ON MEASURING INEQUITY IN TAXATION BETWEEN GROUPS OF INCOME UNITS

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Abstract

Kakwani and Lambert (1998) state three axioms for an income tax to be equitable; the Authors suggest measuring axiom violations by re-ranking indexes of taxes, tax rates and net incomes with respect to pre-tax incomes. In this paper we measure the intensity and the direction of axiom violations between units belonging to different groups; in particular, we consider seven household typologies. In so doing we improve Kakwani and Lambert's analysis which is limited to overall indicators. Our results are obtained by using indicator functions applied to average differences between taxes, tax rates and net incomes. Our microsimulation model uses as input data those provided by the Bank of Italy (2012) in its Survey on Households Income and Wealth on 2010 fiscal year. Here we evaluate the redistributive effect decomposition considering only the Italian personal income taxation: estimates of the distribution of income units are very close to the Ministry of Finance official statistics. The analysis focuses on households, and results stand out that relative re-rankings are lower within groups than across groups. However, what is noteworthy is the disproportion of re-ranking which penalizes households with children with respect to other household typologies. The overall analysis according to the original Kakwani and Lambert approach limits detecting the existence of inequities; here we show that inequities differently behave within groups and more than this across groups; and what is more important, we specify the inequity directions.

JEL Codes: *C81, H23, H24*

Keywords: *Microsimulation Models, Personal Income Tax, Progressive principle, Redistributive Effect, Re-ranking*

1. Introduction

Kakwani and Lambert (1998), hereafter KL, define equity in income tax system by means of tree axioms and propose a measurement system according to which axiom violations exert distinct negative influence on the redistributive effect of the tax. As authors write "*The three negative influences associated with axioms violations provide means to characterize the type of inequity in an income tax system and to assess the extent*" (KL, 1998, p. 369).

KL perform an overall analysis on a population of income units made homogeneous by applying a proper equivalence scale. In so doing they can evaluate how departures from equity, due to axiom violation, impact within and across the groups into which the income units have been split. Differently from the original contribution by KL, who base their analysis on Lorenz curves, we calculate Gini and concentration coefficients by differences between attributes related to pairs of income units, following the methodology described in Pellegrino and Vernizzi (2012). Expressing indexes in this form, we are able not only to seize the magnitude of violations, but also to evaluate how axiom violations discriminate among groups in their reciprocal relations.

The remainder of the paper is structured as follows. Section 2 presents the basic model by Kakwani and Lambert (1998). Section 3 presents the within and across groups decompositions of the redistributive losses. Having described the microsimulation model used for the empirical analysis, Section 4 applies the analytical instruments, introduced in Section 3, to the Italian Personal Income Tax (hereafter PIT). Section 5 concludes.

2. The basic model

According to KL, the three axioms an equitable tax should respect in order to be equitable are defined as follows. Let X, Y, T and A be the pre- and post-tax income distribution, the tax liability distribution and the average tax rate distribution, respectively. For each pair of income units ($\{i,j\}$, $i,j= 1, 2, \ldots, K$) it must hold:

Axiom 1: $x_i \geq x_j \;\Rightarrow\; t_i \geq t_j$;

Axiom 2: $x_i \geq x_j \;\; and \;\; t_i \geq t_j \;\Rightarrow a_i \geq a_j$;

Axiom 3: $x_i \geq x_j \;\; and \;\; t_i \geq t_j \;\; and \;\; t_i / x_i \geq t_j / x_j \Rightarrow y_i \geq y_j$.

The violations of these axioms are detected by inspecting if the ordering of the distribution of *T*, *A* and *Y*, are the same as that of *X*.[1]

As stressed above, KL perform their analysis defining Gini and concentration indexes by Lorenz curves. In particular, they define the concentration curve $L_{Z|X}$ as the Lorenz curve for an attribute Z of income units, when these are ordered by the attribute *X* (KL, 1998, page 373). Then, they suggest the three re-ranking indexes:

$$i)\, R_T = G_T - C_{T|X};\;\; ii)\, R_A = (G_A - C_{A|X});\;\; iii)\, R_Y = G_Y - C_{Y|X}. \tag{1}$$

where G_X, G_T, G_A and G_Y denote the Gini coefficient for pre-tax incomes, tax liabilities, average tax rates and post-tax incomes, respectively; $C_{T|X}$, $C_{A|X}$ and $C_{Y|X}$ denote the corresponding concentration coefficients when *T*, *A* and *Y* are ordered by pre-tax income. Thus, the axiom violations are identified by R_T>0, for Axiom 1, R_A>0 for Axiom 2 and R_Y>0 for Axiom 3.

To evaluate the departure from equity KL start from the Kakwani progressivity index $P = C_{T|X} - G_X$. They observe the redistributive effect of a tax system is equal to $RE = G_X - G_Y = \tau P - R_Y$, where τ is the ratio between the total amount of the tax and the total amount of the after tax income. Then they decompose the redistributive effect as

$$RE = \tau\left[P + R_A\right] - S_1 - S_2 - S_3. \tag{2}$$

In Equation (2), $\tau\left[P + R_A\right]$ represents the potential redistributive effect, while $S_1 = \tau R_{T|X}$, $S_2 = \tau\left(R_A - R_T\right)$ and $S_3 = R_Y$ represent the loss in redistributive effect due to violations of Axiom 1, Axiom 2 and Axiom 3, respectively.[2]

[1] If Axiom 1 is violated, Axiom 2 too is violated: Axiom 2 should be limited to income units which respect Axiom 1. Observe that Axiom 3 can be violated only by income unit pairs $\{i,j\}$ which respect Axiom 2 and, a fortiori, Axiom 1.

[2] Even if Pellegrino and Vernizzi (2012) observe that $S_2 = \tau\left(R_A - R_T\right)$ is not a faithful measure of what KL define as Axiom 2 violations, in this article we remain on KL's original approach.

3. Within and across group decompositions of the redistributive losses

Let's consider a population of income units which can be gathered into L groups, being H_d the number of income units in group d (d=1, 2,…., L). Each income unit has associated a weight $p_{i,d}$ (d =1, 2,…., H_d) which depends either on the sample representativeness of the income unit, in case we deal with a sample, or on the scale coefficient associated to the income unit. Let be $\sum_{i=1}^{H_d} p_{i,d} = N_d$ and $\sum_{d=1}^{L} N_d = N$. Moreover, given a generic attribute Z, ${}_d\mu_Z$ denotes the average of the attribute for group d, and μ_Z is the overall average.

