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THE IMPACT OF TECHNOLOGICAL DEVELOPMENT FACTORS ON THE QUALITY OF LIFE: A COMPARATIVE ANALYSIS OF E7 AND G7

Abstract: *Modern society has to deal with the influence that technological progress has on all aspects of life. The article presents an analysis of the impact that technological development has on the quality of life. The quality of life is assessed by numerous indicators that allow to conduct a comparative analysis of the quality of life in different countries of the world. In the article, the main indicators that assess the quality of life and four indicators of technological development that affect the quality of life are selected. To analyze the impact of technological development on the quality of life, a system of interdependent econometric equations is constructed. Based on the obtained model, the forecast values of quality of life indicators are calculated and their comparison is made for the groups of G7 and E7 countries.*

Keywords: *Quality of life; Technological development; G7; E7; Econometric modeling.*

1. Introduction

In the process of development humanity has moved into a new era of industrialization—Industry 4.0. Society has received the opportunity to use pocket personal computers or smartphones, unmanned vehicles, cloud data storage, home and industrial 3d printers that allow to create products without restrictions in geometry from a wide range of materials (Borisov et al., 2019, Kozlovaet al., 2020) and so on. There is a large-scale automation of work processes, which has affected the increase in productivity and robotization of production, led to the exclusion of the human factor, and the removal of a person from dangerous zones. McKinsey researchers predict that the functions of about 400 million people on the planet or 14% of the workforce will be performed by programs and robots in 2030 (Lost, 2017). Modern technologies have significantly improved the infrastructure, increased the level of medicine and, as a result, increased human life expectancy, technologies have made education more widespread and comfortable, and provided the population with access to basic necessities, as well as changed the way of human communication (Dyatlov et al., 2019; Nevado-Peña et al., 2019; Węziak-Białowolska, 2016; Turkoglu, 2015).

Under the influence of cultural peculiarities, norms of behavior inherent in society, state regulation and the current economic situation, access to modern technologies in various countries of the world is not the same (Estes, 2010; Hagerty et al., 2006; Sachs, 2008; Nations, 2020; Bjørnskov et al., 2010; Unit, 2010; Miščević, 2021). Access to technologies can be different even within the regions of one country under the influence of individual income, gender and age structure, education, and other factors (Richardson et

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al., 2000).

The heterogeneity of access to technological means varies in countries with different levels of development. Some studies conclude that in the current century, the developing countries of the E7 may become more developed in terms of basic socio-economic indicators than the G7 countries. It is predicted that the GDP of E7 will grow by 3.5% per year, while the GDP of G7 will grow by only 1.6% by 2050 (Global, 2017). As a result, it is of interest to compare the quality of population life in the conditions of global technological development in the E7 and G7 countries.

The article examines the impact of technological development on the quality of life. Thus, the purpose of this article is to analyze the impact of technological development factors on the quality of life in the E7 and G7 countries, make a forecast till 2025 and compare them on the basis of the main indicators of quality of life.

To offer a clear answer to the objective, the paper establishes the following structure. A content analysis of the existing literature, which allows to assess the state of the problem raised in the study, is carried out in the second section. Section three describes the conditions under which the econometric model is formed in the study, as well as the exogenous and endogenous variables of the model, and the method by which the model was formed. Section four describes the results obtained at each stage of the methodology. The last section presents the main conclusions of the study.

The paper uses analytical research methods: review of the problem under study, content analysis, analysis and synthesis, deduction and induction; empirical research methods: methods of mathematical and econometric modeling.

