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THE UNIT OF ANALYSIS IN MICROSIMULATION MODELS FOR PERSONEL INCOME TAXES: FISCAL UNIT OR HOUSEHOLD?

by

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The unit of analysis in microsimulation models for personal income taxes: fiscal unit or household?

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Abstract : Administrative data on personal income taxes and household budget surveys differ in at least one important respect: the definition of the unit of observation. The sociological concept of a household does not coincide with the administrative definition of a fiscal unit. We investigate whether the evaluation of a reform of income taxes is sensitive to this difference. The empirical results are obtained for a major reform of personal income taxes in Belgium in 1988. We use the technique of statistical matching to link the fiscal data of the Ministry of Finance with the household budget survey. We find that the characteristics of the tax system before and after the reform, such as liability progression and residual progression, are sensitive to the unit of observation and to the data set used. But this sensitivity evaporates at the level of the reform.

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1 Introduction

Microsimulation models have now become very popular, both for the preparation and evaluation of policy measures, as for the empirical implementation of theoretical research. A wide variety of models have been constructed, focusing on a well defined set of policy instruments: personal income taxes, indirect taxes, benefits, or social security contributions. For an overview of existing static models in Europe, we refer to Sutherland (1996). Behind the many differences between these models, the core and structure of most of them is of course very similar: simulation and evaluation of a change in policy parameters at the *individual or household level*. But up to now relatively little attention has been paid to this last characteristic: the definition of the unit of observation.

In this paper we start from a double observation. On the one hand, a considerable number of microsimulation models, certainly those that deal with personal income taxes, are based on administrative data[1]. They run on databases which use the *fiscal unit* as the basic unit of observation. The definition of this fiscal unit follows from tax law definitions and may diverge considerably from the sociological concept of a *household*. Moreover, in most cases these fiscal databases suffer from lack of representativity for the whole population because people with income below a certain threshold drop out of the income tax system. On the other hand, both from a theoretical point of view and from the perspective of the policy maker who asks for an evaluation, most people agree that the sociological household is the basic unit. In this paper we build a bridge between the two approaches and investigate how sensitive the results of a personal income tax model are with respect to the definition of the unit of observation. The practical relevance of this test should not be underestimated. In the US, e.g. there has been an extensive research and debate about the effects of the tax reforms in the eighties on progressivity and redistribution, with not unexpectedly, conflicting empirical evidence. Bishop, Chow, Formby and Ho (1997) explicitly point to the difference in the recipient unit of the tax files of the TCMP-database and the family unit of the CPS-data as part of the explanation[2]. Also Wagstaff and Van Doorselaer (1997) state that they are hampered by the fact that they can only rely on tax record data to compare the performance of different OECD tax systems.

The major obstacle to provide evidence on this question is the absence of a personal income tax model that runs on a representative household survey. There are at least two explanations why we lack such a model in Belgium. First of all, the only operational personal income tax model

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1 For an overview, see Wagstaff and Van Doorselaer (1997), table 2, p. 13-14.

2 TCMP stands for the Taxpayer Compliance Measurement Program, a database which is comparable to the IPCAL-database used in our study (see below); CPS stands for the Current Population Survey.

(SIRe) has been built within the Ministry of Finance. Therefore it seems quite natural that it has been based on an administrative file (IPCAL) of tax forms that have been entered by persons who are liable to pay income taxes in Belgium. Furthermore, a more substantial reason is that the existing household surveys in Belgium (viz. The Panel Study of Belgian Households - PSBH, and the household budget survey) do not contain gross income information on which tax calculations can be based.

To answer our question, we have complemented the budget survey with gross income information, coming from the fiscal data, by means of a *statistical match*. To make this possible, we first had to split the households in the budget survey into fiscal units. Then we looked for the most resembling fiscal unit in the administrative file, and transferred its gross income information, needed to calculate tax liabilities, to its budget survey counterpart[3].

The approach adopted in this paper is an empirical one. We study the results of the Belgian microsimulation model for personal income taxes, SIRe, which runs on an administrative file, after its output has been transferred into another database, the Belgian household budget survey. The specific simulated results that will be used in our exercise are those that reflect the policy changes which have occurred in the personal income tax legislation from 1988 to 1993. Therefore, as a by-product of the core question, we can provide some tentative policy conclusions about the distributional effects of this reform as well.

In section 2 we give a description of the data. The different steps in the matching procedure are explained in section 3. In section 4 we present the empirical results. We first give a brief overview of the policy changes in the personal income tax in the eighties and then compare the distributional effect of these reforms when analysed on the administrative data and on the household budget survey. Of course, we will not refrain from a short discussion of the outcome of the distributional analysis itself.

Finally, section 5 will show that a successful matching exercise has a broader scope of application than only providing the answer to the question underlying this paper. In many cases the lack of integration between microsimulation models of presonal income and indirect taxes is due to the gap between the underlying data sets. In Belgium e.g. the household budget survey is the underlying data set for the microsimulation program of indirect taxes, ASTER, while the administrative IPCAL data form the backbone of SIRe. As long as these partial models are not

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[3] In principle we might have followed at least two other directions. First, we could try to reconstruct from the net incomes in the household survey, the gross or taxable counterparts and then use SIRe to calculate tax liabilities. But lack of information makes this option a blind alley or at least a very hypothetical one since many ad hoc assumptions have to be made. The second possibility was even more unfeasible: reconstruct IPCAL-households from the fiscal units, and in addition correct the fiscal data set for its lack of representativity.

connected, we cannot investigate the combined distributional effects of the policy change which has occurred in many countries, viz. the shift from personal income to indirect taxation. In section 5 we will use the matched data and the resulting overall tax burdens to test the conjecture that this shift erodes the distributional potential of the combined tax system. Section 6 concludes.

2 The two data sets

2.1 The fiscal data set IPCAL and the personal income tax model SIRe

The tax administration yearly draws a random sample from an administrative tax file, called IPCAL. IPCAL consists of the tax forms that are entered by persons who are liable to pay income tax in Belgium. The sample we used, which we will call the *fiscal data set*, consists of tax forms entered in 1994[4]. The administrative nature of these data shows up clearly in the basic version of the personal income tax model, SIRe, that is based on it. In fact, the basic version of SIRe reproduces the calculation of the tax administration of a given year. The advantage of this approach lies in the degree of accuracy of the model. The calculated tax liabilities are nearly exact. A drawback of this is some loss in flexibility to define reforms. Furthermore, the model does not contain estimates of behavioural responses for changes in personal income taxes. In direct tax benefit models this is rather the rule than the exception, however.

The administrative origin of the data base also implies that administrative units of observation are used. In principle such a fiscal unit is an individual, since each Belgian citizen that is gaining a sufficient amount of income is liable to pay income taxes and thus has to enter a tax form. If a person is legally married however, he will enter only one tax form together with his spouse[5]. Therefore, the final tax liabilities, produced by the model, are calculated on the basis of income that is gained by either one or two physical persons.

Despite the fact that the tax liability for each of these units is nearly exact and the fact that the sum of all tax liabilities is a good approximation of the total revenue, the underlying data base is not representative for the Belgian population as a whole. For some people it is obvious that the administrative calculation of the indebted tax liability will point out that they do not have to pay income taxes. These people are dismissed from entering a tax form. Hence, the 10343 units in our sample are a representative sample, but only for the population of fiscal units that have filed taxable income and for whom it was not immediately clear whether they had to pay taxes or not[6].