We define the Gini coefficient for the overall population as:[3]

$$G_Z = \frac{1}{2\mu_Z N^2} \sum_{d=1}^{L} \sum_{m=1}^{L} \sum_{i=1}^{H_d} \sum_{j=1}^{H_m} \left(z_{d,i} - z_{m,j} \right) p_{d,i} p_{m,j} I_{i-j}^{Z} \,,\; I_{i-j}^{Z} = \begin{cases} 1: & z_{d,i} \geq z_{m,j} \\ -1: & z_{d,i} < z_{m,j} \end{cases} . \qquad (3)$$

When income units are lined up by ascending order of X, the concentration coefficient $C_{Z|X}$ for an attribute Z can be defined as:

$$C_{Z|X} = \frac{1}{2\mu_Z N^2} \sum_{d=1}^{L} \sum_{m=1}^{L} \sum_{i=1}^{H_d} \sum_{j=1}^{H_m} \left(z_{d,i} - z_{m,j} \right) p_{d,i} p_{m,j} I_{i-j}^{Z|X} \,,\; I_{i-j}^{Z|X} = \begin{cases} 1: x_{d,i} > x_{m,j} \\ -1: x_{d,i} < x_{m,j} \\ I_{i-j}^{Z} : x_{d,i} = x_{m,j} \end{cases} . \qquad (4)$$

Consequently the re-ranking index R_Z for Z with respect to X becomes:

$$R_Z = \frac{1}{2\mu_Z N^2} \sum_{d=1}^{L} \sum_{m=1}^{L} \Psi_Z^{d,m} \,, \qquad (5)$$

with $\Psi_Z^{d,m} = \sum_{i=1}^{H_d} \sum_{j=1}^{H_m} \left(z_{d,i} - z_{m,j} \right) p_{d,i} p_{m,j} \left(I_{i-j}^{Z} - I_{i-j}^{Z|X} \right)$. (6)

Focusing on (5), we observe that R_Z can be decomposed as

$$R_Z = R_Z^{W} + R_Z^{AG} \,, \qquad (7)$$

with

[3] Equation (3) is based on Gini's Mean Difference approach to computation of Gini index. For Equations (3) and (4) refer to Vernizzi (2009), Vernizzi, Monti and Mussini (2010) and Pellegrino and Vernizzi (2012).

$$R_Z^W = \frac{1}{2\mu_Z N^2}\sum_{d=1}^{L}\Psi_Z^{d,d} \text{ and } R_Z^{AG} = \frac{1}{\mu_Z N^2}\sum_{d=2}^{L}\sum_{m=1}^{d}\Psi_Z^{d,m}. \qquad (8)$$

where R_Z^W and the R_Z^{AG} represent the *within group* and the *across group* re-ranking, respectively.[4]

The links among Equations (8) and the results obtained by Monti (2007) on the Dagum (1997)'s Gini index decomposition may render clearer the expressions we suggest for the reranking decomposition (7). Given these links, we can write

$$R_Z^W = \sum_{d=1}^{L}\frac{N_d^2 \cdot {}_d\mu_Z}{N^2 \cdot \mu_Z}R_Z^{(d)}$$

$$R_Z^{AG} = \sum_{d=2}^{L}\sum_{m=1}^{d-1}R_Z^{(d,m)}\frac{N_d N_m\left({}_d\mu_Z + {}_m\mu_Z\right)}{N^2}$$

with $R_Z^{(d)} = \dfrac{\Psi_Z^{d,d}}{2\,{}_d\mu_Z N_d^2}$ and $R_Z^{(d,m)} = \dfrac{\Psi_Z^{d,m}}{\left({}_d\mu_Z + {}_m\mu_Z\right)N_d N_m}$.

We can now apply (7) to decompose the losses of the redistributive effect, S_1, S_2 and S_3, into the within and the across group components. Denoting by S_1^W, S_2^W and S_3^W, S_1^{AG}, S_2^{AG} and S_3^{AG}, the within and the across group components of S_1, S_2 and S_3, we can write

$$S_1 = S_1^W + S_1^{AG},\ S_1^W = \tau R_T^W \text{ and } S_1^{AG} = \tau R_T^{AG};$$

$$S_2 = S_2^W + S_2^{AG},\ S_2^W = \tau\left(R_A^W - R_T^W\right) \text{ and } S_2^{AG} = \tau\left(R_A^{AG} - R_T^{AG}\right); \qquad (9)$$

$$S_3 = S_3^W + S_3^{AG},\ S_3^W = R_Y^W \text{ and } S_3^{AG} = R_Y^{AG}.$$

From Equations (8), we can describe and interpret how groups are involved in overall axiom violations. For what concerns the losses of redistributive effect due to axiom violations registered within each group we obtain

[4] Dagum (1997), who considers just the decomposition of G_Z, calls *gross between* the difference between G_Z and G_Z^W.

$$S_1^{d,d} = \frac{\tau \Psi_T^{d,d}}{2\mu_T N^2}$$

$$S_2^{d,d} = \frac{\tau\left(\mu_T \Psi_A^{d,d} - \mu_A \Psi_T^{d,d}\right)}{2\mu_T \mu_A N^2} \qquad (10)$$

$$S_3^{d,d} = \frac{\Psi_Y^{d,d}}{2\mu_Y N^2},$$

with $\sum_{d=1}^{L} S_i^{d,d} = S_i^W$ and $i = 1,2,3$.

Considering across group violations, a previous important remark is required. We observe that the re-rankings across two groups, *d* and *m*, can be classified into two different categories: *i*) in the *X* distribution, the rank of an income unit belonging to group *d* is lower than that of an income unit in *m*, whilst in the *Z* distribution the relation between their ranks reverses; *ii*) in the *X* distribution, the rank of an income unit belonging to group *d* is greater than that of an income unit in *m*, whilst in *Z* the opposite holds.

