

**COMPONENTS OF A COMPARATIVE ANALYSIS OF
THE EFFICIENCY OF THE TAX BURDEN ON INCOME:
APPLICATION OF STOCHASTIC FRONTIER ANALYSIS**

Victor Vladimirovich Gluschenko^{*}

Vyacheslav Victorovich Lyashenko^{**}

Valentyna Valerivna Somova^{***}

Abstract. Sustainable and efficient economic development is largely defined by the current taxation system in which an important role is played by household incomes. Taking into consideration this fact this paper describes separate components of the comparative analysis of the efficiency of household income taxation burden and validates the possibility of using stochastic frontier analysis for this research. In particular the real-life statistics is used to show the relation between the growth of gross regional product and household incomes in their regional aspect. At the same time the author notes that inadequate wage rise of the population and poorly balanced burden of taxation in terms of the part of household income liable to taxation leads to the reduction in the taxes received.

^{*} Dr (Economic), Professor, V.N. Karazin National University of Kharkov, Ukraine

^{**} The chief of the laboratory, Kharkov National University of Radio Electronics, Ukraine

^{***} PhD student, V.N. Karazin National University of Kharkov, Ukraine

Introduction

Taxes are fundamental economic category which helps to implement and provide not only fiscal and enforcing functions of social development but guiding and innovating ones as well.

Herewith Bird & Zolt (2004), Schultz (1998), Lee & Gordon (2005) believe that household income taxes hold a special place among other taxes. This is due to the fact that household income tax is a key tax which determines both the structure of budgeting sources at various levels and orientation of state's social policy in relation to different territories and population groups.

At the same time in the opinion of Andrews (1972) the size of collected household income taxes depends on the size of income received which in its turn can be associated with the level of economic development of a certain territory where the population is able to receive the relevant income.

Thus one of the directions of research into components of efficiency of household income taxation burden can be the comparative analysis of household incomes by reference to the administrative-territorial division of the country and level of development of these separate territories.

Keywords: эффективность, налог, структура доходов, доходы населения, административно-территориальное деление страны, stochastic frontier analysis.

Methodology and data analysis

Kuzemin & Lyashenko (2008) say that the grounds for comparing various economic data which reflect any given phenomena are in the first instance the analysis of spatial and time dynamics of the analyses and processes under consideration.

At the same time with the aim of specifying the comparative analysis of the efficiency of household income burden from the point of view of administrative-territorial division of the country it is reasonable to use stochastic frontier analysis which has been widely applied in the works by Farrell (1957), Aigner, Lovell & Schmidt (1977), Battese & Coelli (1992). The gist of this methodology is in building the frontier of the efficiency of process (phenomenon) being researched by the methods of statistical analysis in the form of a regression relationship

between research-committed factors; in positioning the economic process or object under research in relation to the frontier of efficiency defined earlier; in defining the efficiency of economic process or object under research in the form of a function which will describe attainability of efficiency frontier which in line with the works of Jondrow, Knox Lovell, Materov&Schmidt (1982) can be represented as follows:

$$TE_i = e^{-M(u_i/\hat{\varepsilon}_i)}, \quad (1)$$

if TE_i is efficiency of the process or object under research (TE_i is the total number of objects, processes under research) and more precisely their technical efficiency;

$M(u_i/\hat{\varepsilon}_i)$ is the conditional mathematical expectation u_i in the estimated values $\hat{\varepsilon}_i$, which are integral randomized members of the model of received efficiency frontier of the process of phenomenon under research by the methods of statistical analysis:

$$y = f(x, \beta) + \varepsilon, \quad (2)$$

$$\varepsilon = v - u, \quad (3)$$

y – vector of results of object or process under research, x – vector of the resources used for receiving any given results of the object of process under research, f – function of the efficiency frontier in the object or process under research, β – vector of f function parameters; ε – integral randomized member of model, v – vector of model's random movements, u – vector describing technical inefficiency of the performance of object or phenomenon under research.