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4 This implies that the reported income figures are expressed in prices of 1993.

5 Both, the definition of the fiscal unit and the condition to be part of it when married, are only crude sketches of the real conditions. See f.e. Standaard Belasting-Almanak (1996), p. 7-15 for more detail.

6 The size of this population is 4109965 fiscal units.

2.2 The household budget survey of 1987-88

The household budget survey has been designed as a representative sample of all households living in Belgium. A *household* is defined as all people living under the same roof, using the same accommodation and deciding commonly on their expenditures. The sample consists of 3235 households who registered expenditures during the period of May 1987-May 1988[7]. Beside the very detailed expenditures at the household level, the budget survey also contains information on common income sources like labour income and most social security benefits. These income sources are reported for each member of the household individually while, for example, income from real estates and savings are reported at a household level. All income information in the budget survey is net of taxes. Next to that, the survey also contains a large amount of variables that characterise both the household and its members. Counted over all households, 812 different expenditure codes, 234 different revenue codes and 285 characteristics were registered. Especially when it comes down to the evaluation of reforms, the informational richness of the budget survey offers an advantage over IPCAL.

But the budget survey also has one major disadvantage. The sample consists of 3235 households[8]. But because of the lengthy registration period, the 3235 households only make up 11% of the sample one originally started with. Despite the fact that weights have been constructed to compensate for the attrition bias, this low response rate casts doubts on the representativity of the simulated results (see Verma and Gabilondo, 1993, p. 99).

To provide a better overview of the aforementioned differences and similarities between the fiscal data set and the household budget survey, we give a summary in table 1.

Table 1: IPCAL and the budget survey compared

		IPCAL	***Budget survey***
1	date	1994	1987-88
2	unit of observation	fiscal unit	household
3	population covered	all fiscal units that file taxable income	all households living in Belgium
4	population size	4109965	3867506
5	sample size	10343	3235
6	representativity	yes	yes
7	income	gross (taxable) income	N.A.
8	and	tax liabilities (from SIRe)	N.A.
9	tax information	income net of taxes	income net of taxes
10	characteristics	limited number of characteristics	extended set of characteristics

Source: Decoster et al. (1998)

7 A new survey had been finalised in 1996, but the data of 1987-1988 were the most recent available to us.

8 This sample represents a population of 3867506 households.

3 The matching procedure

Table 1 clearly reveals the two basic problems to be solved: the difference between households and fiscal units (row 2), and the lack of gross income information and hence tax liabilities in the budget survey (rows 7 and 8). Since we will tackle the second one by a statistical match between the two data sets (section 3.2), the solution of the first one is logically prior to it (section 3.1). To express the nominal variables of the budget survey in a level, comparable to the one of the final data set, we have inflated the variables in the budget survey with a factor 1.404. This captures the nominal growth of national income in the National Accounts between 1987-88 and 1993. The adjustment with a uniform growth rate, implies that we do not take into account any change in the income distribution between 1987-88 and 1993.

3.1 Disentangling households into fiscal units

Many non-married but income earning people live under the same roof, take joint decisions about most of their expenditures and therefore make up one household. But since they are not married they are treated as different fiscal units. It is impossible to construct IPCAL-households on the basis of the information in the fiscal data set. Hence we can only proceed by disentangling the households, observed in the budget survey, into fiscal units.

To do this one should basically know two things: the income position of each household member and information on the family ties that exist between the different household members. Since information on family ties is most carefully registered in the survey for the reference individual (he or she who registers the expenditures and was interviewed on the other subjects), we started to check whether the reference individual was part of a fiscal couple yes or no. This basically comes down to checking whether the individual is married and still lives together with his partner. Next to that the family ties between the reference individual and the other members were investigated.

After these operations had been applied we were left with fiscal units containing couples or individuals and other people being potentially dependent of either this couple or individual. For those being potentially dependent, it was necessary to check then the height of their income. If their income was sufficiently high they were split off again as a separate fiscal unit. To check this income condition we had to construct an income variable for each member of the household. An assumption was required here however, since not all the income observations in the budget survey were registered for a specific member of the household. For example real estate income appeared as household income. When such household income was observed, it was attributed to the household member that already had the highest amount of individually registered income.

According to these rules, the 3235 households in the budget survey could be separated into 3444 fiscal units. We will call this manipulated budget survey *the fiscal unit budget survey (FUBS)* (the original one is *the household budget survey*, *HBS*). Since the households of the original budget survey were weighted to be representative for the household population, we also assigned the weight of household x to each fiscal unit belonging to household x. At the population level the increase in the number of households (from sociological to fiscal ones) was only 5.7%. This is much less than we expected before we carried out the split and it might indicate that the multi-earner households (more than two income earners) are underrepresented in the household budget survey.

We now still face the problem that the IPCAL data and the FUBS cover different populations. Since fiscal units do not enter the fiscal data set if it is obvious that they will not have to pay income taxes, IPCAL only contains a subset of the fiscal units that appear within FUBS. We therefore checked for each unit of FUBS whether it was liable to pay income taxes by applying the administrative rules on them. After this operation, the number of units in the fiscal unit budget survey dropped from 3444 to 3217. We will denote this truncated fiscal unit budget survey by *TFUBS*. The corresponding truncated household budget survey is indicated by *THBS*.

3.2 Selection of the matching variables and specification of the distance function

Also in the TFUBS-dataset the empty cells in table 1 are still empty. But since both data sets contain information on common variables (net income figures in row 9 and other characteristics in row 10) we can apply statistical matching techniques to supplement the TFUBS-data set with the missing information. We have chosen here for the direct approach of minimising a distance function to define the fiscal unit in IPCAL which resembles most the fiscal unit of TFUBS.

All together we identified 28 common variables which could be used to identify similar fiscal units in IPCAL and TFUBS (such as labour income for each member of the fiscal household, pensions, unemployment benefits, income from real estate, age, number of dependent children, gifts and other deductible expenses, etc.). In principle we therefore minimise for each fiscal household j in TFUBS the distance function in (1) by calculating for each fiscal unit k of the fiscal data set:

$$D_{jk} = \sum_{i \in M} w_i \left| \frac{x_{ij}^{BS} - x_{ik}^{FD}}{Std(x_{ij}^{BS})} \right| \tag{1}$$

where

M: the subset of the n common variables used in the matching procedure;

x_{ij}^{BS} : the value of common variable i for fiscal unit j in the Truncated Fiscal Unit Budget Survey TFUBS;

x_{ik}^{FD} : the value of common variable i for fiscal unit k in the Fiscal Data set IPCAL;

w_i : the weight of common variable i in the total distance;

$Std(x_i^{BS})$: the standard deviation of common variable i in TFUBS.

The objective is to minimise the distance function given in equation (1). Yet, this does not imply that the best match corresponds to a distance measure D_{jk} that equals zero. After all, one also has to choose the number of matching variables and the probability of exact matches can easily be increased, by decreasing the number of matching variables. Take the case where we only use one single matching variable, e.g. labour income. The probability of finding exact matches will be very high, but one might seriously doubt whether we impute the right tax liabilities. This illustrates that the distance measure alone is not necessarily a good indicator of the success of the matching procedure. The crucial point in matching is the correlation between the common variables and the missing ones (e.g. tax liabilities). In Decoster, Standaert, Valenduc and Van Camp (1998) we describe in detail how a stepwise regression has been used to identify the 14 most important variables to explain the tax liability.

