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# Quality of Life and Sustainable Development

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## **MEASURES OF RERANKING OF TAXPAYERS IN INCOME DISTRIBUTION CAUSED BY THE TAX SYSTEM**

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**Abstract:** Quest for justice in the taxation seems to be the timeless problem. Complexity of issues related to the public finance – combined with the compulsory character of public duties – raises the natural question concerning fair distribution of burdens. One of the basic, undisputed rules within the theory of taxation is the principle of horizontal equity. This principle, postulating equal treatment of equals, embodies both universality and uniformity of taxation. In this sense, horizontal tax equity could be treated as a basic property of the tax system, however, there exists no widely accepted way of measuring this phenomenon. In this context measures of horizontal tax equity applied in literature are based on the decomposition of redistributive effect and the Atkinson-Plotnick-Kakwani index as an index of reranking. The aim of this paper is focus on the problem measuring of reranking among taxpayers. We compare the universally applied Atkinson-Plotnick-Kakwani index with the new suggested measures based on the changes in the ranking of taxpayers in the income distribution. The analysis is performed for the data on income and taxes, originating from one of the Lower-Silesian tax offices.

**Keywords:** reranking, horizontal equity, income tax.

### **1. Introduction**

The fairness of tax burden distribution, representing one of the key aspects of assessing fiscal solutions in the area of public finance, is usually defined in the form of two postulates: vertical equity and horizontal equity (see [Gomułowicz 2001]). As far as the first one, based on the assumption that those better-off have a higher tax burden, gives rise to numerous doubts, the other one, demanding that equals should be treated equally, apparently seems to be obvious. In practice, however, in order to assess the horizontal equity of the tax system it is necessary to define how the term “equal” taxpayers should be understood. In many analyses the “equality” of taxpayers is characterised as the same level of their wealth prior to taxation. In the case of interpersonal comparisons in the context of individual income tax, they can be naturally limited to the income earned by taxpayers. The horizontal equity can also

be perceived as observing the rule of maintaining the sequence of taxpayers in respect of a specific income or revenue category. The fulfilment of this postulate would require maintaining the identical sequence (ranking) of taxpayers before and after taxation. Such understanding of the horizontal equity principle actually represents its slightly less rigorous interpretation and, despite certain inconsistencies, makes it possible to undertake the assessment to what extent the analysed tax system deviates from the fair system (i.e. the one which does not result in the change in the ranking). The measures used for this type of tax system assessment are usually derived from the analysis of tax system redistribution and progressiveness. The possibility of constructing several alternative measures of this type leads to posing a question to what extent they will be accurate in assessing the real change in the ranking of taxpayers in respect of their income before and after taxation, how their results should be interpreted and in what circumstances they should be applied.

In this context the goal of this paper is to present new method for assessing the reranking of taxpayers as a result of the tax system.

## 2. Measurement of reranking

In the analysis of personal income tax system from the point of view of social justice there two basic aspects of the notation of tax equity: horizontal tax equity and vertical tax equity. The vertical tax equity postulates “equal treatment of equals” and is widely accepted as a very general rule. The problem arises, however, when an attempt is made at defining “equals.” Trivial definition, used in this paper, covering only income level, could be easily applied in practical solutions. A.B. Atkinson, R. Plotnick and N.C. Kakwani identify horizontal unfairness with the reranking [Lambert 1993]. The measures of horizontal and vertical tax equity proposed by other authors [Cox, Urban 2007; Urban, Lambert 2008; Vernizzi et al. 2010] are also based on the changes in the ranking of taxpayers in the income distribution. In this paper we propose the new measure of reranking.

Let us assume that vector  $X$  is vector of no decreasing income before taxation for  $n$  taxpayers:

$$X = (x_1, x_2, \dots, x_n), \quad x_1 \leq x_2 \leq \dots \leq x_n.$$

Analogous vector  $Y = (y_1, y_2, \dots, y_n)$  is the vector of income after taxation for  $n$  units (taxpayers). We will define the reranking as situation when it exists although one pair of taxpayers ( $i, j$ ) for which:  $x_i \leq x_j$ , whereas  $y_i > y_j$ . Then A.B. Atkinson [1980], R. Plotnick [1981] and N.C. Kakwani [1984] using the basic properties of Lorenz curve  $L(p)$  define the measure of reranking in the following way:

$$R^{\text{APK}} = G_Y - C_{Y|X}, \quad (1)$$

where:

$$G_Y - \text{Gini coefficient for pre-tax income } G_Y = 1 - 2 \int_0^1 L(p) dp$$

and

$C_{Y|X}$  – concentration coefficient for after-tax income defined as:

$$C_{Y|X} = 1 - 2 \int_0^1 L_Y(p) dp,$$

where  $L_Y(p) = L_{Y|X}(p)$  is concentration curve for post-tax income  $Y$  (with respect to  $X$ ).  $L_Y(p)$  measures the post-tax income share of a group who are the  $100p$  percent poorest in pre-tax income distribution.

If the  $100p$  percent poorest taxpayers in the pre-tax income distribution are also poorest in post-tax income distribution, then tax system does not change ranking of taxpayers in the income distribution. Gini coefficient is equal concentration coefficient and  $R^{\text{APK}} = 0$ . If  $R^{\text{APK}} \neq 0$ , then among taxpayers occurs reranking, tax system is unfair. Maximum value of this index is double Gini index for post tax income,  $R^{\text{APK}} = 2G_Y$ . The value is achieved when tax system completely reverses the order of taxpayers in terms of pre-tax income.

The paper suggests that the analysis of the unfairness of the system, conducted by means of the Atkinson, Plotnick and Kakwani (APK) reranking index, should be extended by adding the proposed measure of the degree of system interference in the ranking of taxpayers. By extending the analysis, the nature of the unfairness can be investigated, namely whether the system is more unfair to poor taxpayers or to the wealthy ones or whether it is, perhaps, the most unfair to middle-class taxpayers.

### 3. Measurement of tax system interference in the ranking of taxpayers

The concept of measuring the degree of system interference in the ranking of taxpayers relies on the counting of the number and measuring of the length of the series of ranks assigned to taxpayers on the basis of their gross income, mixed as a result of the tax system operation.

Let us remind, vector  $X$  is vector of no decreasing income before taxation for  $n$  taxpayers:

$$X = (x_1, x_2, \dots, x_n), \quad x_1 \leq x_2 \leq \dots \leq x_n.$$

Next taxpayers receive the rank from 1 to  $n$ . For establishing attention let us assume that rank 1 receive the poorest taxpayers and rank  $n$  – the richest taxpayers (see Table 1).

**Table 1.** Way of positioning taxpayers

Pre tax income	$x_1$	$x_2$	...	$x_n$
Rank/position	1	2	...	n

When we take vector  $Y = (y_1, y_2, \dots, y_n)$  of income after taxation into consideration, any taxpayers is represented by three characteristics:

$$(x_1, y_1, 1), (x_2, y_2, 2), \dots, (x_n, y_n, n).$$

Next we rewrite the received rank according to order no decreasing income after taxation:

$$y_{(1)}, y_{(2)}, \dots, y_{(n)} \quad (y_{(1)} \leq y_{(2)} \leq \dots \leq y_{(n)}).$$

In the sequence of ranks thus mixed we count the number and determine the length of the series. The series is defined as a number of ranks placed in a certain order. For example, in the sequence of mixed ranks of ten taxpayers: 4, 5, 6, 7, 8, 1, 2, 3, 10, 9 four series can be found with the following lengths: 5 (4, 5, 6, 7, 8), 3 (1, 2, 3), 1 (10), 1(9). The number of the series informs us about the number of taxpayers whose wealth (i.e. the position among all taxpayers in respect of their gross income) has changed as a result of taxation. Thus, we obtain the information about the extent of tax system interference in the order of taxpayers in respect of their earned gross income. Furthermore, the analysis of the distribution of mixed ranks makes it possible to identify the nature of their mixing, i.e. to determine which taxpayers, the poorer or better-off ones, have changed their position in the wealth ranking.

Let us analyse a few examples. Table 2 presents the data for 20 taxpayers concerning their generated gross and net income and the sequence of ranks mixed as a result of the operation of three different tax systems as well as the number of series. In addition, the  $R^{APK}$  reranking index was calculated for each of the examples.

