3. Mowshowitz A. Virtual organization // Association for Computing Machinery. Communications of the ACM; New York; Sep 1997. – New York, 1997. – P. 631-634.
4. Тимашова Л.А., Семесенко Т.М. Проблеми розвитку фінансової системи підприємств середнього та малого бізнесу // ЗНП – К.: МНУЦ ІТ та С НАНУ і МОНУ. – 2012. – С.23-31.

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MODELING OF GNI GROWTH DEPENDENCY ON MACROECONOMIC FACTORS

Вибірка з 10 країн, що представляють всі чотири рівні людського розвитку, сформована на основі прогресу цих країн у рейтингу ІЛР у 2005-2012 роках. Комбінаторний метод МГУА обрано для оцінки впливу частки зайнятих у загальній кількості населення, прямих іноземних інвестицій, сумарного коефіцієнта демографічного навантаження і загального обсягу резервів на ВНД у Бєларусі, Ірані і Танзанії.

***Ключові слова**: індекс людського розвитку, дохід на душу населення, комбінаторний алгоритм МГУА.*

Выборка из 10 стран, представляющих все четыре уровня человеческого развития, сформирована на основе прогресса в рейтинге ИЧР в 2005-2012 годах. Комбинаторный метод МГУА выбран для оценки влияния доли занятых в общей численности населения, прямых иностранных инвестиций, суммарного коэффициента демографической нагрузки и общего объема резервов на ВНД в Беларуси, Иране и Танзании.

***Ключевые слова**: индекс человеческого развития, доход на душу населения, комбинаторный алгоритм МГУА.*

A sample of 10 countries representing all four levels of human development was chosen based on their progress in HDI rating during 2005-2012. Combinatorial GMDA was chosen as a method to assess influence of employment to population ratio, foreign direct investment, total dependency ratio, and total reserves on GNI in Belarus, Iran, and Tanzania.

***Key words**: human development index, per capita income, combinatorial GMDH algorithm.*

Introduction. Over time there has been a better understanding of the social consequences of economic development, and above all an acknowledgement by governments and the public at large that not only is human development achievable, but that it has practical meaning for social and economic progress and the overall prosperity of nations and states [1].

Twenty years ago, the Human Development Index (HDI) was proposed as an alternative to conventional assessments of development based on measures of per capita income. It complements income with health and education indicators. HDI classifications are relative – based on quartiles of HDI distribution across countries and denoted very high, high, medium and low HDI. Because there are 187 countries, the four groups do not have the same number of countries: the very high, high and medium HDI groups have 47 countries each, and the low HDI group has 46 countries [2].

Previous research analysis. The first Human Development Report introduced a new way of measuring development by combining indicators of life expectancy, educational attainment and income into the composite HDI. The breakthrough for the HDI was the creation of a single statistic which was to serve as a frame of reference for both social and economic development. The HDI sets a minimum

and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1.

The education component of the HDI is now measured by mean of years of schooling for adults aged 25 years and expected years of schooling for children of school entering age. Mean years of schooling is estimated based on educational attainment data from censuses and surveys available in the UNESCO Institute for Statistics database. Expected years of schooling estimates are based on enrolment by age at all levels of education and population of official school age for each level of education. Expected years of schooling are capped at 18 years. The indicators are normalized using a minimum value of zero and maximum values are set to the actual observed maximum value of mean years of schooling from the countries in the time series, 1980–2012, that is 13.3 years estimated for the United States in 2010. Expected years of schooling are maximized by its cap at 18 years. The education index is the geometric mean of two indices.

The life expectancy at birth component of the HDI is calculated using a minimum value of 20 years and maximum value of 83.57 years. This is the observed maximum value of the indicators from the countries in the time series, 1980–2012. Thus, the longevity component for a country where life expectancy birth is 55 years would be 0.551.

For the wealth component, the goalpost for minimum income is $100 (PPP) and the maximum is $87,478 (PPP), estimated for Qatar in 2012.