Next to the variable selection itself, the regression also provided the weights w_i in the distance function. Both the 14 selected common variables and their weights, are tabulated in decreasing order of their weight, in table 2.

Table 2: The 14 variables used in the distance function and their weight

Variable	weight	Variable	weight
1 Highest Labour Income	37.73	8 Highest Health Insurance Benefit	0.64
2 Self-employed Income	34.62	9 Fiscal Couple (yes or no)	0.47
3 Highest Pension	16.26	10 Highest Unemployment Benefit	0.45
4 Lowest Labour Income	5.40	11 Mortgage Capital Repayments	0.15
5 Real Estate Income (house)	2.08	12 Received Maintenance Allowance	0.06
6 Dependent Children	1.33	13 Mortgage Interest	0.05
7 Lowest Pension	0.73	14 Charity Gifts	0.03

Source: own calculations, Decoster et al. (1998), Table A7.2

4 Empirical results for the personal income tax reform in Belgium between 1988 and 1993

We have used the IPCAL-, the TFUBS- and the HBS-dataset to simulate changes in the personal income tax in Belgium between 1988 and 1993. In Decoster, Standaert, Valenduc and Van Camp (1998) we describe in detail which measures have been taken into account in the simulations, and which have been omitted. Since the lion's share of the simulated measures were included in the tax reform act of 1988, we start with a short overview of this reform.

4.1 The reform of personal income taxes in 1988

Belgium did not stand aloof from the reforms in personal income taxes that swept through the western countries in the second half of the eighties. An important reform of the personal income tax has been voted in 1988. TRA88, as we will call it, became effective for the declaration year 1990, when taxpayers had to declare their income earned in 1989. The three basic components of the reform were

- a thorough *restructuring of the tax rates* (broader and hence less brackets, lower marginal tariffs);
- *separate taxation* of the main income earned by spouses (labour income, unemployment benefits, pensions, etc.);
- the *transformation of tax reductions into exemptions* (e.g. for children in charge) and of *deductions of taxable income into tax reductions* (e.g. expenditures for life insurance contracts or capital redemptions due to mortgage loans).

Table 3 shows that the brackets have been widened, resulting in a reduction of 14 to 7 brackets. Marginal rates for high incomes (above 1574000 BEF) have been reduced, while for the other old brackets the new rate is something like an average of the old rates. Until 1989 one also used a principle of a maximal mean tariff. The tax liability could not exceed 66,3% of the global taxable income In the post reform column of table 3 we give the brackets and rates as they applied in the declaration year 1990[9].

It is clear that the new rate structure might have considerable redistributive effects. Although there seems to have been a general feeling that the higher income ranges gained relatively more from the new rate structure, it is very difficult to test this conjecture without the use of a microsimulation model.

The second major element of TRA88 was the *separate taxation of professional income* and the creation of the "wedding-fraction" for spouses that make up a fiscal couple. Although in principle,

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[9] Up to 1993 these brackets only changed because they were adjusted for inflation.

the Belgian personal income tax is a global tax on all income together, in practice one distinguishes four broad categories of income: income from real estate, income from movable property, income from various sources, and professional income. With the term ‘professional income’ one denotes a broad class of income sources that are more or less related to some kind of professional activity. Examples of these revenues are wages and salaries paid to employees, salaries paid to managers, profits from agricultural or trading activities and replacement incomes such as unemployment benefits and retirement pensions. To determine the net amount of income, an individual is allowed to deduct costs that are made in the fulfilment of these professional activities, such as transportation costs, from this income. In that case one should hand in receipts that "prove" that these expenditures have been made. If the individual does not provide this kind of information the tax administration automatically applies a scheme of fixed deductions that depends on the height of professional income.

Table 3: Rate structure before and after the reform of 1988

Tax bracket (in BEF)			Marginal tax rate for the part of taxable income ≥ L and ≤ U	
Lower bound L		Upper bound U	before reform	after reform (1990)
0	-	120000	300 Fr.	25%
120001	-	209500	24,0%	25%
209501	-	230000	27,7%	25%
230001	-	262000	27,7%	30%
262001	-	305000	35,8%	30%
305001	-	314000	35,8%	40%
314001	-	419000	39,443%	40%
419001	-	435000	43,6%	40%
435001	-	524500	43,6%	45%
524501	-	787000	45,0%	45%
787001	-	1000000	46,6%	45%
1000001	-	1049000	46,6%	50%
1049001	-	1500000	51,6%	50%
1500001	-	1574000	51,6%	52,5%
1574001	-	2099000	56,5%	52,5%
2099001	-	2200000	61,9%	52,5%
2200001	-	3148000	61,9%	55%
3148001	-	4197000	67,8%	55%
4197001	-	14685085	70,8%	55%
14685686	-		66,3%	55%

Source: own calculations, Decoster et al. (1998), Table A3.1

Until the declaration year 1989 the professional revenues were added together with the other general taxable revenues and the progressive tax scheme was applied on it to determine the taxes to be paid by the couple. Only below rather low ceilings some form of separate taxation for both spouses existed. This could result in a large discrepancy in the amount of taxes paid by a married couple and a couple living together while not being married. Especially when both spouses earned income, these differences could become significant. The implementation of fully separate taxation of professional revenues had to solve this problem. It was complemented with a system which corrects for very unequal division of professional income between both partners. When one of the spouses has earned less than 30% of the sum of professional incomes from both partners, this partner is attributed an amount such that (s)he would have earned 30% while the professional income of the other spouse is reduced by the same amount. This ‘redistribution’ is limited to a ceiling, which in the declaration year 1990 amounted to 270000 BEF. In the case where they both earn more than the maximal amount of the "wedding-fraction" the married couple still has a small disadvantage in comparison with the non-married couple. This is so because the exemption levels for singles are higher than those for spouses and of course both persons of a non-married couple are treated as singles in the tax legislation.

The third component of the reform had to do with the complex system of deductions, tax credits and exemptions. A detailed list of all changes in this field of personal income tax is beyond the scope of this text. We only mention the most important ones. Before the reform of 1988, family size was taken into account by giving a tax credit. Although this credit was calculated as a percentage of tax liability, it was bounded between a floor and ceiling amount which were so close to each other that in practice the tax credit was a fixed amount. The reform of 1988 replaced these credits with a system of *exemption levels*. These exemption levels basically depend on family structure such as being married or not and the number of children one has in charge. We give the most important exemption levels in table 4. They are applied at the bottom, which implies for example that with an exemption of 165000 BEF and an income of 300000 BEF, 65000 BEF of the residual taxable income of 135000 BEF is taxed at 25% and 70000 BEF at 30% (see table 3).