In the first example the tax system operation completely reversed the order of taxpayers. Rank 20 appears at the top, which means that the taxpayer that was the wealthiest one before taxation became the poorest individual after the payment of his income tax, whereas the taxpayer that was the poorest one prior to taxation became the wealthiest person in terms of the generated net income. In this situation all taxpayers changed their wealth position as a result of taxation, and therefore 20 one-element series were obtained. The tax system interfered in the taxpayers' wealth (order) to the maximum extent, without affecting the inequalities in the distribution of income after taxation. The reranking index achieved its maximum value  $R^{APK} = 0.633334 = 2G_y$ , which corresponds to the maximum reranking of taxpayers as a result of taxation.



**Table 2.** Characteristics for three different tax systems

Example 1				Example 2				Example 3			
$R^{APK} = 0.633334$				$R^{APK} = 0.000953$				$R^{APK} = 0.000953$			
Pre-tax income	Post-tax income	Rank	s	Pre-tax income	Post-tax income	Rank	s	Pre-tax income	Post-tax income	Rank	s
105000	1000	20	1	15 000	1 000	2	1	15 000	1 000	2	1
100 000	2 000	19	2	10 000	2 000	1	2	10 000	2 000	1	2
95 000	3 000	18	3	20 000	3 000	3	3	25 000	3 000	4	3
90 000	4 000	17	4	25 000	4 000	4	3	20 000	4 000	3	4
85 000	5 000	16	5	30 000	5 000	5	3	30 000	5 000	5	5
80 000	6 000	15	6	35 000	6 000	6	3	35 000	6 000	6	5
75 000	7 000	14	7	40 000	7 000	7	3	40 000	7 000	7	5
70 000	8 000	13	8	45 000	8 000	8	3	45 000	8 000	8	5
65 000	9 000	12	9	50 000	9 000	9	3	50 000	9 000	9	5
60 000	10 000	11	10	55 000	10 000	10	3	55 000	10 000	10	5
55 000	11 000	10	11	60 000	11 000	11	3	60 000	11 000	11	5
50 000	12 000	9	12	65 000	12 000	12	3	65 000	12 000	12	5
45 000	13 000	8	13	70 000	13 000	13	3	70 000	13 000	13	5
40 000	14 000	7	14	75 000	14 000	14	3	75 000	14 000	14	5
35 000	15 000	6	15	80 000	15 000	15	3	80 000	15 000	15	5
30 000	16 000	5	16	85 000	16 000	16	3	85 000	16 000	16	5
25 000	17 000	4	17	90 000	17 000	17	3	90 000	17 000	17	5
20 000	18 000	3	18	95 000	18 000	18	3	95 000	18 000	18	5
15 000	19 000	2	19	100 000	19 000	20	4	100 000	19 000	19	5
10 000	20 000	1	20	105 000	20 000	19	5	105 000	20 000	20	5

Source: own calculations.

In the second and third examples (Table 2) the tax system interfered in only two pairs (20% of the examined taxpayers marked with bold font in “rank” columns), affecting their wealth position. In the second example the two poorest taxpayers changed their places after taxation (in respect of the generated net income) as well as the two wealthiest ones.

In the third example two pairs composed of the four poorest taxpayers changed their positions. The reranking index was the same for both tax systems,  $R^{APK} = 0.000953$ . This value indicates the absence of the unfairness understood as the reranking of taxpayers subject to a given tax system. The open issue, to be further analysed, is whether the change in position concerning 40% of the taxpayers in this case confirms the existence of the significant reranking among taxpayers. Employing this index to analyse the fairness of the tax system makes it impossible to find out whether the system interferes with the wealth of the well-off taxpayers or the poor ones. Such information is provided by the analysis of the distribution of the lengths of the series (Table 3).

**Table 3.** The distribution of the lengths of the series

Example 2					
Series	1	2	3	4	5
Length of series	1	1	16	1	1
Example 3					
Series	1	2	3	4	5
Length of series	1	1	1	1	16

Source: own calculations.

Series 3, the longest series, occupying the middle position in example 2, shows that 16 taxpayers, located in the middle, did not change their wealth. The changes in the ranks affected only the poorest taxpayers and the wealthiest ones. In example 3, the system interfered in only 20% of the poorest taxpayers and changed their wealth.