Purchasing power parity (PPP) is an economic theory and a technique used to determine the relative value of currencies, estimating the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to (or on par with) each currency's purchasing

power. It asks how much money would be needed to purchase the same goods and services in two countries, and uses that to calculate an implicit foreign exchange rate. Using that PPP rate, an amount of money thus has the same purchasing power in different countries.

The decent standard of living component is measured by Gross National Income (GNI) per capita (PPP$) instead of Gross Domestic Product (GDP) per capita (PPP$) The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean.

The HDI facilitates instructive comparisons of the experiences within and between different countries. [3].

Combinatorial group method of data handling (GMDH) algorithm was used to build models describing dependence of human development index on macroeconomic factors [4]. Inductive GMDH algorithms give possibility to find interrelations in data automatically, and to select optimal structure of model.

Unsolved problems. Theoretical essentials of human capital reproduction, analysis of indices of social and economic progress are subject for research for many studies. Though, due to its complexity issues of human development are still not examined completely. Taking into consideration the importance of this field for the whole mankind, comprehensive studies of human development should be continued.

Goal. The goal of this article is to find out what countries made the most remarkable progress in their human development during 2005-2012. The choice will be based on HDI ranking during the above stated period.

The goal of this paper is modeling of influence of macroeconomic factors on the growth of national income as a

component of human development index. Indicators influencing national income growth should be analyzed. Models that give possibility to analyze what macroeconomic indicators are the most influential on the national income growth will be developed. Also these models enable to assess how national income will change with changing given indicator.

The bulk material. 10 countries with different levels of human development from different regions demonstrated remarkable progress in rating of HDI. Hong Kong, Special Administrative Region of China and Singapore have very high level of human development. Belarus, Saudi Arabia, Bolivarian Republic of Venezuela, Islamic Republic of Iran, and Ecuador have high level of human development. Ghana and United Republic of Tanzania have respectively medium and low level of human development. HDI for these countries in 2005-2012 is presented in the Table 1.

Singapore data from 2006 till 2008 are omitted in the Table 1. Combinatorial algorithm GMDH was used for modelling to restore those values. They are shown in italics in the Table 1.

Models of dependency of restored variable on all others were developed for this purpose. Therefore, we should build dependency of the following type:

$$HDI_{2006} = HDI_{2005}, HDI_{2007}, HDI_{2008}, HDI_{2009}, HDI_{2010}, HDI_{2011}, HDI_{2012}$$

This model is obtained for 2007:

$$HDI_{2007} = -0{,}0538 + 0{,}4818 HDI_{2005} + 0{,}575 HDI_{2012},$$

parameters of model: $AR = 0{,}000109$; $BS = 0{,}00307$.

Table 1.

Human development index

Country	Human Development Index (HDI) value							
	2005	2006	2007	2008	2009	2010	2011	2012
Hong Kong,	0.857	0.865	0.877	0.892	0.894	0.9	0.904	0.906
Singapore	0.852	*0,863*	*0,872*	*0,887*	0.877	0.892	0.894	0.895
Chile	0.789	0.791	0.8	0.807	0.808	0.813	0.817	0.819
Belarus	0.73	0.743	0.756	0.768	0.78	0.785	0.789	0.793
Venezuela	0.694	0.703	0.712	0.738	0.741	0.744	0.746	0.748
Iran	0.685	0.704	0.706	0.717	0.723	0.74	0.742	0.742
Ecuador	0.682	0.686	0.688	0.715	0.716	0.719	0.722	0.724
Ghana	0.491	0.493	0.506	0.52	0.534	0.54	0.553	0.558
Tanzania	0.395	0.401	0.408	0.414	0.458	0.466	0.47	0.476

Source: Human Development Index (HDI) value: HDRO calculations based on data from UNDESA (2011), Barro and Lee (2011), UNESCO Institute for Statistics (2012), World Bank (2012) and IMF (2012).