Table 4: Exemption levels after the tax reform of 1988

Married or not	
single	165000
married person	130000
Number of children in charge	
1 child	35000
2 children	90000
3 children	202000
4 children	327000
each child above the fourth	125000
Special exemptions	
other persons in charge	35000
spouse or others with handicap	35000
widow(er) with children in charge	35000
lone parent	35000
spouse with small revenue in year of marriage	35000
in year of death	90000

Source: Decoster et al. (1998), Table 12

The reform of 1988 also substituted tax reductions for deductions. Contributions to life insurance contracts, capital redemptions due to mortgage loans, expenses on assets distributed by one's employer and payments to group insurance contracts were no longer deducted from professional revenues and contributions to private pension funds were no longer deducted from general income. Instead all these expenses resulted in a reduction of the tax liability.

4.2 Sensitivity of the distributional evaluation w.r.t. the unit of analysis

Contrary to other countries (for the US e.g. see the extensive survey of analyses of TRA86 in Auerbach and Slemrod, 1997), there has been no profound analysis of the distributional effects of the Belgian tax reform act of 1988. A detailed discussion of these effects is given in Decoster, Standaert, Valenduc and Van Camp (1998). Here we focus on the sensitivity w.r.t. the unit of analysis. Therefore we only present the distributional analysis by means of *aggregate* measures. These measures summarise the effects of the reform throughout the different income groups into one number (for an overview of a wide range of measures: see Lambert, 1993).

Basically the measurement can go in two directions. One can measure the deviation of the tax system from proportionality. Among others, this is what is done by the Kakwani-index of *liability progression* (see Kakwani, 1977). In TRA86 in the US, e.g., one of the objectives of the tax reform was to be distributionally neutral, which was explicitly defined as "equal percentage reductions in tax liabilities at all income levels" (see McLure and Zodrow, 1987). This boils down to an unchanged liability progression. The other possibility is a definition of distributional neutrality of a tax reform by an "equal percentage change in after-tax income at all income levels". In that case, the measurement of the progressivity or distributional characteristics of a tax system focuses on the change in the inequality of after-tax income. Measures which gauge this redistributive effect or

residual progressivity of the tax system were proposed by Musgrave and Thin (1948) and Reynolds and Smolensky (1977). In appendix 1 we give the expressions for both measures in terms of the Lorenz- and concentration curves of income before and after tax. The link between the two concepts is provided by the average tax rate. A very progressive system can have a minor redistributive impact indeed, if the average tax rate is very low. The distinction between the two components of the redistributive power of a tax system has attracted considerable attention in the literature (e.g. Formby, Thistle and Smith, 1990 for a summary of the discussion and the possibility of a welfare interpretation of both approaches).

A final remark concerns the pre-tax income we have used in the calculations. For IPCAL and TFUBS, we used pre-tax income of the fiscal unit as the income concept to construct the Lorenz- and concentration curves. In the budget survey, households directly report their 'disposable income'. This variable differs from the concept we use at the fiscal unit level, but we presume that it gives a better indication of the welfare level of the households. Hence, for THBS and for HBS, we have constructed pre-tax income as the sum of this disposable income concept and the personal income tax liabilities which were obtained by the matching process. It was impossible to use this construction in IPCAL and TFUBS since 'disposable income' is defined at the household level while IPCAL and TFUBS only give observations at the fiscal unit level.

The results are given in table 5, where the notation between brackets for the different measures refers to the notation used in appendix 1. Given the aim of the paper, we focus on the horizontal reading of the table by comparing the figures for the four different columns. The vertical structure of the table reveals the effects of the reform itself. The first panel gives the information about the pre-reform situation, the middle panel about the post-reform situation, and the bottom panel makes the percentage difference between the two.

Let us begin at the bottom left of the table. There is a good chance that a government official who asks his administration for an evaluation of a tax reform proposal will get the figure of 2.3% on his desk. The researcher of the Ministry of Finance will explain that he has calculated the percentage changes in tax burdens at different income levels on a representative sample of the tax compliance file. His result indicates that the reform, sketched in section 4.1 is a very slightly progressive one. In fact statistical tests might even indicate that the change in the liability progression from 0.203 to 0.207 is not statistically different from zero[10].

[10] Statistical tests for the shifts in Lorenz and concentration curves, and for the changes in the related indices of measurement of tax incidence and progressivity, have been developed recently. See Bishop, Chow and Formby (1994) and Davidson and Duclos (1997). We did not apply these tests yet.

Table 5 :Sensitivity of the distributional analysis of TRA88 w.r.t. the unit of analysis

		IPCAL	TFUBS	THBS	HBS
	unit of observation	fiscal units	fiscal units	households	households
	data set	fiscal data	truncated budget survey	truncated budget survey	full budget survey
	number of observations	10343	3217	3134	3235
	population size	4109965	3746799	3654248	3876508
	Before tax reform of 1988				
(1)	mean tax rate (t)	0.273	0.311	0.241	0.237
(2)	Gini pre tax (G_X)	0.368	0.352	0.316	0.334
(3)	Gini post tax (G_{X-T})	0.296	0.267	0.269	0.285
(4)	redistributive effect (Π^{RS})	0.076	0.088	0.056	0.058
(5)	liability progression (Π^{K})	0.203	0.194	0.178	0.188
	After tax reform of 1988				
(6)	mean tax rate (t)	0.243	0.284	0.220	0.216
(7)	Gini pre tax (G_X)	0.368	0.352	0.316	0.334
(8)	Gini post tax (G_{X-T})	0.305	0.277	0.274	0.290
(9)	redistributive effect (Π^{RS})	0.067	0.078	0.050	0.052
(10)	liability progression (Π^{K})	0.207	0.197	0.178	0.188
	Effect of the reform				
(11)	% change in redistributive effect	-12.2	-10.8	-11.0	-10.9
(12)	% change in $t/(1-t)$	-14.2	-12.2	-11.2	-11.1
(13)	% change in liability progression	2.3	1.6	0.2	0.2

Source: own calculations

But does this imply that the redistributive power of the personal tax system did not change? Not at all, as the change in the Reynolds-Smolensky index indicates. Scaling down all tax liabilities of a progressive system erodes the redistributive effect. The big drop in the average tax rate (from 27.3% to 24.3%) leads to a reduction of the Reynolds-Smolensky-index of 12.2%. On the other hand the residual progression of the Belgian personal income tax remains high, when compared to other countries. For the US and Canada in 1985 e.g., Silber (1994) reports figures of 0.038 and 0.034 respectively and from the figures in Kakwani (1980) we derive a residual progression of 0.035 for Australia in 1972, 0.024 for Canada in 1970, 0.043 for the UK in 1967 and 0.025 for the US in 1970. Again it is the tax level which offers the explanation. The liability progression underlying this residual progression is not that much lower, but the average tax rates are[11].

We now come to our basic point of interest: is the above conclusion about the effects of the tax reform sensitive to the definition of the unit of observation? Looking at the bottom three lines of table 5, the answer to this question is definitely: no. The choice between fiscal units or households did not influence the perception of the tax *reform*. Nor did it matter whether we omitted or

[11] The liability progression for the US, reported in Silber (1994) is 0.176, while the average tax rate is 0.178. The residual progression figures we derived from Kakwani (1980) are based on liability progressions of 0.189 for Australia, 0.169 for Canada, 0.254 for the UK and 0.156 for the US. The tax rates for these countries are respectively 0.157, 0.123, 0.145 and 0.137. Another numerical estimate of the liability progression for the US is found in Formby, Seaks and Smith (1989) who give an estimate of 0.201 for 1976.

included the households that did not pay taxes. In all cases a considerable drop in the redistributive effect emerged. This drop was always due to the lower level of taxes. The liability progression on the other hand remains approximately unchanged.