The resulting assessments of the efficiency of household income together with the data on economic development of any given administrative –territorial units (regions) of the country are the basis for conducting the relevant comparative analysis.

In order to specify further analysis we shall consider the data which describe the development of certain administrative territorial units of Ukraine and the sizes of income obtained by population in these administrative-territorial units. The specific nature of this research is determined not only by a deeper insight of authors into the issue under consideration but also by the fact that Ukraine being a developing country as stated by Bank for International Settlement and is facing significant economic challenges on its way to market reforms as compared to other European countries.

All the data for further analyses were retrieved from the official site of Ukraine's Service for Statistics ukrstat.gov.ua. Herewith with the aim of further research we chose the period of 2009-2010 which is the period of overcoming the consequences of the first wave of latest global financial-economic crisis. At the same time it should be noted that the data for the further researches for period 2009-2010 are not preliminary but verified.

A simple comparison of the test data

Table 1 shows the data (as generalized and calculated according to ukrstat.gov.ua information) which reflect absolute values and their changes that describe the development of certain Ukrainian regions, the size of household income and the taxes paid therewith.

In particular Table 1 defines:

- digital numbering of some Ukrainian regions;
- absolute values of gross regional product which in broad terms reflects and describes the level of development of each region;
- absolute values of incomes received by population in some regions and absolute values of the sizes of taxes paid from these incomes which generally reflect the existing level of tax burden on household income.

Herewith in Table 1 it can be seen that within the period of time under consideration the growth of gross regional product conditioned the subsequent growth of household income in some regions.

Table 1. Some data which describe development of Ukrainian regions and absolute values of household incomes and the taxes paid from them

Regions	Gross regional product, mln. UAH			Income, mln. UAH			Taxes, mln. UAH		
	2009	2010	changes	2009	2010	changes	2009	2010	changes
1	27396	32426	5030	32046	39282	7236	1320	1828	508
2	20104	23589	3485	26813	33448	6635	1666	1276	-390
3	12225	14429	2204	15177	19194	4017	555	710	155
4	93331	116136	22805	72138	88980	16842	2813	4483	1670
5	103739	128986	25247	96596	118554	21958	4168	5957	1789
6	14731	18743	4012	20655	25957	5302	904	1001	97

7	12542	15299	2757	16492	20812	4320	731	768	37
8	37446	42736	5290	37019	45379	8360	1988	2125	137
9	17241	20446	3205	21023	26537	5514	616	912	296
10	37548	44953	7405	34358	42338	7980	1922	2095	173
11	13389	15749	2360	16149	20069	3920	935	826	-109
12	38451	45541	7090	41916	51523	9607	2040	2335	295
13	35955	41655	5700	43813	55162	11349	1690	2269	579
14	20336	24055	3719	20723	25724	5001	947	1113	166
15	48647	53878	5231	42422	52828	10406	1952	2458	506
16	33629	44291	10662	28239	34548	6309	1204	1683	479
17	13469	15882	2413	17458	22170	4712	732	903	171
18	16060	18333	2273	20318	24693	4375	729	1001	272
19	11173	12726	1553	15608	19399	3791	836	647	-189
20	58923	65293	6370	54519	67377	12858	1870	2878	1008
21	13436	15649	2213	16731	20776	4045	750	770	20
22	15758	18096	2338	21526	26699	5173	1025	993	-32
23	18707	22354	3647	21351	25886	4535	915	1080	165
24	8484	9892	1408	12619	15911	3292	704	541	-163
25	14636	17008	2372	18917	23021	4104	821	850	29
26	169537	196639	27102	122516	145798	23282	11890	10328	-1562
27	6452	7785	1333	7144	8950	1806	589	499	-90

Nevertheless the data of Table 1 indicate that the trend for higher tax deductions from household income is not typical of all the regions. In other words there are regions where we see reductions in tax revenues from household income and there are regions where we can see growth of tax revenues from the income of population. Such a situation can be put down to a fact that the structure of household income consists of both taxable incomes and non-taxable incomes (in particular welfare pays and special transfers).