The re-ranking impact on the two income units is different in the two cases. In *i*), income units of *d* overtake income units of *m* (or, which is obviously the same, income units of *m* are overtaken by income units of *d*) in the ranking of Z when this ranking is compared with the ranking of *X*; we denote these changes by *d*→*m* (or *d*←*m*). In *ii*) income units of *m* overtake income units of *d* (or income units of *d* are overtaken by income units of *m*); we denote these changes by $d \leftarrow m$ (or *m*→*d*). The (unfair) shifts $d \rightarrow m$ favour *d* if *Z* is a desirable attribute (income), whilst they favour *m* if Z is not a pleasant attribute (tax or tax rate). Obviously these last remarks have to be reversed considering case *ii* and the shifts $d \leftarrow m$ (or *m*→*d*). The value of $\left(I_{i-j}^{Z} - I_{i-j}^{Z|X}\right)$ in Equations (5) and (6) is different in case *i*) and *ii*). When re-rankings occur in case *i*) we observe that $\left(I_{i-j}^{Z} - I_{i-j}^{Z|X}\right) = 2$, whilst when it occurs in case *ii*) we verify that $\left(I_{i-j}^{Z} - I_{i-j}^{Z|X}\right) = -2$. Obviously $\left(I_{i-j}^{Z} - I_{i-j}^{Z|X}\right)$ is zero if no re-ranking occurs, that is if the rank of an income unit *i* is greater (lower) than the rank of income unit *j* both in the *Z*-distribution and in the *X*-distribution.

It derives that starting from expressions (5) and (6) we are able to represent the losses, which are due to shifts from *m* towards *d*, by the following expressions:

$$S_1^{d\to m} = \frac{\tau \Psi_T^{d\to m}}{2\mu_T N^2};$$

$$S_2^{d\to m} = \frac{\tau\left(\mu_T \Psi_A^{d\to m} - \mu_A \Psi_T^{d\to m}\right)}{2\mu_T \mu_A N^2}; \tag{11}$$

$$S_3^{d\to m} = \frac{\Psi_Y^{d\to m}}{2\mu_Y N^2}.$$

On the basis of (11), we can state that the sum $S_1^{d\to\bullet} = \sum_{d\neq m} S_1^{d\to m}$ expresses all the losses which are due to Axiom 1 violations, which depend on overtaking of *d* income units on income units of all the other groups. Conversely, $S_1^{\bullet\to d} = \sum_{d\neq m} S_1^{\bullet\to d}$ evaluates all the losses which are due to Axiom 1 violations depending on overtaking of *d* income units on income units of all the other groups; we observe that $\sum_{d=1}^{L} S_1^{d\to\bullet} = \sum_{d=1}^{L} S_1^{\bullet\to d} = S_1^{AG}$. Then, $S_1^{d\to\bullet} + S_1^{\bullet\to d} = S_1^{d,\bullet}$ represents the overall Axiom 1 violations which involve group *d* with the other $L-1$ groups.[5] When considering Axiom 2 and Axiom 3, analogous considerations and notations hold. In the next section we illustrate the relevance of these results in an empirical analysis.

Let's now introduce the following notation for the redistributive effect *RE*:

$$\begin{aligned} RE &= G_X - G_Y \\ &= \frac{1}{2\mu_X \mu_Y N^2} \sum_{d=1}^{L}\sum_{m=1}^{L}\sum_{i=1}^{H_d}\sum_{j=1}^{H_m}\left[\mu_Y\left(x_{d,i} - x_{m,j}\right) I_{i-j}^{X} - \mu_X\left(y_{d,i} - y_{m,j}\right) I_{i-j}^{Y}\right] p_{d,i} p_{m,j} \\ &= \frac{1}{2\mu_X \mu_Y N^2} \sum_{d=1}^{L}\sum_{m=1}^{L} \Omega^{d,m} \end{aligned} \tag{12}$$

The quantities

$$RE^{d,d} = \frac{1}{2\mu_X \mu_Y N^2}\Omega^{d,d} \text{ and } RE^{d,m} = \frac{1}{2\mu_X \mu_Y N^2}\Omega^{d,m} \tag{13}$$

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[5] We note that $\sum_{d=1}^{L} S_1^{d,\bullet} = 2S_1^{AG}$.

represent the contribution to the overall actual redistributive effect due to tax effects within group *d* and between groups *d* and *m*, respectively. $\sum_{d=1}^{L} RE^{d,d} = RE^{W}$ is the within group redistributive effect, whilst $RE^{AG} = RE - RE^{W}$ is the across group redistributive effect. We define the redistributive effect which involves group *d* with the other $L-1$ groups by $RE^{d,\bullet} = \sum_{d \neq m} RE^{d,m}$; observe that $\sum_{d=1}^{L} RE^{d,\bullet} = 2RE^{AG}$.

If we relate the various definitions of group contributions to the redistributive effect to the corresponding axiom violations we can evaluate how a tax system distributes its possible inefficiencies through different groups of tax payers: when dividing Axiom violations indexes by corresponding redistribution indexes, we eliminate effects due to unequal number of people in group selections.

4. Data and results

4.1. Data

As input data, we make use of the Bank of Italy Survey on Household Income and Wealth (hereafter SHIW) published in 2012. It contains information on household post-tax income and wealth in the year 2010, covering 7,951 households, and 19,836 individuals. The sample is representative of the Italian population, composed of about 24 million households and 60 million individuals. For further details on the sample selection and aggregate statistics see Brandolini (1999) and Bank of Italy (2012).

The module of microsimulation model employed for this paper focuses on the Italian Personal Income Tax (PIT). Considering the income units, results concerning the PIT gross income distribution are very close to the Ministry of Finance (2011) official statistics both considering the composition of PIT income units by work status as well as by their mean gross income and the gross income distribution by income classes (see Appendix for further details).

Considering all individual taxpayers, Figure 1 compares the frequency density function obtained with the microsimulation model and the one obtained using the Ministry of

Finance official data by income classes. Similar pictures emerge considering the frequency density function for pensioners and employees.

Table 1 shows the inequality indexes for individual taxpayers. Tax debts consider not only the amount due to the Central government, but also surtaxes due to Regions and Municipalities. The pre- and post-tax Gini coefficient are 44.34 and 38.87, respectively. The overall redistributive effect *RE* is then 5.47. The average tax rate is 20.12 per cent.