Similarly three omitted values for Singapore are restored.

Stated above 10 countries have experienced significant growth of GNI for 2005-2012.

It is an aggregate income of an economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world, converted to international dollars using purchasing power parity (PPP) rates, divided by midyear population and presented in the Table 2.

Since GNI is important component of HDI, it is important to determine what factors influence income and to measure their impact. Four influential factors were chosen.

The Organization for Economic Co-operation and Development defines the employment rate as the employment-to-population ratio (shown in the Table 3). This is a statistical ratio that measures percentage of the population ages 25 years or older that is employed.

Table 2.

Gross National Income (GNI) per capita

Country	2005	2006	2007	2008	2009	2010	2011	2012
Hong Kong,	35,720	38,643	41,057	42,591	40,393	42,591	45,160	45,598
Singapore	42,330	46,112	48,344	49,075	47,502	51,259	52,439	52,613
Chile	11,600	11,678	12,294	13,097	12,942	13,551	14,407	14,987
Belarus	8,540	9,407	10,187	11,311	11,329	12,245	12,770	13,385
Saudi Arabia	20,780	20,896	20,580	20,964	20,552	20,858	21,812	22,616
Venezuela	9,770	10,656	11,599	11,891	11,210	10,848	11,068	11,475
Iran	9,060	9,503	10,177	10,316	10,390	10,834	10,936	10,695
Ecuador	6,190	6,423	6,458	6,936	6,863	7,073	7,288	7,471
Ghana	1,190	1,075	1,130	1,225	1,394	1,451	1,596	1,684
Tanzania	1,050	1,095	1,149	1,197	1,230	1,288	1,324	1,383

Source: GNI per capita in PPP terms (constant 2005 international $): HDRO calculations based on data from World Bank (2012), IMF (2012) and UNSD (2012).

This includes people that have stopped looking for work. The International Labor Organization states that a person is considered employed if they have worked at least 1 hour in "gainful" employment in the most recent week.

Employed persons are all those who, (1) do any work at all as paid employees, work in their own business or profession or on their own farm, or work 15 hours or more as unpaid workers in a family-operated enterprise; and (2) all those who do not work but had jobs or businesses from which they were temporarily absent due to illness, bad weather, vacation, childcare problems, labor dispute, maternity or paternity leave, or other family or personal obligations — whether or not they were paid by their employers for the time off and whether or not they were seeking other jobs.

Unemployed persons are all those who, (1) have no employment during the reference week; (2) are available for work, except for temporary illness; and (3) have made specific

efforts, such as contacting employers, to find employment sometime during the past 4-week period.

Table 3.

Employment to population ratio

Country	2005	2006	2007	2008	2009	2010	2011
Hong Kong,	60.8	61.4	61.9	62	61.1	60.9	61.2
Singapore	66.3	67.7	68.7	69.3	68.5	69	69.2
Chile	58.3	59	59.8	60.6	59.6	62.3	62.9
Belarus	55.6	55.2	54.8	54.4	53.8	54.2	54.4
Saudi Arabia	61.2	60.4	60.8	60.6	60	59.9	59.7
Venezuela	66.8	67.7	68.4	68.9	68.4	68	68.1
Iran	49	48.3	47.9	45.7	46	46.2	46.1
Ecuador	72.2	73.1	72.4	70.8	70.7	71.2	71.5
Ghana	82.1	81.2	81.3	81.4	81.4	81.5	81.3
Tanzania	84.3	84.5	84.4	84.4	84.4	84.4	84.2

Source: Employment to population ratio, population 25+: ILO (2012). ["Key Indicators on the Labour Market: 7th edition". Geneva: ILO.].http://www.ilo.org/empelm/what/lang--en/WCMS_114240. Accessed March 2012.

