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O. Tutova

Problem discription of determination of factors affecting HDI

A sample of 10 countries representing all four levels of human development was chosen based on their progress in HDI rating during 2005-2012. The main factors of human development in these countries were analyzed. Combinatorial GMDA was chosen as a method for further research of trends of human development in these countries.

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

Вибірка з 10 країн, що представляють всі чотири рівні людського розвитку, сформована на основі прогресу цих країн у рейтингу ІЛР у 2005-2012 роках. Проведено аналіз основних показників людського розвитку в цих країнах. Комбінаторний метод МГУА вибрано для подальшого вивчення тенденцій людського розвитку в цих країнах.

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. Проведен анализ основных показателей человеческого развития в этих странах. Комбинаторный метод МГУА выбран для последующего изучения тенденций человеческого развития в этих странах.

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

Introduction. Human development can be defined as enabling people to develop their full potential and lead productive, creative lives in accordance with their needs and interests. However, it took a long time before mankind accepted the rather simple truth that the goal of development is to enhance everyone's abilities and freedoms [1].

Over time there has been a better understanding of the social consequences of economic development, of the increasing inequality between rich and poor countries that accompanied globalization 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 [2].

Analysis of recent research. 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 [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 main factors describing their development will be analyzed. In order to determine what factors were the most influential for the achievements of these countries in the field of human development GMDH is chosen to be used.

Methods of economical and mathematical analysis should be used for calculating dependencies of HDI on different factors describing the level of development in chosen countries.

The bulk material. 10 countries with different levels of human development from different regions were chosen in order to explore the reasons for their 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.

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	..	..	..	0.877	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).

Table 2. Carbone dioxide emissions per capita

Country	2005	2006	2007	2008
Hong Kong,	6	5.6	5.8	5.5
Singapore	11.8	10.9	7.8	6.7
Chile	3.9	4	4.2	4.4
Belarus	6	6.4	6.2	6.5
Saudi Arabia	15.3	15.5	15.6	16.6
Venezuela	6	5.7	6	6.1
Iran	6.6	7	7.1	7.4
Ecuador	2.2	2.2	2.2	1.9
Ghana	0.3	0.4	0.4	0.4
Tanzania	0.1	0.1	0.1	0.2

Source: Carbon dioxide emissions per capita: World Bank (2012a). "World Development Indicators 2012." Washington, D.C.: World Bank. <http://data.worldbank.org>. Accessed April, 2012.

Human-originated carbon dioxide emissions presented in the Table 2 stem from the burning of fossil fuels, gas flaring and the production of cement, including carbon dioxide emitted by forest biomass through depletion of forest areas. Carbon dioxide emissions per capita is carbon dioxide emissions divided by mid-year population.

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.

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. 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.

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.

Table 4. Expenditure on health, public (% of GDP), (%)

Country	2005	2006	2007	2008	2009	2010
Hong Kong,	-	-	-	-	-	-
Singapore	1	1	0.9	1.2	1.5	1.4
Chile	2.8	2.8	3	3.3	4	3.8
Belarus	5.2	4.5	4.5	3.9	3.9	4.4
Saudi Arabia	2.6	2.8	2.7	2.1	2.7	2.7
Venezuela	2.3	2.4	2.7	2.4	2.4	1.7
Iran	2.5	2.6	2.4	2.7	2.3	2.2
Ecuador	2.1	1.6	1.7	1.9	3.1	3
Ghana	3.1	2.5	3.7	3.2	2.8	3.1
Tanzania	1.9	3.8	3.7	3.4	3.7	4

Source: Public expenditure on health (% of GDP): World Bank (2012a). "World Development Indicators 2012." Washington, D.C.: World Bank. <http://data.worldbank.org>. Accessed April, 2012.

Public expenditure on health presented in the Table 4 is current and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds, expressed as a percentage of GDP.

Table 5. 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.

Foreign direct investment presented in the Table 5 is a sum of equity capital, reinvestment of earnings, other long-term capital and short-term capital, expressed as a percentage of GDP.

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.

Table 6. Adolescent fertility rate (women aged 15-19 years)
(births per 1000 women aged 15-19 years)

Country	2005	2006	2007	2008	2009	2010
Hong Kong,	4	..	..	5.7	..	3.2
Singapore	7	..	..	4.5	..	4.8
Chile	61.6	..	..	59.6	..	58.3
Belarus	23.9	..	..	21.3	..	22.1
Saudi Arabia	20.6	..	..	26.1	..	11.6
Venezuela	92.1	..	..	89.9	..	89.9
Iran	33.5	..	..	18.3	..	29.5
Ecuador	84.5	..	..	82.8	..	82.8
Ghana	79.9	..	..	64	..	71.1
Tanzania	132	..	..	130.4	..	130.4

Source: Adolescent fertility rate (women aged 15-19 years): UNDESA (2012b). Population Division Database. Detailed Indicators. Accessed May 2012.

Adolescent fertility rate shown in the Table 6 is a number of births to women ages 15–19 per 1,000 women ages 15–19.