Figure 1: Frequency density function for all individual taxpayers

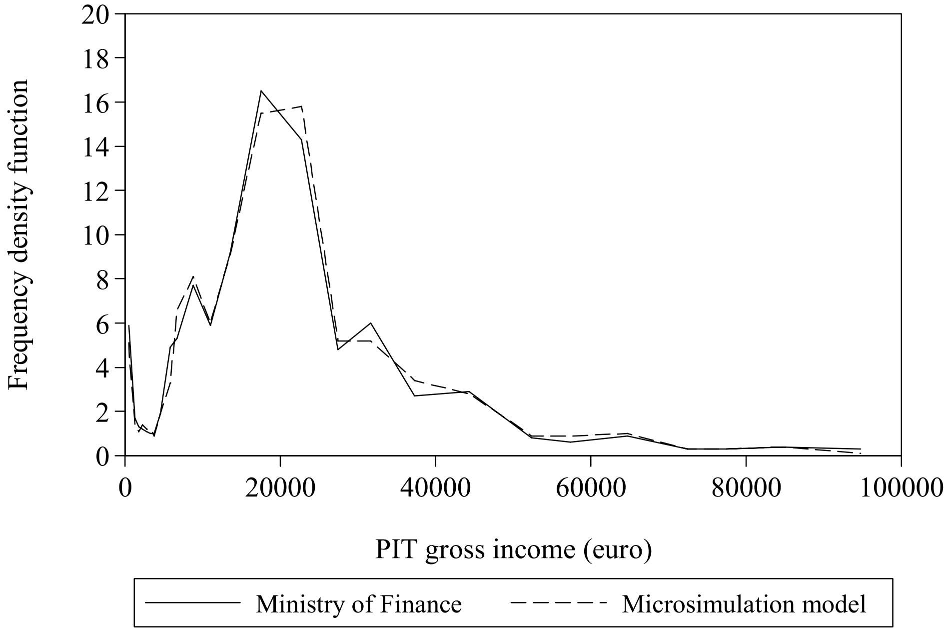

Table 1: Inequality indexes for individual taxpayers (%)

Coefficients	2010
Average tax rate	20.12
Gini coefficient for the gross income	44.34
Gini coefficient for the net income	38.87
Gini coefficient for the tax	67.22
Redistributive effect	5.47
Concentration coefficient for the net income	38.80
Concentration coefficient for the tax	66.34
Kakwani index	22.00
Reynolds-Smolensky index	5.54
Atkinson-Plotnick-Kakwani index	0.07

Source: Own elaborations on SHIW.

The concentration coefficient for the net income distribution is 38.80, whilst that on the tax debt distribution is 66.34. Then the Kakwani index is 22.00, whilst the Reynolds-Smolensky index is 5.54. Finally, the Atkinson-Plotnick-Kakwani index is 0.07.

Once each individual gross and net money incomes have been simulated, we evaluate them also at household level. In order to obtain equivalent incomes, we divided household money income by the same equivalence scale *ES* proposed in the original paper by KL, defined as follows:

$$ES = \left(a + 0.2c_1 + 0.4c_2 + 0.7c_3\right)^{0.8} + 0.1w$$

where a is the number of adults within the households, c_1 is the number of children aged 5 years or less, c_2 the number of children aged between 6 and 14 years, c_3 the number of children aged between 15 and 17 years , w the number of employees or self-employed within the households, and 0.8 the parameter that indicates the economies of scale attached to the equivalence scale.

Focusing on equivalent households, Table 2 shows the inequality indexes. These are the inequality coefficient we are going to decompose in the second part of this paragraph. The pre- and post-tax Gini coefficient are 38.88 and 33.70, respectively. The overall redistributive effect *RE* is then 5.18 and the average tax rate is 20.12 per cent. The concentration coefficient for the net income distribution is 33.62, whilst that on the tax debt distribution is 59.75. Then the Kakwani index is 20.88, whilst the Reynolds-Smolensky index is 5.26. Finally, the Atkinson-Plotnick-Kakwani index is 0.08.

Table 2: Inequality indexes for equivalent households (%)

Coefficients	2010
Average tax rate	20.12
Gini coefficient for the gross income	38.88
Gini coefficient for the net income	33.70
Gini coefficient for the tax	60.49
Redistributive effect	5.18
Concentration coefficient for the net income	33.62
Concentration coefficient for the tax	59.75
Kakwani index	20.88
Reynolds-Smolensky index	5.26
Atkinson-Plotnick-Kakwani index	0.08

Source: Own elaborations on SHIW.

4.2. The identification of households groups

In what follows we focus on equivalent households. In order to decompose the redistributive effect across and within groups of households and state the importance of the intensity and the direction of each Axiom violations, we have to define the number of groups and the typologies of households to be considered in each group. We split households in seven groups: 1) singles (24.9 per cent of total households); 2) couples without children (23.3 per cent); 3) couples with one child (16.1 per cent); 4) couples with two children (16.9 per cent); 5) couples with three or more children (4.9 per cent); 6) parent alone with one or more children (6.9 per cent); 7) all other households typologies (7.1 per cent). For each group, Table 3 reports equivalent average pre- and post tax incomes as well as tax liabilities.

Table 3: Equivalent average pre- and post-tax incomes and tax liabilities by group

Group	Number of households	Comp. %	Gross income	Net income	Tax debt
Singles	5,966,592	24.9	18,950	15,150	3,800
Couples without children	5,570,245	23.3	19,877	15,740	4,138
Couples with one child	3,846,501	16.1	17,402	13,782	3,620
Couples with two children	4,036,392	16.9	15,641	12,386	3,255
Couples with three or more children	1,163,623	4.9	11,277	9,212	2,065
Parent alone with children	1,659,689	6.9	13,744	11,333	2,412
Other typologies	1,700,247	7.1	14,746	12,160	2,586
Total	**23,943,289**	**100.0**	**16,750**	**13,380**	**3,370**

Source: Own elaborations on SHIW.

The choice of these groups is coherent with both the kind of decomposition we are going to study and the structure of the Italian personal income tax, which provides different linearly decreasing systems of tax credits for dependent individuals within the household.[6] The equivalence scale we adopted depends also on the number of working individuals within each household, so that we are also able to consider the working status of each individual without increasing too much the number of groups to be considered for estimations.

[6] For more details on the PIT structure see Pellegrino and Vernizzi (2010).

We know that the degree of heterogeneity is lower within groups 1-4 than within groups 5-7: the equivalence scale can only partially mitigate this heterogeneity. However, if we want to maintain all observations of the database (as we did), it is unavoidable that one or more groups are less homogeneous than others and one of these is a residual one.