Studying the problem of the state of quality of life, it is necessary to highlight the contribution of international organizations. Thus, the OECD developed a Better Life Index to assess the quality of life, in which 11 areas of human life activity that determine the well-being of society were identified. The OECD concluded that the quality of life depends on housing conditions and expenses, household income and financial wealth, earnings, job security and unemployment, quality of social support network, education, health and environment, involvement in democracy, life satisfaction, murder and assault rates, and work-life balance (OECD, 2019). The UNDP researchers consider that the main components of the quality of life are long and healthy life, education conditions and dissent standard of living determined by GNI per capital. The geometric mean of normalized these three indicators is called the Human Development Index (UNDP, 2018). It is also worth mentioning The Legatum Prosperity Index developed by The Legatum Institute Foundation, which defines the quality of life as a set of the following indicators: safety and security, personal freedom, governance, social capital, investment, environment, enterprise conditions, market access and infrastructure, economic quality, living conditions, health, education, natural environment (Legatum Institute, 2014). However, these are not all systems for assessing the quality of life (Gibson, 2018; Kaklauskas et al., 2018; Lazauskaitė, et al., 2015; Chen, 2016). Such a variety of indicators combinations is associated with the existence of many points of view on the definition of quality of life.

From the above, it follows that modern research gives preference to economic, political, and social conditions in society, considering the quality of life.

However, considering the development of technologies, it is impossible to deny their impact on the state of a modern person life. Therefore, there are several studies aimed at studying such an influence. Studies show that the use of technologies has a positive effect on life satisfaction as well as on assessment of the effectiveness of public administration in society. In addition, investing in R&D entails an improvement of cultural and sports activities perception by population (Nevado-Peña et al., 2019). In some studies, it is said that social development is impossible without technological innovations that allow effective distribution of information in society (Castells, 1999). Access to technology reduces the level of poverty, increases the level of education and health care, and leads to an improvement in the economic condition of the population. Moreover, access to advanced technologies is the reason for the growing need for citizens to participate in the political and cultural life of the country (Kenny, 2002; Madon, 2000; DiMaggio et al., 2001).

However, there are studies confirming the negative impact of technology development on the quality of life. Despite the economic contribution to the development of society, distribution of technologies in some countries leads to an increase in the well-being of the rich, thereby provoking an increase in inequality (Nulens, 2017; Forestier et al.,2002).

A review of studies shows that there is no single point of view for assessing the quality of life and the factors affecting it. There are many indices, methods and approaches that allow to study the state of the quality of life in various countries of the world, therefore, in this article, considering the trends of technological progress, it is proposed to study the influence of technical development factors on the quality of life using econometric modeling.

2. Methodology

2.1. The conditions taken as the basis for the analysis of technological development impact on the quality of life

To assess the impact of technological development on the quality of life of the population in the G7 and E7 countries, an econometric model was used in the study. The econometric model is formed under the following conditions:

- The quality of life is assessed by a set of indicators (endogenous variables, designated as Y_t^k,where k is the number of estimated indicators of quality of life).
- There is a prehistory of the process, i.e. each endogenous variable is influenced by the values of previous periods Y_{t-1}^k.
- There is a mutual influence of endogenous variables on each other.
- Each endogenous variable is influenced by exogenous variables- internal and external factors (factors of technological development, designated as X_t^l,where l is the number of technological development factors).

2.2. Selection of variables for the model and data collection

The choice of variables was made based on meaningful evidence, provided that the selected endogenous variables evaluate the state of the object, and the selected exogenous variables affect the dynamics of endogenous variables.

Indicators that assess the quality of population life, selected, and justified for the study:

- The Human Development Index (HDI) was selected as it reflects the following estimates that determine human well-being: life expectancy, access to education and a decent standard of living, measured by the value of gross national income (GNI) per capita in US dollars at purchasing power parity (PPP).
- The Gini Index was selected to determine the depth of social inequality. The Gini Index measures the degree of income distribution between individuals or households within the economy, indicates changes in the levels of social tension, income and wage policies.

A Gini Index of 0 represents perfect equality, while an index of 100 implies perfect inequality. The quality of life of the population is growing in conditions of decreasing differentiation in society.

- The International Poverty Line (IPL) was selected as it allows to assess the level of poverty. IPL is the percentage of the population living below the national poverty line. National estimates are based on population-weighted subgroup estimates obtained from household analysis. The lower the percentage of the population living below the poverty line, the higher the level of quality of life.
- The Consumer Price Index (CPI) was selected as it allows to determine the cost of the consumer basket. CPI is an indicator that examines the weighted average prices of a basket of consumer goods and services, such as transport, food and medical care. CPI changes are used to assess changes in prices related to the cost of living, i.e. to determine periods of inflation or deflation that affect the state of the economy as a whole, as well as the ability to consume and meet the needs of the population.