Included in the group ‘Not in the labor force’ are all persons in the civilian non-institutional population who are neither employed nor unemployed. Information is collected on their desire for and availability to take a job at the time of the interview, job search activity in the prior year, and reason for not looking for work in past 4-week period.

Multiple jobholders are employed persons who, have two or more jobs as a wage and salary worker, are self-employed and also held a wage and salary job, or work as an unpaid family worker and also hold a wage and salary job.

Foreign direct investment presented in the Table 4 is a sum of equity capital, reinvestment of earnings, other long-term capital and short-term capital, expressed as a percentage of GDP.

Table 4.

Foreign direct investment, net inflows (% of GDP), (%)

Country	2005	2006	2007	2008	2009	2010	2011
Hong Kong,	18.9	23.7	26.3	27.7	25	31.7	34.1
Singapore	12.5	21.1	22	5.1	8.7	18.1	-
Chile	5.7	4.7	7.2	8.4	7.5	7	-
Belarus	1	1	4	3.6	3.8	2.5	7.2
Saudi Arabia	3.8	5.1	6.3	8.3	9.7	4.8	2.8
Venezuela	1.9	-0.3	0.7	0.4	-0.8	0.3	1.7
Iran	1.6	0.7	0.6	0.5	0.9	-	-
Ecuador	1.3	0.7	0.4	1.9	0.6	0.3	-
Ghana	1.4	3.1	5.6	9.5	5.5	7.9	-
Tanzania	6.6	2.8	3.5	1.9	1.9	1.9	-

Source: Foreign direct investment, net inflows (% of GDP): World Bank (2012a). "World Development Indicators 2012." Washington, D.C.: World Bank. http://data.worldbank.org. Accessed April, 2012.

It is a direct investment into production or business in a country by a company in another country, either by buying a company in the target country or by expanding operations of an existing business in that country. Foreign direct investment is in contrast to portfolio investment which is a passive investment in the securities of another country such as stocks and bonds.

Foreign direct investment has many forms. Broadly, foreign direct investment includes mergers and acquisitions, building new facilities, reinvesting profits earned from overseas operations and company loans. In a narrow sense, foreign direct investment refers just to building new facilities.

Total dependency ratio shown in the Table 5 is ratio of the sum of the population ages 0–14 and ages 65 and older to the population ages 15–64.

Table 5.

Total dependency ratio

Country	2005	2006	2007	2008	2009	2010	2011	2012
Hong Kong,	35.9	35.1	34.2	33.4	32.6	32	32.1	32.3
Singapore	39	38.2	37.5	36.8	36.3	35.9	35.6	35.4
Chile	49.2	48.4	47.6	46.8	46.2	45.7	45.4	45.2
Belarus	43	42.3	41.5	40.8	40.3	40	40.2	40.5
Saudi Arabia	57.6	55.1	53.3	52	50.9	49.9	49.5	49
Venezuela	56.9	56.2	55.5	54.9	54.4	54	53.6	53.3
Iran	45.2	43.3	41.8	40.7	39.8	39.2	38.9	38.7
Ecuador	60.9	60.2	59.5	58.9	58.3	57.7	57	56.3
Ghana	76.1	75.7	75.2	74.6	74.1	73.6	73.3	73
Tanzania	90.6	90.9	91.1	91.3	91.5	91.8	92.2	92.6

Source: Total dependency ratio: UNDESA (2011). 2010 Revision of World Population Prospects.

Countries that with high dependency ratio have more people who are not of working age, and fewer who are working and paying taxes. The higher the number, the more people that need to be looked after.

Total reserves minus gold shown in the Table 6 is a sum of special drawing rights, reserves of International Monetary Fund (IMF) members held by the IMF and holdings of foreign exchange under the control of monetary authorities, excluding gold holdings, expressed as a percentage of GDP.

In order to explore the level of impact of these factors on HDI GMDH should be used. It was shown how GMDH can be used for revealing of dependencies in social and economic data and their analysis. Models were developed by Combinatorial GMDH algorithm [5,6].

