listed in Table 6 in appendix C) by income decile. Food (expenditure category 1), housing (cat. 3) and heating fuels (cat. 4) clearly take up a larger share of the budget for lower income deciles. Second, a comparison of budget shares in aggregate data and microdata shows roughly the same expenditure pattern. Third, price changes induced by the two policy reforms are displayed in the lower part of the table. The increase in excises on oil mainly raises prices of transport fuels (cat. 9). Price increases for heating fuels (cat. 4) and public transport (cat. 10) are rather limited. This can be explained by the importance of the excise component (paid by consumers) in transport fuels. The use of heating fuels is more diversified, as many households use heating systems based on electricity and natural gas. The price increases of other goods categories are minimal because the share of oil excises (paid by producers) in total production costs is limited. Since the burden of excises mostly falls on transport fuels and budget shares of this category are not decreasing by income decile, the impact on inequality is ambiguous.

Table 3: Expenditure shares and price changes by consumption categories

Budget	***Expenditure categories***												
shares	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Income deciles													
1	22.7	3.5	18.5	8.2	4.2	0.1	6.2	4.7	3.4	0.8	3.9	13.4	10.5
2	22.3	3.9	15.3	7.9	4.5	0.1	6.5	5.2	3.6	0.6	3.9	15.2	11.1
3	21.9	4.2	13.6	7.7	4.9	0.1	7.0	5.1	3.7	0.5	3.8	15.8	11.7
4	21.2	4.4	12.4	7.3	5.0	0.1	6.4	6.1	4.0	0.6	3.8	17.1	11.6
5	20.6	4.9	11.4	6.8	5.2	0.2	6.0	6.7	4.2	0.6	3.9	17.9	11.8
6	19.4	5.3	9.7	6.3	5.4	0.2	5.5	8.8	4.3	0.5	3.8	18.5	12.1
7	19.2	5.6	9.2	6.1	5.8	0.2	5.4	8.0	4.4	0.5	3.7	19.3	12.6
8	18.8	5.8	8.2	5.8	6.0	0.2	5.2	8.7	4.3	0.6	3.7	20.0	12.8
9	18.0	6.1	7.5	5.4	6.4	0.2	5.0	9.1	4.2	0.5	3.5	20.7	13.4
10	16.9	5.9	6.5	5.2	7.0	0.3	4.9	10.4	3.7	0.6	3.2	21.4	14.0
Total	20.0	5.0	11.0	6.6	5.5	0.2	5.8	7.4	4.0	0.6	3.7	18.1	12.2
CGE	17.5	5.6	16.6	4.3	5.3	0.7	4.6	7.9	6.8	1.2	2.1	14.1	13.1
Price changes													
Transfer scen.	0.3	0.4	0.3	0.8	0.3	0.2	0.5	0.2	14.3	1.2	0.3	0.4	0.4
Soc. Sec. scen.	0.1	0.1	0.0	0.6	0.0	0.0	-0.1	0.0	14.0	0.8	0.0	0.0	-0.1

4.5 Winners and losers

To illustrate the richness of microdata, we can decompose the impact by household characteristics. CGE models with representative households usually lack the details to do this kind of analysis. An insightful way to map the effects by household characteristics is by ranking households according to how they are affected by the policy reform (from biggest loss to largest gain) and then grouping them in quintiles. Table 4 describes some characteristics of these quintiles. The households for which the burden is largest in the transfer scenario are highly dependent on employment income[6] and receive low amounts of welfare payments. Moreover, these households spend a larger than average share of their budget on transport fuels. Households benefitting from the reform tend to be smaller and contain on average more elderly (aged over 60) and less children. A potential explanation is that households with pensioners receive more welfare payments (pensions). The highest education level (ranging from 0 to 5) in households that gain seems to be lower than average. This may be explained by a positive correlation between education level and employment income. The second part of Table 4 presents the same information for the social security scenario. Households that benefit from reduced labour taxes tend to rely heavily on employment income, have a higher education level and include less people with an age of 60 or higher.