The level of scientific and technological development forms competition, affects the level of productivity and economic development of countries. Therefore, the following factors affecting the economy and the quality of life of the population are highlighted:

- The number of patent applications that provide a new way of doing something or offer a new technical solution to a problem. The growth of their number directly indicates the development of the scientific sector within the country. Such new technical solutions can affect the convenience and comfort of a person.
- The number of technical cooperation grants, including independent grants for technical cooperation and investment-related grants for technical cooperation.
- Number of technicians in R&D. The growing demand for human resources in high-paying areas such as R&D increases the well-being of the population due to higher wages and better working conditions, in addition, raises the need for a high level of education.
- The volume of high-technology exports, which allows the country to occupy a competitive position in the world. The export of high-tech solutions leads to additional attraction of FDI and, as a result, brings to the release of money that can be directed to R&D initiated in the country.

Exogenous and endogenous variables are denoted as follows:

Y_t^1 – HumanDevelopmentIndex in the year t.

Y_t^2 – Giniindex in the year t.

Y_t^3 – InternationalPovertyLine in the year t.

Y_t^4 – ConsumerPriceIndex in the year t.

X_t^1 – Patent applications, residents in the year t.

X_t^2– Technical cooperation grants, current US$ in the year t.

X_t^3– Technicians in R&D, per million people in the year t.

X_t^4– High-technology exports, current US$ in the year t.

X_{t-i}^1 – Patent applications, residents in the year t-i.

X_{t-i}^2 – Technical cooperation grants, current US$ in the year t-i.

X^3_{t-i}– Technicians in R&D, per million people in the year t-i.

X^4_{t-i} – High-technology exports, current US$ in the year t-i.

Y^1_{t-i} – HumanDevelopmentIndex in the year t-i.

Y^2_{t-i} – Giniindex in the year t-i.

Y^3_{t-i} – InternationalPovertyLine in the year t-i.

Y^4_{t-i} – ConsumerPriceIndex in the year t-i.

For the study purposes, international organizations data in the period from 2008 to 2018 were used: UNDP (Human Development Indices and Indicators Statistical Update 2018), CIA (The World Factbook - Gini Index coefficient – distribution of family income), World Bank (Data: Poverty headcount ratio at national poverty lines (% of population); Consumer price index (2010 = 100); Patent applications, residents, Technicians in R&D (per million people); High-technology exports (current US$); Technical cooperation grants (BoP, current US$)) (UNDP, 2018, The World Bank Open Data).

2.3. Methodology for calculating the parameters and analysis of the model

Calculating the parameters and analyzing the model, the stage-by-stage analysis of a simultaneous econometric equations system was used (Didenko et al., 2018):

- Bringing the model into a general form.
- Checking the time series of variables for stationarity using the Dickey-Fuller test.
- Selection of endogenous and exogenous variables of the model based on the analysis of correlation coefficients. For this purpose, the correlation coefficients of a pair of endogenous and exogenous variables were considered. The significance of the correlation coefficients was checked using the Student's t-test.
- Selection of lags of endogenous variables that have a strong correlation with the value of the variable in the last period and checking the significance of the autocorrelation coefficients using the Ljung-Box Q-test.
- Displaying a system of equations in a structural form based on the analysis of variables, converting the structural form of the model to the reduced form using linear transformations.
- Analysis of the identifiability of the system of equations.
- Determination of the coefficients of each equation of the model by the selected type of the least squares method.
- Forecast of endogenous variables.

3. Results

3.1. Generalization of primary data

The study was conducted and presented in the form of a comparative analysis of the impact of technological development on the quality of life in the E7 and G7 countries.

The initial values of endogenous indicators are shown in Table 1, 2.

The initial values of exogenous indicators are shown in Table 3, 4.