**Table 4.** Characteristics three different tax systems for examples 4, 5 and 6

Example 4				Example 5				Example 6			
$R^{APK} = 0.004762$				$R^{APK} = 0.02381$				$R^{APK} = 0.157143$			
Pre-tax income	Post-tax income	Rank	s	Pre-tax income	Post-tax income	Rank	s	Pre-tax income	Post-tax income	Rank	s
15 000	1000	2	1	25 000	1 000	4	1	55 000	1 000	10	1
10 000	2000	1	2	20 000	2 000	3	2	50 000	2 000	9	2
25 000	3 000	4	3	15 000	3 000	2	3	45 000	3 000	8	3
20 000	4 000	3	4	10 000	4 000	1	4	40 000	4 000	7	4
35 000	5 000	6	5	45 000	5 000	8	5	35 000	5 000	6	5
30 000	6 000	5	6	40 000	6 000	7	6	30 000	6 000	5	6
45 000	7 000	8	7	35 000	7 000	6	7	25 000	7 000	4	7
40 000	8 000	7	8	30 000	8 000	5	8	20 000	8 000	3	8
55 000	9 000	10	9	65 000	9 000	12	9	15 000	9 000	2	9
50 000	10 000	9	10	60 000	10 000	11	10	10 000	10 000	1	10
65 000	11 000	12	11	55 000	11 000	10	11	100 000	11 000	20	11
60 000	12 000	11	12	50 000	12 000	9	12	100 000	12 000	19	12
75 000	13 000	14	13	85 000	13 000	16	13	95 000	13 000	18	13
70 000	14 000	13	14	80 000	14 000	15	14	90 000	14 000	17	14
85 000	15 000	16	15	75 000	15 000	14	15	85 000	15 000	16	15
80 000	16 000	15	16	70 000	16 000	13	16	80 000	16 000	15	16
95 000	17 000	18	17	105 000	17 000	20	17	75 000	17 000	14	17
90 000	18 000	17	18	100 000	18 000	19	18	70 000	18 000	13	18
105 000	19 000	20	19	95 000	19 000	18	19	65 000	19 000	12	19
100 000	20 000	19	20	90 000	20 000	17	20	60 000	20 000	11	20

Source: own calculations.

In order to determine when, i.e. at what degree of the change in the ranking, the  $R^{APK}$  index reacts, pointing to the unfairness of the system, three tax systems were

analysed in addition and the results were collected in Table 4. In example 4, the tax system changes the ranking (position) of each pair of neighbouring taxpayers. Thus, 20 series having the length of 1 are obtained, as each taxpayer changed his position in the ranking as a result of taxation. However, since the change in position occurs each time with regard to two neighbouring taxpayers, the  $R^{APK}$  index reaches the value of only 0.00048, despite the fact that the whole examined population is affected. In the fifth example, the system reversed completely the order in each subsequent group consisting of four taxpayers. Again, the change in the ranking concerns the whole population, however, in comparison with the previous example, the taxpayers changed their position in the ranking not by one place, but within the range from 1 to 4 places. Even in this case the  $R^{APK}$  index does not show the significant reranking of the taxpayers, although each of them changed his wealth position, which is evidenced by the analysis of the number of the series.

In example 6, the position of 50% of the poorer taxpayers and 50% of the wealthier taxpayers changed completely. Also in this situation 20 one-element series were obtained and the reranking index was recorded at the level of 0.16. Supplementing the information provided by the Atkinson, Plotnick and Kakwani index with the number and length of the series makes it possible to determine the number of taxpayers who changed their wealth position as a result of the operation of the system and to find out which class of taxpayers, in terms of wealth, is subject to change.

#### 4. The real data analysis

The comparison of the described methods in terms of the possibility of employing them to assess the fairness of taxation, in the meaning of reranking, was conducted on the basis of the data from tax returns. The analysed tax returns were obtained from one of tax offices in Wrocław and they concerned the fiscal year 2007.

The tax returns, taking into account the purpose of their submission, contain only the information indispensable for the proper assessment of the amount of income tax due. Thence, contrary to, for example, the research on household budgets, they provide only the limited information for drawing conclusions on the situation and structure of respective taxpayers (their households). However, they are superior to survey research in terms of data credibility – although the existence of the phenomenon of tax evasion cannot be denied, the entry of false data to the tax return is subject to severe penalties. Furthermore, for the income declared (irrespective of whether it conforms to the facts or not), the tax returns contain the correct (in the formal sense) calculation of the amount of income tax due. It is the latter which differentiates the tax return data from the survey data – in the case of surveys the discrepancies with the facts may concern both the income and the amount of tax paid.