Table 7. Fixed Broadband Internet subscription

Country	2005	2006	2007	2008	2009	2010
Hong Kong,	24.4	26.3	27.6	27.9	28.9	29.9
Singapore	15.4	17.9	19.5	21.5	23.7	24.9
Chile	4.3	6.2	7.7	8.5	9.8	10.5
Belarus	-	0.1	1.7	4.9	11.3	17.4
Saudi Arabia	0.3	0.9	2.4	4	5	5.5
Venezuela	1.3	2	3.1	4.7	4.7	5.4
Iran	-	0.1	0.3	0.4	0.5	0.7
Ecuador	0.2	0.3	0.7	1.1	1.7	1.4

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Ghana	0	0.1	0.1	0.1	0.1	0.2
Tanzania	0	0	0	0	0	0

Source: Fixed broadband internet subscription: International Telecommunication Union (2012). <http://www.itu.int/ITU-D/ict/statistics/> Accessed March 23, 2012.

Fixed broadband Internet subscription is broadband high-speed access to the public Internet (a TCP/IP connection), at speeds equal to or greater than 256 kilobits per second, in one or both directions, expressed per 100 people and presented in the Table 7.

Table 8. Internet users

Country	2005	2006	2007	2008	2009	2010
Hong Kong,	56.9	60.6	64.3	66.2	69.2	71.8
Singapore	61	59.1	67.9	68	68.4	71.1
Chile	31.2	34.5	35.9	37.3	38.8	45
Belarus	-	16.3	19.8	23.2	27.8	32.1
Saudi Arabia	12.7	19.5	30	36	38	41
Venezuela	12.6	15.3	20.9	26	31.3	35.9
Iran	8.1	8.8	9.5	10.2	11.1	13
Ecuador	6	7.2	10.8	18.8	24.6	29
Ghana	1.8	2.7	3.9	4.3	5.4	9.5
Tanzania	4.3	5.8	7.2	9	10	11

Source: Internet users: International Telecommunication Union (2012). <http://www.itu.int/ITU-D/ict/statistics/> Accessed March 23, 2012.

Internet users are people with access to the worldwide network, expressed per 100 people and shown in the Table 8.

Table 9. 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

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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).

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 9.

Table 10. 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.

Total dependency ratio shown in the Table 10 is ratio of the sum of the population ages 0–14 and ages 65 and older to the population ages 15–64.

Table 11. Total fertility rate

Country	2005	2006	2007	2008	2009	2010	2011
Hong Kong,	0.9	0.9	1	1	1	1.1	1.1
Singapore	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Chile	1.9	1.9	1.9	1.9	1.9	1.9	1.8

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Belarus	1.3	1.3	1.4	1.4	1.4	1.4	1.5
Saudi Arabia	3.2	3.1	3	3	2.9	2.8	2.7
Venezuela	2.6	2.6	2.6	2.5	2.5	2.5	2.4
Iran	1.8	1.8	1.8	1.7	1.7	1.7	1.6
Ecuador	2.7	2.6	2.6	2.6	2.5	2.5	2.4
Ghana	4.4	4.4	4.4	4.3	4.2	4.2	4.1
Tanzania	5.6	5.6	5.6	5.6	5.6	5.5	5.5

Source: Total fertility rate: UNDESA (2011). 2010 Revision of World Population Prospects.

Total fertility rate (TFR) presented in the Table 11 is a number of children that would be born to each woman if she were to live to the end of her child-bearing years and bear children at each age in accordance with prevailing age-specific fertility rates.

The TFR is a synthetic rate, not based on the fertility of any real group of women since this would involve waiting until they had completed childbearing. Nor is it based on counting up the total number of children actually born over their lifetime. Instead, the TFR is based on the age-specific fertility rates of women in their "child-bearing years," which in conventional international statistical usage is ages 15–44 or 15–49.

The TFR is, therefore, a measure of the fertility of an *imaginary* woman who passes through her reproductive life subject to *all* the age-specific fertility rates for ages 15–49 that were recorded for a given population in a given year. The TFR represents the average number of children a woman *would* have were she to fast-forward through all her childbearing years in a single year, under all the age-specific fertility rates for that year. In other words, this rate is the number of children a woman would have if she was subject to prevailing fertility rates at all ages from a single given year, and survives throughout all her childbearing years.

Table 12. Total reserves minus gold

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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.

Total reserves minus gold shown in the Table 12 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.

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):

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

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):

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

Summary. 10 countries from different geographical regions were chosen based on their progress in HDI rating during 2005-2012. These countries represent all four human development levels. 11 factors describing different aspects of human development for the period of 2005-2012 were analyzed. In order to reveal dependency of HDI on these factors for chosen countries Combinatorial GMDH should be used. Also this method will be chosen for HDI forecasting based on main factors dynamics.

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О.М. Чистик

Адаптивна модель прогнозування фінансового забезпечення структурних елементів збройних сил України

Представлено методичний підхід використання адаптивних моделей для прогнозування фінансового забезпечення структурних елементів Збройних Сил України. Наведено приклад застосування комбінованого прогнозу для аналізу затверджених прогнозних показників видатків із загального фонду державного бюджету на потреби Збройних Сил України із використанням моделі Брауна.

***Ключові слова** адаптивні моделі прогнозування, модель Брауна, асигнування на потреби Збройних Сил України, державне прогнозування видатків.*

Представлен методический подход использования адаптивных моделей для прогнозирования финансового