The tables calculate the results of the arithmetic mean for each of the endogenous and exogenous indicators from 2008 to 2018 for the studied group of countries.

Table 1. The average value of endogenous indicators for the group of G7 countries.

Year	Y_t^1	Y_t^2	Y_t^3	Y_t^4
	HDI	Gini	IPL	CPI
2008	0.895286	33.98571	15.52857	98.46305
2009	0.895143	33.71429	15.77143	98.69019
2010	0.897714	33.81429	16.27143	100
2011	0.899143	33.97143	16.42857	102.375
2012	0.900286	34	16.17143	104.3017
2013	0.902857	34.15714	16.3	105.597
2014	0.904714	34.17143	16.48571	107.0023
2015	0.905143	34.28571	16.61429	107.4575
2016	0.906143	34.48571	16.25714	108.1063
2017	0.906857	34.47143	16.74286	109.7478
2018	0.908	34.47143	16.9	111.7547

Table 2. The average value of endogenous indicators for the group of E7 countries.

Year	Y_t^1	Y_t^2	Y_t^3	Y_t^4
	HDI	Gini	IPL	CPI
2008	0.691143	42.44286	21.78571	88.82079
2009	0.695571	42.14286	21.37143	94.03491
2010	0.705286	42.08571	20.54286	100
2011	0.714143	42.62857	19.17143	106.3892
2012	0.721286	42.94286	17.92857	112.4456
2013	0.729714	42.51429	17.62857	119.6339
2014	0.736	42.31429	17.55714	126.8617
2015	0.741714	42.02857	17.64286	135.8889
2016	0.746286	41.61429	17.11429	143.2885
2017	0.750286	41.47143	16.68571	150.0158
2018	0.753	41.55714	16.27143	158.6284

Table 3. The average value of exogenous indicators for the group of G7 countries.

Year	X_t^1	X_t^2	X_t^3	X_t^4
	Patentapplications, residents	Tech. cooperation grants, BoP, current US$	Technicians in R&D, per million people	High-technology exports, current US$
2008	89397.14	4.1E+08	524.2913	1.05118E+11
2009	91770.43	4.96E+08	1400.308	1.0051E+11
2010	92151.29	3.53E+08	1361.286	1.03504E+11
2011	90961.71	3.89E+08	1407.146	1.03124E+11
2012	91672	4.04E+08	1367.594	1.0917E+11
2013	92778.71	3.7E+08	1325.209	1.07708E+11
2014	92210.43	3.56E+08	1310.264	1.08429E+11
2015	89408.86	3.29E+08	1371.226	1.08307E+11
2016	88967.14	2.83E+08	1264.09	1.015E+11
2017	87436	2.66E+08	1313.055	87194167563
2018	93681.14	2.82E+08	1331.698	1.13264E+11

Table 4. The average value of exogenous indicators for the group of E7 countries.

Year	X_t^1 Patentapplications, residents	X_t^2 Tech. cooperation grants, BoP, current US$	X_t^3 Technicians in R&D, per million people	X_t^4 High-technology exports, current US$
2008	207161.1	3.09E+08	181.8802	1.22548E+11
2009	185815.3	3.15E+08	274.1501	1.09965E+11
2010	179830.9	2.87E+08	233.4279	1.00163E+11
2011	146073.6	2.84E+08	230.1615	1.08115E+11
2012	121231.4	3.29E+08	447.605	1.08927E+11
2013	107942	3.25E+08	434.0412	1.08584E+11
2014	83574.57	3.73E+08	417.9822	98905906885
2015	65906.14	3.66E+08	414.3433	90217036890
2016	48501.14	3.78E+08	330.9005	79685006853
2017	38574.14	3.66E+08	379.133	70740546596
2018	33755.43	4.3E+08	355.7621	90593678480