4.3. Results

First of all we evaluate the original KL decomposition of the redistributive effect by considering all households together. This is our starting point. Results are presented in Table 4. Let the overall *RE* be 100. The potential redistributive effect is 115.42 per cent of *RE*. It follows that the overall inequities due to violation of Axiom 1, 2 and 3 are 15.42 per cent of *RE*: in particular, 3.6 per cent is due to Axiom 1, 10.27 to Axiom 2 and 1.55 per cent to Axiom 3.

Then, by considering separately each Axiom violation and every possible pair wise comparisons, we are able to decompose axiom violations into their within and across group components. We present results under two different points of view. Tables 5, 6 and 7 highlights the importance of Axiom 1, 2 and 3 violations, respectively, for each possible pair wise comparison (note that this kind of analysis permits to look not only to dimension of the redistributive losses but also to their direction), with respect to the overall Axiom 1, 2 and 3, respectively. Differently, Tables 8, 9 and 10 present the importance and the direction of Axiom violations with respect to the across redistributive effect of each pair wise comparison. Finally, Tables 11, 12 and 13, that can be derived by Tables 5-10, complete the analysis by presenting the magnitude of contrasting directions of Axiom violations when observing a pair wise comparison at a time.

Table 5 presents the composition of S_1, that is the absolute value of Axiom 1 violation of each pair wise comparison divided by overall S_1. The last but one column refers to the within component: overall violations happening within the seven groups sum up to 16.12 per cent of the overall S_1, whilst the overall across component to 83.88 per cent. Similarly, Table 6 and 7 present the decomposition of S_2 and S_3, respectively. Note that overall within and across percentages, with respect to total S_1, S_2 and S_3, for Axiom 1, 2 and 3 are very close to each other, but their compositions differ.

As Frosini (2011) observes, the more the number of groups increase, the lesser the contribution of the within component is with respect to the overall Gini index. To overcome this problem, we can then relate axiom violations to the correspondent redistributive effects (Tables 8-10), in order to get more pertinent comparisons between within and across group violations; from Table 8 we can observe that the overall within group violations is 3.20 per cent of the within group *RE* whilst is 3.69% of the across group *RE* for what concerns S_1; for what concerns S_2 the two percentages are 9.12% and 10.53%, respectively, and they are 1.38 per cent and 1.59 per cent for what concerns S_3. We can then conclude that the impact of axiom violations is a bit greater when considering income units of different groups than when considering relations with a same group.

Focusing on Table 5, our decomposition (see Equation 11) permits to analyse the contribution to overall S_1 of each possible pair wise comparison. Consider for example m=1 and d=2: 3.13 per cent of S_1 is due to income units in group 2 overtaking income units in group 1, when passing from the *X*-ordering to the *T*-ordering. Conversely, from the cell d=1, m=2, we can see that 1.67 per cent of S_1 is due to group 1 income units overtaking group 2 income unit. Looking at Table 11, which adds complementary information to Tables 5 and 8, we can see that the 34.82 per cent of tax liability re-ranking, which happens between groups 1 and 2, penalizes income units in group 1, whilst the 65.18 per cent penalizes income units in group 2. Similarly, Table 12 and 13 give complementary information for each pair wise comparison described in Tables 6 and 7.

Having defined the meaning and the interpretation of the contents of each Table 5 (6 and 7) cell, we can summarize first results. Looking to the first row of Table 5 (d=1) the overall re-ranking due to income units of group 1 overtaking income units in groups 2-7 is 4.28 per cent; on the contrary, the re-ranking due to income units of groups 2-7 overtaking income units in group 1 is 18.30 per cent (column m=1).

This means that (see Table 11) the 18.96 per cent of tax liability re-ranking, which involves group 1 with the remaining groups, penalizes group 1, whilst the 81.04 per cent is in favour of group 1.

Analogously, the overall re-ranking of group 2 with the remaining groups (row d=2) is due (Table 11, row 2 and column 2) for the 29.55 per cent to tax liability re-rankings which penalize group 2, and for the 70.45 per cent to re-rankings which penalize the remaining groups.

From Table 11 we can see that, in general, the relative percentage of tax liability re-ranking increases with the number of components.

Similar results arise considering Table 6, that permits to analyse the contribution to overall S_2 of each possible pair wise comparison. Again groups 4, 3, 2 and 5 are the most disadvantaged: 27.36 percent, 18.74 per cent, 9.83 per cent and 8.78 per cent, respectively.

Finally, Table 7, together with Table 10 and Table 13, consider the composition of Axiom 3 (related to the post-tax income re-ranking). As explained on page 6, here unfair shifts have to be considered on the contrary with respect to those observed for Axiom 1 and 2 (that refer to tax liability and tax rate re-ranking, respectively). As it can be noted, here the most advantaged are groups 1 and 2; whist the most penalized are families with children.

The analysis described in Tables 5, 6 and 7 is very helpful to understand the magnitude and the direction of each Axiom violation. Note also that these decompositions depend on the size of the groups. In order to overcome this unpleased disadvantage, Table 8, 9 and 10 reports absolute value of each axiom violation divided by the across redistributive effect of each possible pair wise comparison. Results presented in Table 5, 6 and 7 are confirmed, even if magnitude of Axiom violations get compressed.

5. Concluding remarks

In this paper we extend the original approach by Kakwani and Lambert (1998) for defining equity in income tax system. We start by their axiomatic measurement system and initially consider the whole pre- and post-tax income distribution. Focusing on Italian households and on the personal income taxation, we then split households into groups characterized by socio-demographic differences, and evaluate the impact of departures from equity due to Axiom violations within and across groups. This kind of analysis gives an important set of tools for the identification of possible unfairness between groups of households. By applying our methodology to the Italian income distribution we observe that relative re-rankings are lower within groups than across groups. Moreover, by evaluating redistributive losses for every pair wise comparison, we specify the inequity directions. Looking to our main results, it is quite clear that the re-ranking is not proportionally distributed among the different groups considered. In particular, households with more than one child appear to be particularly disadvantaged.

Table 4: *RE* decomposition for households

Decomposition	Pre-tax income	Post-tax income	*RE*	Potential equity	Axiom 1	Axiom 2	Axiom 3	Total Axioms
Kakwani and Lambert	38.88	33.70	5.18	5.98	0.19	0.53	0.08	0.80
	-	-	100.00	115.42	3.60	10.27	1.55	15.42

Source: Our elaborations on SHIW 2012.