GMDH is a family of inductive algorithms for computer-based mathematical modeling of multi-parametric datasets that features fully automatic structural and parametric optimization of models.

Table 6.

Total reserves minus gold

Country	2005	2006	2007	2008	2009	2010	2011
Hong Kong,	69.9	70.1	73.7	84.7	122.2	119.7	117.1
Singapore	93.9	97.8	96.6	104.3	106.6	105.8	99.1
Chile	13.8	12.5	9.7	12.8	14.6	12.9	16.9
Belarus	3.8	2.9	8.7	4.4	9.8	6.2	10.9
Saudi Arabia	49.1	63.4	79.4	92.9	108.8	98.7	93.7
Venezuela	16.4	16	10.5	10.5	6.6	3.3	3.1
Iran	3.2	5.2	7.6	8.4	12.2	20.1	16.3
Ecuador	4.6	3.6	6.2	6.9	5.5	2.5	2.5
Ghana	16.4	10.3	8.1	6.2	13	14.8	14
Tanzania	14.5	15.8	17.2	13.8	16.2	17	15.7

Source: Total reserves minus gold: World Bank (2012a). "World Development Indicators 2012." Washington, D.C.: World Bank. http://data.worldbank.org. Accessed April, 2012.

GMDH algorithms are characterized by inductive procedure that performs sorting-out of gradually complicated polynomial models and selecting the best solution by means of the so-called external criterion.

A GMDH model with multiple inputs and one output is a subset of components of the base function (1):

$$Y(x_1,...,x_n) = a_0 + \sum_{i=1}^{m} a_i f_i \qquad (1)$$

where *f* are elementary functions dependent on different sets of inputs, *a* are coefficients and *m* is the number of the base function components.

In order to find the best solution GMDH algorithm consider various component subsets of the base function (1) called partial models. Coefficients of these models are estimated by the least squares method. GMDH algorithm gradually increase the number of partial model components and find a model structure with optimal complexity indicated by

the minimum value of an external criterion. This process is called self-organization of models.

The most popular base function used in GMDH is the gradually complicated Kolmogorov-Gabor polynomial (2):

$$Y(x_1,...,x_n) = a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} x_i x_j + \sum_{i=1}^{n}\sum_{j=i}^{n}\sum_{k=j}^{n} a_{ijk} x_i x_j x_k + ... \quad (2)$$

The most influential factors for HDI were chosen for research of their impact on GNI growth for all 10 countries. Values of pair correlation between HDI and all other parameters were calculated for that purpose. Those parameters for which the value of pair correlation was more than 0.9 were selected. Since GNI shows the level of prosperity, it was chosen as an output variable:

y - gross national income per capita.

Four most influential factors were selected:

x_1 - employment to population ratio;

x_2 - foreign direct investment, net inflows (% of GDP), (%);

x_3 - total dependency ratio;

x_4 - total reserves minus gold.

Two options of models – regression model by least square method and model by combinatorial algorithm GMDH – were developed. Models for Belarus, Iran, and Tanzania are presented below.

This model is obtained with least square method:

$$y = 19{,}292 + 1{,}181x_1 + 0{,}174x_2 - 1{,}777x_3 - 0{,}066x_4 .$$

This model is obtained with combinatorial algorithm GMDH by regularity criterion with after-determination by bias error criterion [5]:

$$y = 7{,}926 + 1{,}643x_1 - 2{,}109x_3 .$$

Parameters of model: $AR = 0{,}014;\ BS = 0{,}310.$

Results of modeling by least square method (LSM) and combinatorial algorithm GMDH (Combi) for Belarus are presented in the Table 7.

Table 7.