Table 4: Impact by household characteristics

Characteristics of winners and losers	*Av.*	*Quintiles* 20% losers	2	3	4	20% winners
Transfer scenario						
Share employment income in disp. income (%)	74.81	137.28	128.21	88.42	15.56	4.68
Share transfers in disposable income (%)	42.05	2.23	3.67	20.80	82.90	100.50
Highest education level in household	3.52	4.47	3.96	3.41	2.78	2.95
Share 'private transport' expenditures (%)	3.98	4.31	4.67	4.14	3.42	3.34
Household size	2.43	3.37	2.73	2.16	1.80	2.08
Number of people aged over 60 per household	0.39	0.02	0.02	0.13	0.69	1.09
Number of people aged under 18 per household	0.29	0.51	0.40	0.26	0.14	0.10
Absolute gain or loss (-)	0.30	-75.57	-36.57	-1.66	41.40	73.97
Social security scenario						
Share employment income in disp. income (%)	74.81	6.95	8.83	67.57	136.37	154.29
Share transfers in disposable income (%)	42.05	70.54	88.39	41.80	6.58	2.94
Highest education level in household	3.52	3.55	2.65	3.13	3.81	4.43
Share 'private transport' expenditures (%)	3.98	3.95	3.53	3.77	4.70	3.93
Household size	2.43	2.43	1.79	2.18	2.57	3.17
Number of people aged over 60 per household	0.39	0.82	0.79	0.26	0.04	0.03
Number of people aged under 18 per household	0.29	0.24	0.15	0.27	0.35	0.42
Absolute gain or loss (-)	2.36	-17.01	-6.22	-0.84	9.56	26.33

[6] Note that these numbers involve pre-tax incomes, such that the share can exceed 100%.

5. Conclusion

We analyse aggregate and distributional effects of increased excise levies on oil in Belgium. Revenue is recycled either by raising welfare payments or by reducing employers' social security contributions. In terms of methodology, we follow a recent strand of literature that attempts to link CGE models with a (non-behavioural) microsimulation framework. The main benefit of this approach is that it includes general equilibrium feedbacks and endogenous price changes, but nevertheless exploits the rich set of details of microlevel data. A number of conclusions can be drawn.

First, the results suggest the existence of a weak double dividend. On the country level, GDP drops when additional revenue is handed out to households as a transfer. When labour taxes are reduced, the country's GDP slightly increases, which indicates the potential for a strong double dividend. Second, we point out important regional impact differences. Due to the sectoral composition, GDP in the region that hosts more energy intensive industries (Wallonia) decreases in both scenarios. Third, increasing welfare benefits results in gains for lower income households. A reduction in wage and return to capital makes high income deciles worse off in this scenario. When the revenue is recycled through lower social security transfers, the environmental tax reform is slightly regressive. Fourth, the distributional effects seem to be driven by sources side effects (relative factor prices). Effects on the uses side (relative consumption prices) do not contribute much to the impact variation because the increase in oil excises mainly falls on transport fuels, which do not particularly take up a larger share of expenditures for lower income households.