Table 5: Decomposition of the loss of redistributive effect due to Axiom 1 violations by groups and direction (% of overall S_1)

$\frac{S_1^{d\to m}}{S_1}\%$	*m*=1	*m*=2	*m*=3	*m*=4	*m*=5	*m*=6	*m*=7	$\frac{S_1^{d\to\bullet}}{S_1}\%$	$\frac{S_1^{d,d}}{S_1}\%$	$\frac{S_1^{d,\bullet}}{S_1}\%$
d=1	-	1.67	0.76	0.76	0.20	0.38	0.51	4.28	1.10	22.58
d=2	3.13	-	2.39	2.14	0.54	0.96	1.52	10.67	4.76	36.11
d=3	4.55	7.07	-	3.33	0.81	1.47	2.31	19.53	3.67	31.53
d=4	6.27	9.95	5.32	-	1.26	2.18	3.32	28.30	5.07	37.79
d=5	1.82	2.86	1.53	1.39	-	0.63	0.97	9.20	0.45	12.56
d=6	1.18	1.80	0.95	0.90	0.25	-	0.60	5.68	0.39	11.76
d=7	1.35	2.07	1.05	0.97	0.31	0.46	-	6.21	0.67	15.43
$\frac{S_1^{\bullet\to d}}{S_1}\%$	18.30	25.44	12.00	9.49	3.36	6.08	9.22	$\frac{S_1^{AG}}{S_1}\% = 83.88$	$\frac{S_1^{W}}{S_1}\% = 16.12$	

Source: Our elaborations on SHIW 2012.

Table 6: Decomposition of the loss of redistributive effect due to Axiom 2 violations by groups and direction (% of overall S_2)

$\frac{S_2^{d\to m}}{S_2}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_2^{d\to\bullet}}{S_2}\%$	$\frac{S_2^{d,d}}{S_2}\%$	$\frac{S_2^{d,\bullet}}{S_2}\%$
d=1	-	1.78	1.06	1.25	0.49	0.51	0.70	5.80	1.14	22.48
d=2	2.61	-	2.18	2.16	0.58	0.88	1.40	9.83	4.08	33.4
d=3	4.05	6.33	-	3.64	1.03	1.43	2.25	18.74	3.62	31.00
d=4	5.81	9.06	5.30	-	1.68	2.17	3.34	27.36	5.50	38.46
d=5	1.67	2.56	1.46	1.53	-	0.62	0.94	8.78	0.54	13.53
d=6	1.25	1.90	1.17	1.32	0.51	-	0.76	6.91	0.52	13.03
d=7	1.29	1.94	1.09	1.19	0.45	0.51	0.00	6.47	0.73	15.86
$\frac{S_2^{\bullet\to d}}{S_2}\%$	16.68	23.57	12.26	11.10	4.75	6.12	9.39	$\frac{S_2^{AG}}{S_2}\% = 83.88$	$\frac{S_2^{W}}{S_2}\% = 16.12$	

Source: Our elaborations on SHIW 2012

Table 7: Decomposition of the loss of redistributive effect due to Axiom 3 violations by groups and direction (% of overall S_3)

$\frac{S_3^{d\to m}}{S_3}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_3^{d\to\bullet}}{S_3}\%$	$\frac{S_3^{d,d}}{S_3}\%$	$\frac{S_3^{d,\bullet}}{S_3}\%$
d=1	-	3.05	4.50	6.42	1.96	1.10	1.28	18.31	0.95	21.98
d=2	1.48	-	7.03	10.08	2.93	1.78	1.99	25.30	4.76	35.83
d=3	0.74	2.43	-	5.43	1.77	0.90	0.96	12.23	3.93	32.22
d=4	0.61	2.04	3.76	-	1.60	0.86	0.94	9.81	5.10	38.29
d=5	0.14	0.50	0.81	1.15	-	0.20	0.28	3.07	0.41	12.96
d=6	0.28	1.01	1.50	2.06	0.66	-	0.42	5.91	0.38	11.33
d=7	0.41	1.50	2.39	3.34	0.98	0.58	-	9.21	0.64	15.08
$\frac{S_3^{\bullet\to d}}{S_3}\%$	3.67	10.53	19.99	28.48	9.89	5.42	5.87	$\frac{S_3^{AG}}{S_3}\% = 83.84$	$\frac{S_3^{W}}{S_3}\% = 16.16$	

Source: Our elaborations on SHIW 2012

Table 8: Decomposition of the loss of redistributive effect due to Axiom 1 violations by groups and direction (% of corresponding *RE*)

$\frac{S_1^{d\to m}}{RE^{d,m}}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_1^{d\to\bullet}}{RE^{d,\bullet}}\%$	$\frac{S_1^{d,d}}{RE^{d,d}}\%$	$\frac{S_1^{d,\bullet}}{RE^{d,\bullet}}\%$
d=1		0.89	0.52	0.43	0.39	0.92	0.89	0.65	2.04	3.43
d=2	1.67		0.93	0.69	0.59	1.29	1.48	1.05	2.95	3.54
d=3	3.10	2.76		1.33	1.08	2.51	2.89	2.25	3.58	3.64
d=4	3.57	3.23	2.12		1.38	3.11	3.50	2.86	3.30	3.81
d=5	3.65	3.16	2.04	1.52		3.44	3.89	2.63	3.74	3.59
d=6	2.87	2.43	1.62	1.28	1.37		3.07	2.02	5.49	4.17
d=7	2.36	2.01	1.31	1.02	1.25	2.34		1.64	4.98	4.07
$\frac{S_1^{\bullet\to d}}{RE^{d,\bullet}}\%$	2.78	2.50	1.38	0.96	0.96	2.15	2.43	1.85	$\frac{S_1^{W}}{RE^{W}}\% = 3.20$	$\frac{S_1^{AG}}{RE^{AG}}\% = 3.69$

Table 9: Decomposition of the loss of redistributive effect due to Axiom 2 violations by groups and direction (% of corresponding *RE*)