Despite the stability of the measurement of the distributional effect of the reform, one observes important differences in the characteristics of the tax system itself over the different columns. The average tax rate drops considerably from column (2) to column (3). A further drop in the tax rate occurs if we add the households that are not liable to pay income taxes. Both in column (3) and in column (4) the redistributive effect is much lower than before the fiscal units were joined into households and the non-taxpaying population was added. The drop in the redistributive effect of joining fiscal units into households (column (2) to column (3)), comes both from the lower tax rate and the smaller degree of liability progression. Adding the non-taxpaying subpopulation (column (3) to column (4)) further lowers the tax rate, but liability progression increases. This leads to a slight increase in the redistributive effect, when compared to column (3). Yet it is still much lower than when measured on the fiscal data set.

Hence, if one compares the first and the last column of table 5, one would be tempted to say that the fiscal data lead to higher estimates of the parameters of the tax system such as the tax rate, the redistributive effect and the liability progression, than if they are calculated at the household levels. But one should be cautious with these conclusions, since more elements than the unit of observation alone, differ between the first and the last column. As explained above, we also used a different income concept for the first two and the last two columns of table 5. To single out possible differences that are due to differences in the income concept we recalculated the concepts, reported in table 5, with the same income concept in all columns. We used the pre-tax income of the fiscal data and the results are reported in table A2.1 of appendix 2. It turns out that our conclusion about the robustness of the tax reform measurement with respect to the unit of analysis is unaffected. But at the level of the tax systems, the underestimation of the parameters seems to be caused by the difference in the income concept underlying the columns of table 5.

Summarising, we are led to two main conclusions. Our measurement of the distributional effects of the tax reform does not depend on the unit of analysis that is used. The latter conclusion emerged despite the fact that there is empirical evidence for the overestimation of the parameters of the tax system when measured on a fiscal data set with fiscal units instead of measuring it on a household survey. The overestimation can be traced back to differences in the after-tax income of IPCAL and disposable income in the budget survey.

4.3 Equivalence scales once again

In the introduction we referred to the conflicting evidence on the distributional effects of the TRA86 tax reform in the US. Among other possible explanations, Bishop, Chow, Formby and Ho (1997) also suggest that the adjustment for family size might be responsible for some of the divergent results. This should not come as a surprise. It is well known that the measurement of inequality and redistribution is sensitive to the use of equivalence scales and their specification, see Coulter, Cowell and Jenkins (1992) and Jenkins and Cowell (1994). We have therefore repeated the analysis of table 5, after we corrected the income figures with the OECD equivalence scale[12]. After all, this can be seen as one of the additional advantages of the statistical match. The budget survey contains more detailed information on the age of the household members, than IPCAL does[13]. We could therefore use more precise equivalent income figures after the match had been executed.

The results after correction with the equivalence scale are presented in table 6. Evidently, the use of equivalent incomes adds another possible dimension of comparison, viz. with and without correction. Yet, we first concentrate on our basic question: is the evaluation of the reform sensitive to the definition of the unit? Table 6 has exactly the same format as table 5. Hence, to answer the question, we look at the different columns of the bottom panel in table 6. Our basic conclusion remains the same: the effect of the reform is rather insensitive to the unit of observation or the data set which is used. Moving from column 1 towards column 4 in table 6, we find that TRA88 reduced the residual progression with between 3 and 4%. This small reduction follows from an increase in liability progression which is counterbalanced by a substantial decrease in the tax rate.

Also the conclusion that both in the tax system before and after the reform, the IPCAL analysis overestimates the parameters of the tax system when compared to the analysis in terms of households, keeps upright. Again, the overestimation of the tax rate and hence of the residual progression has to do with the different income concepts in IPCAL and the HBS[14].

Of course, this robustness of the conclusion as far as the sensitivity with respect to the unit of observation is concerned, should not divert the attention from the important differences between the figures in table 5 and table 6 as such. To highlight this effect, we have replicated the two last

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[12] The scale gives a weight of 1 to the first adult, 0.7 to all other adults and 0.5 to childeren. One is considered as a child until the age of 13.

[13] The most appropriate translation of the OECD-scale would require one to take into account the age-barrier of 13 to separate children from adults. Since no information on the childrens age is available in IPCAL we have limited ourselves to the variable 'child in charge' to construct the OECD-scale for the IPCAL observations. The same construction was used at the fiscal unit level in the fiscal unit budget survey. But at the household level we were able to take into account the age information that is available in the budget survey.

[14] To underpin the latter conclusions we recalculated table 6 with the uniform income concept. The results are reported in table A2.2 of appendix 2.

columns of table 5 and 6 in a new table 7. We have added a column which gives the ratio between the value of the statistic with and without correction with an equivalence scale. This leads to some useful insights.

Table 6: Sensitivity of the distributional analysis of TRA88 w.r.t. the unit of analysis after correction with an equivalence scale

		IPCAL	**TFUBS**	**THBS**	**HBS**
	unit of observation data set	fiscal units fiscal data	fiscal units truncated budget survey	households truncated budget survey	households full budget survey
	Before tax reform of 1988				
(1)	mean tax rate (t)	0.262	0.299	0.235	0.228
(2)	Gini pre tax (G_X)	0.327	0.327	0.282	0.291
(3)	Gini post tax (G_{X-T})	0.259	0.254	0.237	0.241
(4)	redistributive effect (Π^{RS})	0.074	0.080	0.057	0.061
(5)	liability progression (Π^{K})	0.209	0.187	0.184	0.205
	After tax reform of 1988				
(6)	mean tax rate (t)	0.238	0.277	0.217	0.211
(7)	Gini pre tax (G_X)	0.327	0.327	0.282	0.291
(8)	Gini post tax (G_{X-T})	0.260	0.255	0.237	0.242
(9)	redistributive effect (Π^{RS})	0.072	0.078	0.055	0.058
(10)	liability progression (Π^{K})	0.229	0.203	0.198	0.218
	Effect of the reform				
(11)	% change in redistributive effect	-3.4	-2.6	-2.8	-3.6
(12)	% change in $t/(1-t)$	-12.0	-10.2	-9.6	-9.6
(13)	% change in liability progression	9.8	8.5	7.6	6.6

Source: own calculations

It is not surprising that the use of an equivalence scale has a big impact on the description of the tax system both before and after the reform. Using the figures in the last column of table 5 and 6, we observe that the correction for family size, increases liability progression and decreases the tax rate in terms of equivalent income[15]. For the tax system before the reform, this results in a redistributive effect which is almost unaffected by the use of equivalence scales (0.058 compared to 0.061).

[15] The average tax rate is defined here as the ratio of the sum of all equivalised tax liabilities over the sum of all equivalised taxable incomes. Although the average tax rate for a single household is unaffected by the equivalence scale (the scale cancels out in numerator and denominator), the average tax rate for the whole population is affected by the use of an equivalence scale.