Influence of those four factors on GNI for Belarus

Belarus	x_1	x_2	x_3	x_4	y	$y_{\text{mod}}(LSM)$	$y_{\text{mod}}(Combi)$
2005	55,6	1	43	3,8	8,54	8,4891	8,5348
2006	55,2	1	42,3	2,9	9,407	9,3202	9,3545
2007	54,8	4	41,5	8,7	10,187	10,4077	10,3852
2008	54,4	3,6	40,8	4,4	11,311	11,3948	11,2050
2009	53,8	3,8	40,3	9,8	11,329	11,25083	11,27435
2010	54,2	2,5	40	6,2	12,245	12,2687	12,5643
2011	54,4	7,2	40,2	10,9	12,77	12,6576	12,4708

x_1 and x_3 turned out to be the most influential factors for Belarusian GNI. Furthermore, increase of employment to population ratio to the level of 2005 will increase GNI by approximately 11 %. And increase of total dependency ratio to the level of 2005 will have the same effect.

Similarly models for Iran are obtained. This model is obtained with least square method:

$$y = 16{,}428 + 0{,}048x_1 - 0{,}205x_2 - 0{,}212x_3 + 0{,}039x_4 .$$

This model is obtained with combinatorial algorithm GMDH by regularity criterion:

$$y = 19{,}434 + 0{,}111x_1 - 0{,}35x_3 - 0{,}0026x_4 .$$

Parameters of model: $AR = 0{,}0166;\ \ BS = 0{,}428.$

Results of modeling by least square method (LSM) and combinatorial algorithm GMDH (Combi) for Iran are presented in the Table 8.

Table 8.

Influence of those four factors on GNI for Iran

Iran	x_1	x_2	x_3	x_4	y	$y_{\text{mod}}(LSM)$	$y_{\text{mod}}(Combi)$
2005	49	1,6	45,2	3,2	9,06	9,0159	9,02899
2006	48,3	0,7	43,3	5,2	9,503	9,6480	9,61183
2007	47,9	0,6	41,8	7,6	10,177	10,0618	10,0868
2008	45,7	0,5	40,7	8,4	10,316	10,2412	10,2259
2009	46	0,9	39,8	12,2	10,39	10,5147	10,5648
2010	46,2	1,6	39,2	20,1	10,834	10,821	10,777
2011	46,1	0,7	38,9	16,3	10,936	10,9134	10,8807

For Iran increase of employment to population ratio to the level of 2005 will lead to increase of the GNI by 1% and increase of total reserves to the level of 2010 will have the same influence.

This model is obtained with least square method for Tanzania:

$$y = -35{,}736 + 0{,}2x_1 + 0{,}008x_2 + 0{,}212x_3 - 0{,}0004x_4.$$

This model is obtained with combinatorial algorithm GMDH by regularity criterion:

$$y = -15{,}3 + 0{,}18x_3 + 0{,}0008x_4.$$

Parameters of model: $AR = 0{,}005;\ BS = 0{,}464.$

As fertility levels decline, the dependency ratio falls initially because the proportion of children decreases while the proportion of the population of working age increases. The

period when the dependency ratio declines is known as the "window of opportunity" when a "demographic dividend" may be reaped because society has a growing number of potential producers relative to the number of consumers. However, as fertility levels continue to decline, dependency ratios eventually increase because of the proportion of working age starts declining and the proportion of older persons continues to increase. As populations grow older, increases in old-age dependency ratios are indicators of the added pressures that social security and public health systems have to withstand. Tanzania and Ghana may face this challenge in future.

Results of modeling by least square method (LSM) and combinatorial algorithm GMDH (Combi) for Tanzania are presented in the Table 9.

Table 9.