$\frac{S_2^{d\to m}}{RE^{d,m}}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_2^{d\to\bullet}}{RE^{d,\bullet}}\%$	$\frac{S_2^{d,d}}{RE^{d,d}}\%$	$\frac{S_2^{d,\bullet}}{RE^{d,\bullet}}\%$
d=1		2.71	2.07	2.04	2.80	3.52	3.50	2.51	5.99	9.75
d=2	3.98		2.43	2.00	1.84	3.40	3.88	2.75	7.21	9.35
d=3	7.89	7.06		4.14	3.92	6.97	8.07	6.17	10.07	10.21
d=4	9.44	8.39	6.02		5.27	8.80	10.03	7.88	10.21	11.07
d=5	9.53	8.07	5.55	4.80		9.75	10.75	7.16	12.93	11.04
d=6	8.68	7.30	5.67	5.34	7.99		11.13	6.99	20.62	13.18
d=7	6.40	5.38	3.92	3.59	5.18	7.37		4.87	15.43	11.93
$\frac{S_2^{\bullet\to d}}{RE^{d,\bullet}}\%$	7.23	6.60	4.04	3.20	3.87	6.19	7.07	5.26	$\frac{S_2^{W}}{RE^{W}}\% = 9.12$	$\frac{S_2^{AG}}{RE^{AG}}\% = 10.53$

Table 10: Decomposition of the loss of redistributive effect due to Axiom 3 violations by groups and direction (% of corresponding *RE*)

$\frac{S_3^{d\to m}}{RE^{d,m}}\%$	*m*=1	*m*=2	*m*=3	*m*=4	*m*=5	*m*=6	*m*=7	$\frac{S_3^{d\to\bullet}}{RE^{d,\bullet}}\%$	$\frac{S_3^{d,d}}{RE^{d,d}}\%$	$\frac{S_3^{d,\bullet}}{RE^{d,\bullet}}\%$
d=1		0.70	1.32	1.57	1.69	1.15	0.96	1.20	0.76	1.44
d=2	0.34		1.18	1.41	1.39	1.03	0.83	1.07	1.27	1.51
d=3	0.22	0.41		0.93	1.02	0.66	0.52	0.61	1.65	1.60
d=4	0.15	0.29	0.65		0.75	0.52	0.42	0.43	1.43	1.66
d=5	0.12	0.24	0.46	0.54		0.47	0.49	0.38	1.46	1.59
d=6	0.29	0.59	1.10	1.26	1.55		0.92	0.90	2.27	1.73
d=7	0.31	0.63	1.29	1.51	1.71	1.29		1.05	2.05	1.71
$\frac{S_3^{\bullet\to d}}{RE^{d,\bullet}}\%$	0.24	0.44	0.99	1.24	1.22	0.83	0.67	0.79	$\frac{S_3^{W}}{RE^{W}}\% = 1.38$	$\frac{S_3^{AG}}{RE^{AG}}\% = 1.59$

Table 11: Axiom 1 - Comparisons of losses between group pairs and between one group with all the others (% of the two contrasting directions)

$\frac{S_1^{d\to m}}{S_1^{d,m}}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_1^{d\to \bullet}}{S_1^{d,\bullet}}\%$
d=1	-	34.82	14.34	10.83	9.70	24.35	27.40	18.96
d=2	65.18	-	25.23	17.69	15.76	34.76	42.30	29.55
d=3	85.66	74.77	-	38.46	34.55	60.75	68.80	61.95
d=4	89.17	82.31	61.54	-	47.46	70.78	77.38	74.89
d=5	90.30	84.24	65.45	52.54	-	71.47	75.66	73.26
d=6	75.65	65.24	39.25	29.22	28.53	-	56.80	48.33
d=7	72.60	57.70	31.20	22.63	24.34	43.20	-	40.23
$\frac{S_1^{\bullet\to d}}{S_1^{d,\bullet}}\%$	81.04	70.45	38.05	25.11	26.74	51.67	59.77	

Source: Our elaborations on SHIW 2012

Table 12: Axiom 2 - Comparisons of losses between group pairs and between one group with all the others (% of the two contrasting directions)

$\frac{S_2^{d\to m}}{S_2^{d,m}}\%$	*m*=1	*m*=2	*m*=3	*m*=4	*m*=5	*m*=6	*m*=7	$\frac{S_2^{d\to\bullet}}{S_2^{d,\bullet}}\%$
d=1	-	40.51	20.79	17.75	22.69	28.85	35.32	25.79
d=2	59.49	-	25.65	19.26	18.59	31.78	41.89	29.42
d=3	79.21	74.35	-	40.73	41.39	55.14	67.32	60.45
d=4	82.25	80.74	59.27	-	52.31	62.22	73.65	71.14
d=5	77.31	81.41	58.61	47.69	-	54.97	67.48	64.90
d=6	71.15	68.22	44.86	37.78	45.03	-	60.15	53.01
d=7	64.68	58.11	32.68	26.35	32.52	39.85	-	40.80
$\frac{S_2^{\bullet\to d}}{S_2^{d,\bullet}}\%$	74.21	70.58	39.55	28.86	35.10	46.99	59.20	

Source: Our elaborations on SHIW 2012

Table 13: Axiom 3 - Comparisons of losses between group pairs and between one group with all the others (% of the two contrasting directions)

$\frac{S_3^{d\to m}}{S_3^{d,m}}\%$	m=1	m=2	m=3	m=4	m=5	m=6	m=7	$\frac{S_3^{d\to\bullet}}{S_3^{d,\bullet}}\%$
d=1	-	67.31	85.83	91.30	93.40	79.66	75.68	83.31
d=2	32.69	-	74.31	83.14	85.52	63.87	57.14	70.62
d=3	14.17	25.69	-	59.08	68.67	37.53	28.57	37.96
d=4	8.70	16.86	40.92	-	58.21	29.40	21.91	25.62
d=5	6.60	14.48	31.33	41.79	-	23.29	22.17	23.67
d=6	20.34	36.13	62.47	70.60	76.71	-	41.67	52.19
d=7	24.32	42.86	71.43	78.09	77.83	58.33	-	61.07
$\frac{S_3^{\bullet\to d}}{S_3^{d,\bullet}}\%$	16.69	29.38	62.04	74.38	76.33	47.81	38.93	

Source: Our elaborations on SHIW 2012

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Appendix

Tables below compare results of the microsimulation model with the Ministry of Finance official statistics. Individual taxpayers with gross income equal or less than zero are not considered. Table A1a reports the number of taxpayers, the composition of taxpayers, the total amount of gross income and the mean income by income classes according to the Ministry of Finance official statistics of fiscal year 2010. Table A1b reports the same statistics as evaluated by the microsimulation model on the same year.