Table 7: Comparison of the distributional analysis of TRA88 with and without correction with an equivalence scale (results for households in the full HBS)

		without e.s.	**with e.s.**	**index**
		col (4) table 5	col (4) table 6	with / without
	Before tax reform of 1988			
(1)	mean tax rate (t)	0.237	0.228	96.498
(2)	Gini pre tax (G_X)	0.334	0.291	87.072
(3)	Gini post tax (G_{X-T})	0.285	0.241	84.621
(4)	redistributive effect (Π^{RS})	0.058	0.061	104.054
(5)	liability progression (Π^{K})	0.188	0.205	109.001
	After tax reform of 1988			
(6)	mean tax rate (t)	0.216	0.211	97.729
(7)	Gini pre tax (G_X)	0.334	0.291	87.072
(8)	Gini post tax (G_{X-T})	0.290	0.242	83.199
(9)	redistributive effect (Π^{RS})	0.052	0.058	112.644
(10)	liability progression (Π^{K})	0.188	0.218	115.983
	Effect of the reform			
(11)	% change in redistributive effect	-10.9	-3.6	32.831
(12)	% change in $t/(1-t)$	-11.1	-9.6	86.083
(13)	% change in liability progression	0.2	6.6	3688.673

Source: own calculations

But the effect of the equivalence scale has itself been affected by the reform. The stability of the redistributive effect with and without equivalence scales, observed before the reform, has disappeared after the reform. The reason is that the reform has considerably strengthened the impact of the use of an equivalence scale on the measure of liability progression. After the reform, the correction for family size boosts up the Kakwani index with as much as 16%. This differential impact of equivalence scales before and after the reform also shows up in the bottom panel. The observed erosion of the redistributive effect of the tax system due to TRA88 is much smaller after correction with equivalence scales. This is due both to the smaller drop in the tax rate when a correction is used, as to the increase in liability progression which is much bigger when equivalence scales are used.

Since our equivalence scales only take into account differences in family size, their changing influence before and after the reform indicates that the reform has been family size related. It is obvious that the translation of tax credits into exemptions is family size related since both are explicitly designed to take into account family size. But there could also have played another, implicit, family size related effect. Married couples benefited more from the reform than singles or cohabitating spouses because their professional income was treated separately after the reform while the other ones were already treated in this way before the reform. Since family size and being married are positively correlated, larger families might have benefited more from the reform than smaller ones.

Next to the specific insights about the evaluated reform itself, our results illustrate again the importance of equivalence scales for the evaluation of reforms. The importance of these equivalence scales also underlines the relevance of the matching exercise as such. After all, the information, necessary for the calculation of an equivalence scale, and hence for the construction of an appropriate welfare measure, is more readily available in a budget survey rather than in an administrative data set. Therefore, it seems advisable not to work with the latter but to transfer the necessary information from the administrative data into the survey.

5 Linking the personal income and indirect tax model

On top of the results discussed above, the link which we established between the fiscal data and the budget survey, also proved useful for some other interesting applications. One of them is the evaluation of a joint reform in personal income and indirect taxes. We did dispose of fiscal data at the level of the fiscal unit and transferred them into a household budget survey to observe personal income taxes at different levels of the unit of observation. However, as a consequence, we ended up with the necessary ingredients to calculate both personal income and indirect taxes at the household level since detailed consumption data are one of the core elements of the household budget survey.

Such joint analyses seem to be scarce in the literature. This is probably a consequence of the fact that personal income tax and indirect tax microsimulation models seem to coexist rather than that they appear in a single integrated form. This coexistence, on its turn, is probably due to the fact that the appropriate income and consumption data are seldom available within one single data set. It is all the more surprising that so few efforts have been made to bridge this gap since the question of joint evaluations is of interest both from a theoretical and from a policy oriented point of view. In the recent past, for example, many European countries have implemented tax cuts in their income tax system that have been compensated by increases in excises and VAT rates.

After the link between both data sets had been established, it became fairly easy for us to evaluate such reforms for Belgium. The fiscal data set is the underlying data set of the Belgian personal income tax model SIRe, while the budget survey serves as input of the Belgian indirect tax model ASTER. Hence, we were freed from the construction of a new model. The integration of both data sets can be seen as a first step in the direction of the complete integration of two existing microsimulation models. In the joint analyses, that will be presented below, we have complemented the personal income tax reforms that were already discussed above with changes in excises and VAT rates that have been installed in Belgium in the period ranging from 1988 to 1993.

The main change in the indirect tax system took place in April 1992. This reform had the intention to bring the Belgian indirect tax system more in line with the EC recommendations that prescribed a normal rate of at least 15% and one or two rates of at least 5%. The newly installed government decided to drop the rates of 17, 25 and 33%. The normal rate became 19.5%. The reduced rate of 6% was maintained and a second reduced rate of 12% was introduced.

To compensate for the decrease of the VAT rate on car fuels, excises on these products were simultaneously increased. This increase in excises was only one step in a continuous increase of excise taxation on these products during the period of investigation. Per litre of gasoline, the consumer paid an excise of 11,2 BEF in 1988 and 18,45 BEF in 1993. For gasoil the figures are respectively 5,25 BEF in 1988 and 11,33 BEF in 1993. The same continuous increase in excise holds to a lesser extent for cigarettes, although in this case it has partially been offset by a decrease in the ad valorem tax. The excises on most other products remained constant throughout the studied period, which implies an effective decrease of the tax burden. The impact on the consumer price of gasoline (+31%), gasoil (+39%) and tobacco products (+12%) has been substantial. The abolition of the VAT rate of 33% and of 25% shows up in a price decrease of durables (-3%).

The results are reported in table 8. Remark that in a first round we have not taken into account the trickle down effect of the personal income tax reform into expenditure behaviour and hence the indirect tax liabilities. This amounts to the implicit assumption that the change in disposable income because of the reduction in the personal income tax liability, has been absorbed completely into savings. The figures in column 2 of table 8 only reflect the impact effect of the change in the indirect tax structure[16]. The rightmost column of table 8 gives the combined impact of the policy change which reshuffles the tax burden from personal income to indirect taxes. It simply makes the sum of the changes in both the personal income and the indirect tax liabilities.

The picture that emerges in column (3) is substantially different from the one in column (1). Adding the policy change in indirect taxes, erodes the increase in the liability progression from 6.6% to 1.4%. It absorbs 3 percentage points of the tax reduction (-6.2% instead of -9.6%), which was of course the objective of the indirect tax increase. And the final result is that the redistributive potential of the combined tax system is further reduced (from -3.6% to -4.9%).

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[16] This impact effect incorporates behavioural reactions as a response to the changed relative prices. The behavioural reactions are the ones underlying the microsimulation model for indirect taxes, ASTER.