At the same time the analysis of changes in household income structure in terms of some Ukrainian regions (see Table 2 data as generalized and calculated using ukrstat.gov.ua information) does not give any clear explanation of the changes in size of taxes levied from household income.

Table 2. Changes in the structure of household incomes as resulted from 2009-2010 period

Regions	absolute change from 2009 to 2010, mln. UAH		structure of income in 2009, %		structure of income in 2010, %	
	non-taxable income	taxable-income	non-taxable income	taxable income	non-taxable income	taxable income
1	2124	5112	44,02	55,98	41,32	58,68
2	2547	4088	40,86	59,14	40,37	59,63
3	1840	2177	43,34	56,66	43,85	56,15
4	3752	13090	37,93	62,07	34,97	65,03
5	5478	16480	40,06	59,94	37,26	62,74
6	2189	3113	44,08	55,92	43,51	56,49
7	2348	1972	43,35	56,65	45,64	54,36
8	2360	6000	37,32	62,68	35,64	64,36
9	2492	3022	44,92	55,08	44,97	55,03
10	2358	5622	39,96	60,04	38,00	62,00
11	1662	2258	42,97	57,03	42,86	57,14
12	2733	6874	46,26	53,74	42,94	57,06
13	4136	7213	41,21	58,79	40,23	59,77
14	1912	3089	39,87	60,13	39,55	60,45
15	3069	7337	42,24	57,76	39,73	60,27
16	2031	4278	39,85	60,15	38,45	61,55
17	2106	2606	43,25	56,75	43,56	56,44
18	1653	2722	40,65	59,35	40,14	59,86
19	1778	2013	46,35	53,65	46,46	53,54
20	3994	8864	40,46	59,54	38,66	61,34
21	1609	2436	42,86	57,14	42,26	57,74
22	2247	2926	42,25	57,75	42,48	57,52
23	1731	2804	43,29	56,71	42,39	57,61
24	1517	1775	45,78	54,22	45,84	54,16
25	1504	2600	43,63	56,37	42,39	57,61
26	-2723	26005	35,69	64,31	28,13	71,87
27	671	1135	48,22	51,78	45,99	54,01

As it can be seen from Table 2 and Table 1 it is quite difficult to find a simple relation between the changes in household income structure in its regional aspect and the changes in the size of taxes paid from the income of population.

Thus it would be reasonable to analyse efficiency of household income generation in the regional aspect for which we are going to use stochastic frontier analysis.

Stochastic frontier analysis of the test data

With the aim of solving the task we primarily should define the formula of the function of efficiency frontier of the object (process) under research /

Using the results of works by Gluschenko, Lyashenko, & Somova (2013) for calculating the efficiency of incomes received by population we will employ the following model of efficiency frontier :

$$\ln(DN) = \beta_0 + \beta_1 \cdot \ln(VN) + \beta_2 \cdot \ln(ZN) + v - u, \quad (4)$$

DN – vector which defines the size of values of that part of household income in terms of some regions which is liable to taxation;

VN – vector which determines the number of employed population in any given region;

ZN – vector that determines the average wage in any given region during the period under consideration .

Herewith we shall assume that randomized components of frontier model formulation (4) are distributed as follows: $v \approx N(0, \sigma_v^2)$, $u \approx N_+(0, \sigma_u^2)$. In their turn model's output data for formula (4) are the basis for receiving the assessment of efficiency of received household income and the the assessment of efficiency of population income taxation in line with formula (1).

Table 3 (all the calculations were completed using ukrstat.gov.ua information and with the help of FRONTIER4.1 software available free) gives parameters and statistical values for the model according to formula (4) that determined the frontiers of efficiency after the results of their approval in real2009 and 2010 data for Ukraine. The calculations were completed at the level of significance at 0,05.

As it can be seen in Table 3 the general value of taxable household income in terms of regions is mostly determined by the size of average wage in the region.