As the main goal of this paper is to compare the two methods for assessing fiscal fairness, the data set subject to analysis was reduced. From among all tax returns

submitted, only the joint tax returns submitted by married couples maintaining three or more children and having completed a PIT-37 (type of tax return form) were included in the research. The number of children was determined on the basis of the information provided by the taxpayers in the PIT-O attachment to the submitted tax return. The gross income (income before tax) was defined as the revenue reduced by tax deductible expenses. The net income (income after tax) was defined as the gross income reduced by the amount of income tax due.

Thus, a sample consisting of 469 taxpayers was obtained. On the basis of the data the reranking index was calculated:

$$R^{APK} = 0.0000994.$$

The result shows that the taxation system effective in 2007 was fair for the selected group of taxpayers. The analysis of the number and length of the series indicates that more than a half of the taxpayers, i.e. as many as 285, changed their wealth position in comparison with their situation prior to taxation. Out of these, the length of the first series is 101, of the fifth series – 14, and of the last one – 11, whereas the length of the remaining series varies from 1 to 4 at a maximum. It means that the tax system interfered in 60% of the examined taxpayers, out of which the first series concerns 22% of the poorest taxpayers who are tax exempt. In this situation it seems necessary to conduct an additional analysis, focused on a more thorough examination of the issue whether or not the interference in the wealth position of more than a half of the taxpayers provides the grounds for recognising a given tax system as unfair.

## 5. Conclusions

The measure of the unfairness of the system, discussed in the literature, understood as the interference in the ranking of taxpayers' wealth, i.e. the Atkinson, Plotnick and Kakwani reranking index, achieves its maximum value in the case where the tax system reverses completely the order of taxpayers in respect of their earned income before and after taxation. It is obviously unquestionable that in such a case the tax system is most unfair to taxpayers. However, the index is insensitive to the change in the order of neighbouring taxpayers, both before and after taxation. This fact is interesting as far as the horizontal justice postulates the equal treatment of equals and these are the taxpayers neighbouring in the ranking in respect of their gross income that can be recognised as "equal" individuals. Therefore, when the order of these taxpayers is changed the horizontal justice is violated by the tax system. This unfairness can be detected by the proposed analysis of the number and length of the series.

The open issue, to be further examined, is the analysis of not only the change in the ranking but also of the distance between respective positions in the ranking,

resulting from taxation, in respect of the income before and after tax. What also seems to be of interest in assessing the unfairness of the tax system is the number of taxpayers who change their wealth position as a result of taxation.

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## POMIAR ZMIANY KOLEJNOŚCI PODATNIKÓW W ROZKŁADZIE DOCHODÓW SPOWODOWANEJ SYSTEMEM PODATKOWYM

**Streszczenie:** Sprawiedliwe opodatkowanie jest i będzie zawsze problemem aktualnym. Jest to problem złożony i wieloaspektowy i trudno jest wyczerpująco przeprowadzić dyskusję na ten temat. Pomimo powszechnego zainteresowania tym tematem nie ma ściśle sformułowanych rozwiązań, które spełniałyby oczekiwania zarówno władzy stanowiącej podatki, jak i podatników. W doktrynie podatkowej bezspornie jednak przyjmuje się zasadę sprawiedliwości poziomej obejmującej zarówno powszechność, jak i równomierność opodatkowania. Do oceny sprawiedliwości opodatkowania w aspekcie wspomnianej sprawiedliwości poziomej, a także sprawiedliwości pionowej wykorzystane są dekompozycje wskaźnika redystrybucji dochodów ( $RE$ ) oraz wskaźnika rerankingu Atkinsona-Plotnicka-Kakwaniego ( $R^{APK}$ ). Obie wspomniane metody opierają się na identyfikacji i pomiarze pojawiającego się rerankingu wśród podatników spowodowanego systemem podatkowym. Głównym celem artykułu jest porównanie wykorzystywanej w literaturze metody identyfikacji rankingu opartej na współczynniku Giniego i współczynniku koncentracji z nowo sugerowanymi metodami opartymi na analizie rang. Analiza zostanie przeprowadzona na podstawie rzeczywistych danych dotyczących osiągniętych dochodów brutto i netto.

**Słowa kluczowe:** reranking, sprawiedliwość pozioma, podatek dochodowy.