Influence of those four factors on GNI for Tanzania

Tanzania	x_1	x_2	x_3	x_4	y	$y_{\text{mod}}(LSM)$	$y_{\text{mod}}(Combi)$
2005	84,3	6,6	90,6	14,5	1,05	1,0484	1,0554
2006	84,5	2,8	90,9	15,8	1,095	1,1176	1,1106
2007	84,4	3,5	91,1	17,2	1,149	1,1411	1,1478
2008	84,4	1,9	91,3	13,8	1,197	1,1868	1,1811
2009	84,4	1,9	91,5	16,2	1,23	1,2203	1,2192
2010	84,4	1,9	91,8	17	1,288	1,2827	1,274
2011	84,2	1,9	92,2	15,7	1,324	1,3361	1,345

Summary. Ten countries with different levels of human development from different regions were chosen in order to explore the reasons for their remarkable progress in the rating of HDI during 2005-2012. HDI growth means growth of the per capita income along with improvement in the field of education and health care. Since the gross national per capita

income characterizes decent standard of living, it was chosen as the main component of HDI for research.

For that purpose macroeconomic data influencing the gross national per capita income were analyzed. Values of pair correlation between HDI and all other parameters were calculated for that. Impact of such indicators as employment to population ratio, total dependency ratio, amount of foreign direct investment, and amount of total reserves minus gold on the gross national per capita income was explored by the example of Belarus, Iran, and Tanzania. Two types of economical and mathematical models were developed for that. Regression model was built by least square method, and the other model was built by combinatorial algorithm GMDH by regularity criterion with after-determination by bias error criterion.

Both models display that employment to population ratio and total dependency ratio are turned to be the most influential indicators for growth of the gross national income in Belarus. Thus, increase of employment to population ratio to the level of 2005 will increase the GNI by approximately 11 %. And increase of total dependency ratio to the level of 2005 will have the same effect. For Iran increase of employment to population ratio to the level of 2005 will lead to increase of the GNI by 1% and increase of total reserves to the level of 2010 will increase the GNI by 1% as well. Total dependency ratio has the most significant impact on the GNI of Tanzania.

References

1. Тутова О.В. Концептуальні основи формування людського капіталу. - Економіко-математичне моделювання соціально-економічних систем. Збірник наукових праць. Вип. 17 // Відп. ред. – докт. тех. наук, професор Л.А. Пономаренко. – Київ: Міжнародний науково-навчальний центр інформаційних технологій та систем НАН України і МОН України, 2012. – 379 с. – С. 119-129.

2. Human Development Report 2013 / [Електронний ресурс] - Режим доступу: http://hdr.undp.org/en/reports/global/hdr2013
3. Human Development Report 2010 / [Електронний ресурс] - Режим доступу:http://hdr.undp.org/en/reports/global/hdr2010/
4. Ивахненко А.Г. Индуктивные методы самоорганизации сложных систем. – Київ: Наук. думка, 1982. – 296 с.
5. Savchenko Ie., Tutova O. Analysis of Human Development Level by Inductive Algorithms. - Proceedings of International Workshop of Inductive Modeling. Kyiv, 8-14 May. – 2012. – P. 28 – 33.
6. Savchenko E., Tutova O. Use of GMDH for investigation of impact of non-income components on HDI. – Індуктивне моделювання складних систем, випуск 4, 2012. – с.28-37.

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АДАПТИВНА МОДЕЛЬ ВИЗНАЧЕННЯ ЕФЕКТИВНОСТІ ПРОГНОЗУВАННЯ ФІНАНСОВИХ РЕСУРСІВ НА РОЗВИТОК ЗБРОЙНИХ СИЛ УКРАЇНИ

Анотація *У статті розглядаються актуальні питання оцінки ефективності використання бюджетних коштів на закупівлю новітнього озброєння та військової техніки. Також запропоновані шляхи визначення та перерозподілу кошторисних призначень Збройних Сил України з використанням адаптивних моделей та програми Excel.*

Ключові слова *фінансові ресурси Збройних Сил України, адаптивна модель, ефективність використання фінансових ресурсів.*

Аннотация *В статье рассматриваются актуальные вопросы оценки эффективности использования бюджетных средств на закупку новейшего вооружения и военной техники. Также предложены пути*