3.2. The structural form of the model in the general form

In the structural form, the system of equations took the following form:

$$\begin{cases} Y_t^1 = a_0 + a_1 Y_{2018}^1 + \cdots + a_n Y_{2008}^1 + b_1 Y_{2018}^2 + \cdots + b_n Y_{2008}^2 + c_1 Y_{2018}^3 + \\ + \cdots + c_n Y_{2008}^3 + d_1 Y_{2018}^4 + \cdots + d_n Y_{2008}^4 + e_1 X_{2018}^1 + \cdots + e_n X_{2008}^1 + \\ + f_1 X_{2018}^2 + \cdots + f_n X_{2008}^2 + g_1 X_{2018}^3 + \cdots + g_n X_{2008}^3 + h_1 X_{2018}^4 + \cdots + h_n X_{2008}^4 \\ Y_t^2 = a_0 + a_1 Y_{2018}^1 + \cdots + a_n Y_{2008}^1 + b_1 Y_{2018}^2 + \cdots + b_n Y_{2008}^2 + c_1 Y_{2018}^3 + \\ + \cdots + c_n Y_{2008}^3 + d_1 Y_{2018}^4 + \cdots + d_n Y_{2008}^4 + e_1 X_{2018}^1 + \cdots + e_n X_{2008}^1 + \\ + f_1 X_{2018}^2 + \cdots + f_n X_{2008}^2 + g_1 X_{2018}^3 + \cdots + g_n X_{2008}^3 + h_1 X_{2018}^4 + \cdots + h_n X_{2008}^4 \\ Y_t^3 = a_0 + a_1 Y_{2018}^1 + \cdots + a_n Y_{2008}^1 + b_1 Y_{2018}^2 + \cdots + b_n Y_{2008}^2 + c_1 Y_{2018}^3 + \\ + \cdots + c_n Y_{2008}^3 + d_1 Y_{2018}^4 + \cdots + d_n Y_{2008}^4 + e_1 X_{2018}^1 + \cdots + e_n X_{2008}^1 + \\ + f_1 X_{2018}^2 + \cdots + f_n X_{2008}^2 + g_1 X_{2018}^3 + \cdots + g_n X_{2008}^3 + h_1 X_{2018}^4 + \cdots + h_n X_{2008}^4 \\ Y_t^4 = a_0 + a_1 Y_{2018}^1 + \cdots + a_n Y_{2008}^1 + b_1 Y_{2018}^2 + \cdots + b_n Y_{2008}^2 + c_1 Y_{2018}^3 + \\ + \cdots + c_n Y_{2008}^3 + d_1 Y_{2018}^4 + \cdots + d_n Y_{2008}^4 + e_1 X_{2018}^1 + \cdots + e_n X_{2008}^1 + \\ + f_1 X_{2018}^2 + \cdots + f_n X_{2008}^2 + g_1 X_{2018}^3 + \cdots + g_n X_{2008}^3 + h_1 X_{2018}^4 + \cdots + h_n X_{2008}^4 \end{cases}$$

The structural form of the model is represented as a set of econometric equations, each of which is an ADL model. This type of model allows to trace the dependence of an endogenous variable on exogenous variables considering time changes.

3.3. Checking the time series of variables for stationarity using the Dickey-Fuller test

The use of non-stationary time series in the regression model leads to fictitious results or to the construction of a spurious regression.
The results of checking the time series of variables for stationarity considering the reduced non-stationary series in a stationary

form using the Dickey-Fuller test are shown in Table 5. Checking for stationarity was carried out using Excel commands

Table 5. Results of checking of time series for the stationarity $Y_t^1 \dots Y_t^4$, $Y_{t-1}^1 \dots Y_{t-1}^4$, $X_t^1 \dots X_t^4$, $X_{t-1}^1 \dots X_{t-1}^4$

Time series	The value of the autoregression equation coefficient	Satisfaction of the stationarity hypothesis
Y_t^1	0.430323502	yes
Y_t^2	0.713373716	yes
Y_t^3	0.53135246	yes
Y_t^4	0.958296061	yes
Y_{t-1}^1	0.353450499	yes
Y_{t-1}^2	0.247939461	yes
Y_{t-1}^3	-0.107208108	yes
Y_{t-1}^4	0.925881473	yes
X_t^1	0.931158863	yes
X_t^2	0.963609331	yes
X_t^3	0.474093933	yes
X_t^4	0.656438465	yes
X_{t-1}^1	0.886004553	yes
X_{t-1}^2	0.97757813	yes
X_{t-1}^3	0.258425594	yes
X_{t-1}^4	0.553199774	yes

According to the results of the Dickey-Fuller test, the series Yt1, Yt3, Yt-11, Yt-13 are not stationary. Therefore, the series are reduced to a stationary form by calculating first-order differences.