Table 8: Combined distributional effect of changes in personal income and indirect taxes 1988-1993 (results for households in the full HBS after correction with the OECD equivalence scale)

		(1) personal income taxes	(2) indirect taxes	(3) personal income + indirect taxes
	Before tax reform of 1988			
(1)	mean tax rate (t)	0.228	0.077	0.305
(2)	Gini pre tax (G_X)	0.291	0.291	0.291
(3)	Gini post tax (G_{X-T})	0.241	0.300	0.248
(4)	redistributive effect (Π^{RS})	0.061	-0.009	0.056
(5)	liability progression (Π^{K})	0.205	-0.102	0.128
	After tax reform of 1988			
(6)	mean tax rate (t)	0.211	0.081	0.292
(7)	Gini pre tax (G_X)	0.291	0.291	0.291
(8)	Gini post tax (G_{X-T})	0.242	0.300	0.249
(9)	redistributive effect (Π^{RS})	0.058	-0.009	0.053
(10)	liability progression (Π^{K})	0.218	-0.103	0.130
	Effect of the reform			
(11)	% change in redistributive effect	-3.6	-7.1	-4.9
(12)	% change in $t/(1-t)$	-9.6	5.5	-6.2
(13)	% change in liability progression	6.6	-1.6	1.4

Note: since the values for Π^{RS} and for Π^{K} are negative for indirect taxes, we have calculated the percentage change in rows (11) and (13) w.r.t. the absolute value of these measures. A negative sign then denotes that the indirect tax system becomes more regressive and still less redistributive.

Source: own calculations

The explanation for this is found in column (2). The well known slightly regressive character of the indirect tax system shows up in the negative liability progression Π^{K} and the negative residual progression Π^{RS}. Although the main ingredients of the reform were the removal of the VAT rate of 33% and 25%, the average tax rate has increased with 5.5%. This is mainly due to the substitution of the 19.5% rate for the rate of 17% and the important increase in some excise duties. That these changes of rates and excise duties have also strengthened the regressivity of the system, does not come as a surprise. The liability progression has further decreased from -0.102 to -0.103. In a progressive system an increase of the average tax rate leads to an increase of the redistributive effect. In a regressive system however, the increased average tax rate amplifies the redistribution from poor to rich. This shows up in the considerable decline of the redistributive effect of the indirect tax system with 7.1%.

In a second round we have also taken into account the induced effect of the change in disposable income on expenditures, and hence tax liabilities. We made a simple assumption of a constant savings ratio, and used the demand system underlying ASTER to obtain the fresh expenditures. Taking this effect into account led to an increase in the liability progression of the

overall system by 1.3% instead of the 1.4% previously reported (in row (13) of table 8). Despite this smaller increase, the reduction in the redistributive effect was further dampened from 4.9% (the figure on row (11) in table 8) to 4.5% because there was also a smaller change in the average tax rate. The latter only decreased with 5.7% instead of 6.2% previously.

6 Conclusion

There is a wide variety of data sets on which microsimulation models for personal income taxes can be based. A recurrent example is the difference between an administrative database such as a tax compliance file, and a household budget survey. As a consequence, the question arises whether the evaluation of a tax reform is sensitive to this heterogeneity of the data sets underlying the microsimulation model, and more specifically to the unit of observation. This has been the basic question of this paper.

We tried to answer this question empirically by simulating a major reform of the Belgian personal income tax system, which was installed in 1988. The most obvious way to simulate this reform was to use the administrative data file, IPCAL. This is current practice in the evaluation of a personal income tax reform, since normally administrative data do not require many data manipulations. They also contain sufficiently detailed information such that the calculated tax figures are fairly accurate, not to say exact, estimates of the taxes one really pays. But administrative data have the disadvantage that they are measured for fiscal units, which are typical administrative constructs, and therefore less relevant from a sociological point of view. For welfare analysis, the household definition which is used in surveys seems to be a more appropriate one. Furthermore, surveys have the advantage over administrative data that they contain much more background information about the observed units. They are also intended to be representative for the population as a whole, while administrative data generally only cover those that are obliged to enter a tax form. Surveys, on the other hand, have the disadvantage that they contain less information than administrative data to calculate tax figures.

To see whether the use of such different data sets would have an influence on the perception of the tax reform, we first simulated the tax reform with the administrative data. Next to that we established a link between the administrative fiscal data set and the household budget survey such that the simulated tax figures could be transferred into the household budget survey. This not only allowed us to study the differences between an evaluation at the level of the fiscal unit and the household, but also to see the effect of using either the complete population or only the subset of those that were obliged to enter a tax form.

To establish the link between both data sets we first disentangled the households of the budget survey into fiscal units. We then exploited the common information in both data sets to

connect each unit in the budget survey with its most resembling counterpart in the fiscal data set. In this way we could impute for each household in the budget survey its personal income tax liabilities. This allowed us to estimate the distributional effects of the tax reform both at the level of the fiscal unit and at the level of the sociological household. The empirical results pointed towards the following conclusions.

(1) The reform of the Belgian personal income tax in 1988 *eroded the redistributive power* (or residual progression) of the tax system. This was only due to the considerable drop in the average tax rate, not to a decrease of the liability progression. The latter even increased.

(2) As long as the *reform* is concerned, this conclusion is *robust w.r.t. the definition of the unit of observation* (fiscal unit or household), and is not affected by the inclusion or exclusion of the non tax filing units.

(3) Yet, this insensitivity for the unit of analysis or for the data set used, has much to do with the focus on the reform, which is the differential of the tax system before and after the reform. At the level of the tax systems themselves, fiscal data which exclude the non tax paying units, *lead to higher estimates of the parameters of the tax system*, as compared to calculations at the household level.

(4) This conclusion seems to depend on the *difference in income concepts* underlying the fiscal data and the household budget survey. This difference produces an average tax rate in the fiscal data set that is considerably higher than the one obtained from the household budget survey. On its turn this higher tax rate in the fiscal data set, leads to a larger redistributive effect as compared to the one measured on the household data.

(5) *Conclusion (2) is unchanged after a correction for family size* is introduced by means of an equivalence scale. But the perception of the distibutional effects of the reform (i.e. conclusion (1)), is substantially affected by the correction for family size. The erosion of the redistributive power of the personal income tax system is much smaller when calculated on the basis of equivalised income. This is mainly due to a *liability progression which is much greater after correction with an equivalence scale.* The impact of the introduction of equivalence scales is different in the tax system before and after the reform. This indicates that the reform was related to family size.

(6) The link between the fiscal data and the budget survey allowed us to estimate the total tax liability of a household, composed of personal income taxes and *indirect taxes.* We could also simulate the combined tax reform of personal income and indirect taxes in the period 1988-1993. The results indicate that the increase of VAT and excise taxes, strengthened the slight regressivity of the indirect tax system. As a consequence the shift from personal income to

indirect taxation amplified the erosion of the redistributive power of the joint personal income and indirect tax system.

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Appendix 1: The measurement of liability progression and redistributive effect

Our use of the Kakwani-index of liability progression and of the Reynolds-Smolensky-index of residual progression relies heavily on the exposition in Lambert (1993), Chapter 7. Nonetheless, the essentials, for the purpose at hand, will be recapitulated here.