Table A1a: Overall taxpayers – Ministry of Finance

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	4,135,928	10.1	4.0	966
2,500-5,000	2,029,547	5.0	7.5	3,718
5,000-10,000	7,317,904	17.9	53.8	7,358
10,000-15,000	6,219,096	15.2	77.9	12,530
15,000-20,000	6,745,543	16.5	118.0	17,494
20,000-29,000	7,851,917	19.2	187.8	23,921
29,000-40,000	3,584,552	8.7	119.7	33,396
40,000-60,000	1,756,914	4.3	83.9	47,751
60,000-100,000	920,930	2.2	69.3	75,272
above 100,000	413,523	1.0	72.5	175,326
Total	**40,975,854**	**100.0**	**794.6**	**19,391**

Source: Ministry of Finance, 2011.

Table A1b: Overall taxpayers – Microsimulation model

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	3,690,583	9.0	3.7	997
2,500-5,000	2,147,552	5.2	7.8	3,650
5,000-10,000	7,372,101	18.0	55.1	7,471
10,000-15,000	6,197,873	15.1	77.5	12,510
15,000-20,000	6,364,894	15.5	110.6	17,382
20,000-29,000	8,649,831	21.1	206.5	23,868
29,000-40,000	3,528,774	8.6	119.8	33,942
40,000-60,000	1,882,470	4.6	91.8	48,751
60,000-100,000	891,121	2.2	65.6	73,576
above 100,000	317,050	0.8	57.1	180,230
Total	**41,042,250**	**100.0**	**795.5**	**19,382**

Source: Own elaborations on SHIW.

Similarly, Tables A2a and A2b as well as Tables A3a and A3b focus on employees and pensioners, respectively.

Finally, Table A4 compare results of the microsimulation model with the official statistics for what concerns gross income, tax base, gross tax liability, central government net liability as well as regional and municipal surtaxes.

Table A2a: Employees – Ministry of Finance

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	1,679,333	8.0	1.8	1,079
2,500-5,000	1,102,300	5.3	4.1	3,721
5,000-10,000	2,460,477	11.8	18.7	7,603
10,000-15,000	2,688,442	12.9	33.7	12,548
15,000-20,000	3,850,905	18.4	67.9	17,622
20,000-29,000	5,035,807	24.1	120.4	23,914
29,000-40,000	2,234,144	10.7	74.5	33,337
40,000-60,000	1,075,296	5.1	51.2	47,653
60,000-100,000	547,004	2.6	41.2	75,302
above 100,000	241,303	1.2	42.9	177,926
Total	**20,915,011**	**100.0**	**456.5**	**21,826**

Source: Ministry of Finance, 2011.

Table A2b: Employees – Microsimulation model

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	1,765,199	8.5	2.4	1,350
2,500-5,000	1,122,147	5.4	4.0	3,564
5,000-10,000	2,605,442	12.5	19.5	7,476
10,000-15,000	2,461,205	11.8	31.0	12,596
15,000-20,000	3,293,533	15.8	57.2	17,376
20,000-29,000	5,384,727	25.9	129.4	24,024
29,000-40,000	2,183,762	10.5	74.0	33,887
40,000-60,000	1,219,335	5.9	59.5	48,808
60,000-100,000	539,956	2.6	40.4	74,887
above 100,000	215,159	1.0	36.4	169,349
Total	**20,790,466**	**100.0**	**453.8**	**21,829**

Source: Own elaborations on SHIW.

Table A3a: Pensioners – Ministry of Finance

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	504,256	3.3	0.6	1,166
2.500-5,000	396,168	2.6	1.5	3,749
5.000-10,000	4,207,114	27.6	30.4	7,217
10.000-15,000	2,993,729	19.7	37.5	12,527
15.000-20,000	2,519,913	16.5	43.7	17,331
20.000-29,000	2,496,936	16.4	59.8	23,955
29.000-40,000	1,193,100	7.8	39.9	33,449
40.000-60,000	530,279	3.5	25.3	47,713
60.000-100,000	272,519	1.8	20.4	74,845
above 100,000	114,874	0.8	19.6	170,867
Total	**15,228,888**	**100.0**	**278.7**	**18,298**

Source: Ministry of Finance, 2011.

Table A3b: Pensioners – Microsimulation model

Income class	Frequency	Composition	Total amount (billion euro)	Mean (euro)
0-2,500	584,099	3.8	0.7	1,170
2,500-5,000	644,206	4.2	2.3	3,639
5,000-10,000	3,568,810	23.4	26.7	7,483
10,000-15,000	2,904,382	19.1	36.3	12,505
15,000-20,000	2,555,441	16.8	44.5	17,397
20,000-29,000	2,900,499	19.0	68.5	23,615
29,000-40,000	1,186,181	7.8	40.3	33,995
40,000-60,000	573,883	3.8	28.1	48,958
60,000-100,000	245,501	1.6	17.8	72,540
above 100,000	72,164	0.5	13.6	188,184
Total	**15,235,166**	**100.0**	**278.8**	**18,301**

Source: Own elaborations on SHIW.

Table A4: Overall individual taxpayers – Statistics on gross income, tax base, gross tax liability and net tax liability

	Ministry of Finance			Microsimulation model		
Variables	**Frequency**	**Total amount (billion of euro)**	**Mean value (euro)**	**Frequency**	**Total amount (billion of euro)**	**Mean value (euro)**
Gross income	**40,975,854**	**794.57**	**19,391**	**41,042,250**	**795.48**	**19,382**
Tax base	**39,894,420**	**762.18**	**19,105**	**40,167,551**	**765.93**	**19,068**
Gross tax liability	**39,077,531**	**205.61**	**5,262**	**39,620,176**	**205.35**	**5,183**
Central government net liability	**30,897,189**	**149.44**	**4,837**	**31,028,220**	**148.57**	**4,788**
Regional surtax	**30,652,846**	**8.63**	**282**	**31,028,220**	**8.56**	**276**
Municipal surtax	**25,264,796**	**3.02**	**120**	**25,162,983**	**2.92**	**116**

Source: Ministry of Finance, 2011 and own elaborations on SHIW.