Table 4 (as calculated with the help of FRONTIER 4.1 software using ukrstat.gov.ua information) introduces the results of efficiency assessment in the formation of received taxable household incomes for each region taken separately in line with formula (4).

Table 3. Parameters and statistical values for the model in line with formula (4) which considers the frontiers of efficiency after the results of their approval in real 2009 and 2010 years data for Ukraine

Parameter	Periods under consideration			
	2009 год		2010 год	
	Parameters assessment	t-value	Parameters assessment	t-value
β_0	0,52021334E+01	6,82	0,56256455E+01	7,94
β_1	-0,99045414E-09	-3,89	-0,12771256E-0	-5,63
β_2	0,72631597E+00	5,82	0,70265811E+00	6,09
σ^2	0,1355	–	0,1149	–
γ	0,0500	–	0,9300	–

$$\sigma^2 = \sigma_v^2 + \sigma_u^2, \gamma = \frac{\sigma_u^2}{\sigma^2}.$$

Table 4 Result of efficiency assessment in the generation of received taxable household income for each region taken separately

Regions	Efficiency assessment		Regions	Efficiency assessment	
	2009	2010		2009	2010
1	0,9442	0,7220	15	0,9475	0,7534
2	0,9422	0,8682	16	0,9433	0,9449
3	0,9441	0,8085	17	0,9338	0,4688
4	0,9366	0,3881	18	0,9375	0,5842
5	0,9371	0,9555	19	0,9437	0,7700
6	0,9367	0,5781	20	0,9360	0,3712
7	0,9327	0,4104	21	0,9331	0,2781
8	0,9475	0,7449	22	0,9381	0,6146
9	0,9368	0,5749	23	0,9306	0,5911
10	0,9463	0,7345	24	0,9403	0,6016
11	0,9452	0,8776	25	0,9352	0,5063
12	0,9474	0,7455	26	0,9515	0,9998
13	0,9476	0,7180	27	0,9285	0,3865
14	0,9381	0,6247			

In Table 4 it can be seen that as of the results of 2010 the efficiency of generating received taxable income decreased as compared to the results of 2009. Taking into consideration the growth of gross regional product and growth of household income in some regions on the whole it can be presumed that reduction of collected taxes in terms of separate regions is

primarily resulting from the lower efficiency of received taxable income. At the same time this reduction considered in line with given model of efficiency frontier after formula (4) can be insufficient rise in wages. This conclusion is made on the basis of parameters and statistics for the model under consideration after formula (4) as compared to the data of Table 1 and Table 4. This conclusion is back up by the fact that the structure of taxable income 85%-90% of it are made up by the wages (according to ukrstat.gov.ua). At the same time even though throughout 2009-2010 the tax burden on wages remained intact but was different from the level of wages, the tax burden to other taxable incomes is not sufficiently regulated. This in particular concerns so much disputed source of income as bank deposit incomes (see the relevant discussion at the Internet-site of the National Bank of Ukraine or Association of Ukrainian Banks: bank.gov). In other words the absolute changes in the structure of household income after the results of 2009-2010 (see Table 2) are conditioned not only by the rise of wages which on average in Ukraine was 17% (as retrieved from ukrstat.gov.ua). At the same time the average rise of taxable household income for the same period made 27% (calculated based on ukrstat.gov.ua). Thus we received the following results of the assessment of efficiency of received taxable household income for each region taken separately (see Table 4).

Conclusions

Thus the researches we have completed make it possible to assume that among the components of the comparative analysis of the assessment of tax burden's efficiency on household income we should consider both the efficiency of receiving this income with the consideration of economic development of administrative territorial units of the country and the structure of income received by population and specific character of tax burden in terms of any given element of such a structure.

At the same time our completed researches show the possibility and feasibility of using stochastic frontier analysis for analysing efficiency of population's income generation in their regional aspect. Herewith on the basis of actual model of building efficiency frontier for generating received income we have concluded about insufficiency of wage rise which eventually impacts the size of received income.

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