If the main objective of the evaluation of a tax reform is to give empirical content to the redistributive effects of different tax systems before and after the reforms, a formal expression of the concept of redistribution is required. Redistribution is defined here as the shift of income which occurs in the post-tax distribution from high to low incomes. Hence, it can be measured by comparing the pre-tax Lorenz curve with the post-tax concentration curve. Our measure of redistributive effect is therefore defined as:

$$\Pi^{RS} = 2\int_0^1 \left[L_{X-T}(p) - L_X(p)\right]dp \qquad (2)$$

where the superscript of Π^{RS} refers to Reynolds and Smolensky (1977) who applied this measure to the US tax system, and

$$L_X(p) = \int_0^y \frac{xf(x)dx}{\mu} \qquad 0 \le p \le 1 \quad \text{and} \quad p = F(y) \qquad (3)$$

$$L_{X-T}(p) = \int_0^y \frac{(x - t(x))f(x)dx}{\mu(1-t)} \qquad 0 \le p \le 1 \quad \text{and} \quad p = F(y) \qquad (4)$$

are, respectively, the Lorenz curve of pre-tax income (x) and the concentration curve with respect to pre-tax income of after-tax income ($x - t(x)$), with:

p: the population shares of the pre-tax distribution
$f(x)$: the density function of x
$F(x)$: the distribution function of x
μ: mean income (pre tax)
$t(x)$: the tax liability corresponding with taxable income x
t: the average tax rate.

Defining areas by:

$$G_X = 1 - 2\int_0^1 L_X(p)\,dp \qquad (5)$$

$$C_{X-T} = 1 - 2\int_0^1 L_{X-T}(p)\,dp \qquad (6)$$

it is easily seen that the measure of redistribution Π^{RS}, can be rewritten as:

$$\Pi^{RS} = G_X - C_{X-T} \qquad (7)$$

where G_X is of course the Gini coefficient of pre-tax income and C_{X-T} is the area between the diagonal and the concentration curve of post-tax income with respect to pre-tax income. The difference between the Lorenz curve of post-tax income, and the concentration curve of post-tax income is important, if there is reranking. Only in the absence of reranking, C_{X-T} equals the Gini coefficient of the post-tax income distribution, and Π^{RS} can be interpreted as the reduction of the Gini coefficient.

The redistribution, if any, is obtained because the tax system is not proportional. It should not surprise therefore that interesting relationships between measures of redistribution like Π^{RS}, and measures of *disproportionality* of the tax system, have been proven. The latter try to give an aggregate measure of the difference between the share in total income and the share in total taxes, for given fractions of the population. One of these measures has been proposed by Kakwani (1977), and is based on the formal definition of proportionality as the coincidence of the pre-tax income Lorenz curve $L_X(p)$ and the concentration curve of tax liabilities, $L_T(p)$. Disproportionality, also called liability progression, is measured then as the difference between both curves:

$$\Pi^K = 2\int_0^1 \left[L_X(p) - L_T(p)\right]dp = C_T - G_X \qquad (8)$$

and can be used to measure the progressivity or regressivity of a tax structure, where progressivity is defined as an average tax rate which increases with pre-tax income. Theorem 6.1 in Lambert (1993) states that progressivity, defined as a departure from proportionality, and the redistributive effect defined as equalising post-tax incomes, are but two sides of the same coin. Hence, Π^{RS} and Π^K are closely related:

$$\Pi^{RS} = \frac{t}{1-t}\Pi^K \qquad (9)$$

Remark however that the amount of income equalisation which is obtained, not only depends on the liability progression, but also on the average level of taxation, denoted by $\frac{t}{1-t}$, which is the tax rate as a percentage of income after tax.

We are interested in the change of the redistributive properties of the personal income tax system, induced by the reform of 1988. Denoting the pre-reform situation with a subscript 0 and the post-reform situation with 1, we calculated:

$$\Delta\Pi^{RS} = \Pi_1^{RS} - \Pi_0^{RS} \qquad (10)$$

This difference in redistributive effect can of course easily be decomposed in a term which captures the change in the liability progression, and a term which measures the change in the

average tax level. Denoting the tax rate on net income ($\frac{t}{1-t}$) as τ, and expressing the differences into percentage changes, we have:

$$\frac{\Delta \Pi^{RS}}{\Pi_0^{RS}} = \frac{\Delta \tau}{\tau_0} + \frac{\Delta \Pi^{K}}{\Pi_0^{K}} + \left(\frac{\Delta \tau}{\tau_0}\right) \cdot \left(\frac{\Delta \Pi^{K}}{\Pi_0^{K}}\right) \qquad (11)$$

percentage change in redistribution	=	percentage change in tax rate	+	percentage change in liability progression	+	residual term

The left hand side, and the first two terms at the right hand side of equation (11) appear in the bottom three lines of table 5.

Appendix 2: Sensitivity of the distributional analysis with a uniform income concept

Table A2.1 :Sensitivity of the distributional analysis of TRA88 w.r.t. the unit of analysis with a uniform income concept

		IPCAL	TFUBS	THBS	HBS
	unit of observation	fiscal units	fiscal units	households	households
	data set	fiscal data	truncated budget survey	truncated budget survey	full budget survey
	number of observations	10343	3217	3134	3235
	population size	4109965	3746799	3654248	3876508
	Before tax reform of 1988				
(1)	mean tax rate (t)	0.273	0.311	0.311	0.305
(2)	Gini pre tax (G_X)	0.368	0.352	0.347	0.362
(3)	Gini post tax (G_{X-T})	0.296	0.267	0.262	0.274
(4)	redistributive effect (Π^{RS})	0.076	0.088	0.087	0.090
(5)	liability progression (Π^{K})	0.203	0.194	0.194	0.205
	After tax reform of 1988				
(6)	mean tax rate (t)	0.243	0.284	0.284	0.279
(7)	Gini pre tax (G_X)	0.368	0.352	0.347	0.362
(8)	Gini post tax (G_{X-T})	0.305	0.277	0.272	0.284
(9)	redistributive effect (Π^{RS})	0.067	0.078	0.078	0.081
(10)	liability progression (Π^{K})	0.207	0.197	0.198	0.209
	Effect of the reform				
(11)	% change in redistributive effect	-12.2	-10.8	-10.3	-10.4
(12)	% change in $t/(1-t)$	-14.2	-12.2	-12.2	-12.1
(13)	% change in liability progression	2.3	1.6	2.1	1.9

Source: own calculations

Table A2.2 :Sensitivity of the distributional analysis of TRA88 w.r.t. the unit of analysis with a uniform income concept and after correction with an equivalence scale

		IPCAL	TFUBS	THBS	HBS
	unit of observation	fiscal units	fiscal units	households	households
	data set	fiscal data	truncated budget survey	truncated budget survey	full budget survey
	Before tax reform of 1988				
(1)	mean tax rate (t)	0.262	0.299	0.298	0.289
(2)	Gini pre tax (G_X)	0.327	0.327	0.327	0.332
(3)	Gini post tax (G_{X-T})	0.259	0.254	0.257	0.259
(4)	redistributive effect (Π^{RS})	0.074	0.080	0.077	0.081
(5)	liability progression (Π^{K})	0.209	0.187	0.182	0.200
	After tax reform of 1988				
(6)	mean tax rate (t)	0.238	0.277	0.275	0.267
(7)	Gini pre tax (G_X)	0.327	0.327	0.327	0.332
(8)	Gini post tax (G_{X-T})	0.260	0.255	0.258	0.260
(9)	redistributive effect (Π^{RS})	0.072	0.078	0.075	0.079
(10)	liability progression (Π^{K})	0.229	0.203	0.197	0.215
	Effect of the reform				
(11)	% change in redistributive effect	-3.4	-2.6	-2.9	-3.6
(12)	% change in $t/(1-t)$	-12.0	-10.2	-10.4	-10.3
(13)	% change in liability progression	9.8	8.5	8.4	7.5

Source: own calculations

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