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Appendix

A. Structure of consumption and production in CGE model

Figure 5: Consumption structure

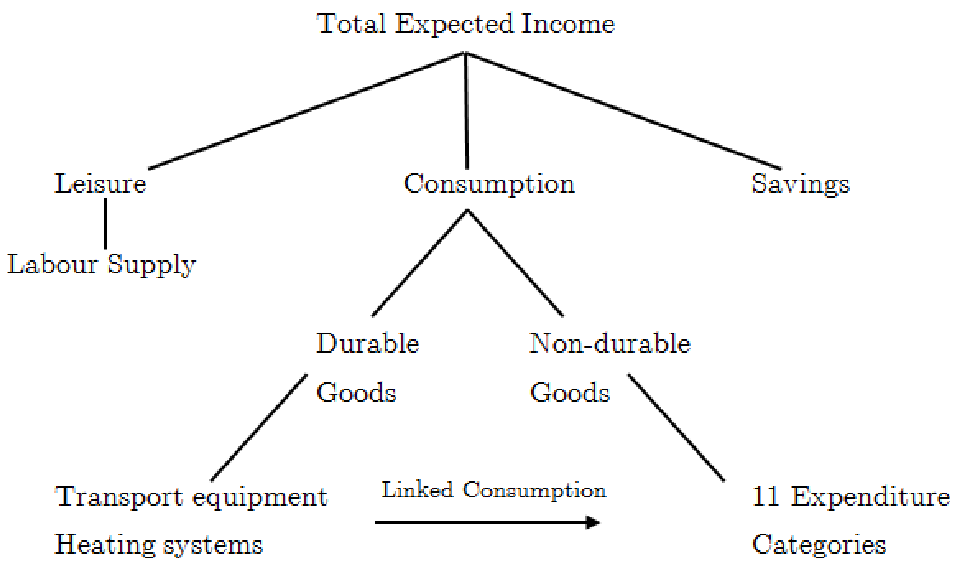
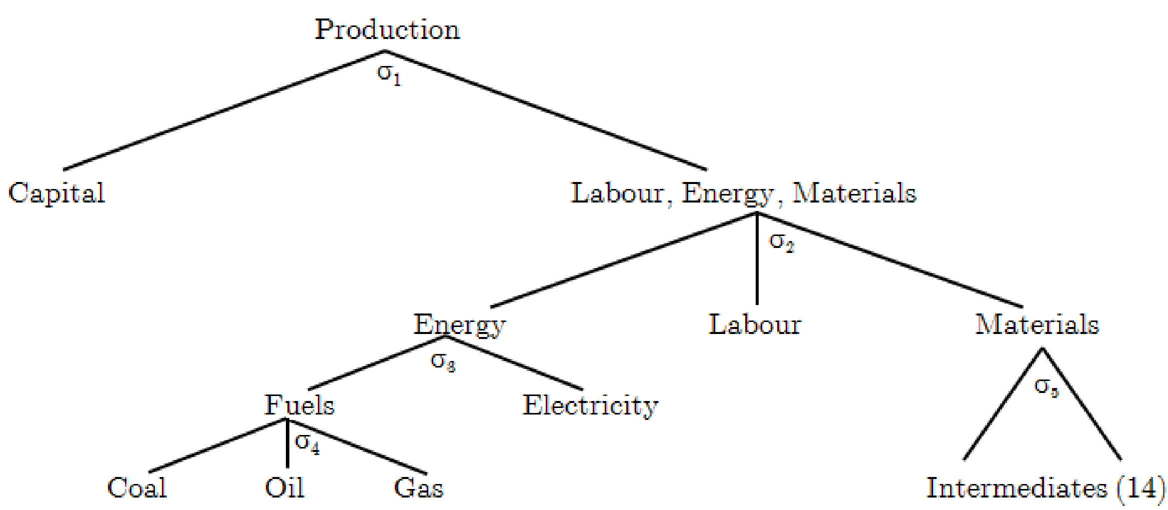


Figure 6: Nested CES production structure



B. Matching production sectors

Table 5: The combination of sectoral info from the CGE and microdata results in 7 industry sectors

Sectors after linking	*Microsimulation*	*CGE*
1 Agriculture and Fishing	1 Agriculture and Fishing	1 Agriculture
2 Mining, Manifact. and Utilities	2 Mining, Manifact. and Utilities	2 Coal 3 Crude oil and refined oil products 4 Natural gas 5 Electric Power 6 Ferrous and non-fer. ore and metals 7 Chemical products 8 Other energy intensive ind. 9 Electrical goods 10 Transport equipment 11 Other equipment goods 12 Consumer goods industries
3 Construction	3 Construction	13 Building and construction
4 Other market services	4 Wholesale and retail 5 Hotels and restaurants 8 Real estate and business	17 Other market services
5 Transport and communication	6 Transport and communication	14 Land Transport 15 Other Transport
6 Financial intermediation	7 Financial intermediation	16 Credit and insurance
7 Non-market services	9 Public administ. and defence 10 Education 11 Health and social work 12 Other	18 Non-market services

C. Expenditure categories

Table 6: Aggregation of COICOP categories into 13 expenditure categories

	Expenditure categories	*COICOP Classification*
1	Food, Beverages and Tobacco	1
2	Clothing and Footwear	2
3	Housing and Water expenses	3111, 3113, 3114, 3261
4	Fuels and Power	32 (without 3261)
5	Housing Furniture and Operation	4 (without 4311)
6	Heating and Cooking Appliances	4311
7	Medical Care and Health Expenses	5
8	Transport Equipment	61, 62 (without 6221)
9	Operation of Transport Equipment	6221
10	Purchased Transport	63
11	Telecommunication services	64
12	Recreation, Entertainment, Culture, etc.	7
13	Other Services	8

D. Income distribution by source

Figure 7: Distribution of income by source