3.4. Selection of endogenous and exogenous variables

The criterion for choosing endogenous and exogenous variables of the equation was the value of the paired correlation coefficient. Therefore, the correlation coefficient of a pair of endogenous and exogenous variables was considered. If the coefficient of pair correlation between exogenous variables exceeded 0.6 in absolute value, one variable from the pair was excluded from further analysis. The paired correlation coefficients for variables for the G7 group of countries is shown in Table 6.

The values where the dependence of the variable on y was greater than the dependence of the second variable were excluded from the equation.

Table 6. Paired correlation coefficients for variables of the G7.

	y_t^1	y_t^2	y_t^3	y_t^4	x_t^1	x_t^2	x_t^3	x_t^4
y_t^1	1	-0.650	-0.474	0.778	0.806	-0.504	-0.676	0.798
y_t^2	-0.650	1	0.029	-0.697	-0.714	0.598	0.829	-0.328
y_t^3	-0.474	0.029	1	-0.446	-0.472	0.344	-0.046	-0.691
y_t^4	0.778	-0.697	-0.446	1	0.996	-0.864	-0.664	0.843
x_t^1	0.806	-0.714	-0.472	0.996	1	-0.858	-0.681	0.837
x_t^2	-0.504	0.598	0.344	-0.864	-0.858	1	0.542	-0.639
x_t^3	-0.676	0.829	-0.046	-0.664	-0.681	0.542	1	-0.380
x_t^4	0.798	-0.328	-0.691	0.843	0.837	-0.639	-0.380	1

The system of equations took the following form:

$$\begin{cases} y_t^1 = f(y_{t-j}^1;\ X_t^1) \\ y_t^2 = f(y_{t-j}^1; X_t^1;\ X_t^3) \\ y_t^3 = f(y_{t-j}^1;\ X_t^3;\ X_t^4) \\ y_t^4 = f\left(y_{t-j}^1; X_t^1\right) \end{cases}$$

The correlation analysis for the E7 group of countries was carried out in a similar way, the results are shown in Table 7.

The values where the dependence of the variable on y was greater than the dependence of the second variable were excluded from the equation.

Table 7. Paired correlation coefficients for variables of E7.

	y_t^1	y_t^2	y_t^3	y_t^4	x_t^1	x_t^2	x_t^3	x_t^4
y_t^1	1	-0.612	-0.470	0.728	0.762	-0.496	-0.608	0.751
y_t^2	-0.612	1	0.003	-0.697	-0.714	0.598	0.829	-0.328
y_t^3	-0.470	0.003	1	-0.418	-0.444	0.331	-0.080	-0.665
y_t^4	0.728	-0.697	-0.418	1	0.996	-0.864	-0.664	0.843
x_t^1	0.762	-0.714	-0.444	0.996	1	-0.858	-0.681	0.837
x_t^2	-0.496	0.598	0.331	-0.864	-0.858	1	0.542	-0.639
x_t^3	-0.608	0.829	-0.080	-0.664	-0.681	0.542	1	-0.380
x_t^4	0.751	-0.328	-0.665	0.843	0.837	-0.639	-0.380	1

The system of equations took the following form:

$$\begin{cases} y_t^1 = f(y_{t-j}^1;\ X_t^1) \\ y_t^2 = f(y_{t-j}^1; X_t^1;\ X_t^3) \\ y_t^3 = f(y_{t-j}^1;\ X_t^3;\ X_t^4) \\ y_t^4 = f\left(y_{t-j}^1; X_t^1\right) \end{cases}$$

The result of checking the significance of the pair correlation coefficients using the Student's t-test revealed that the value of the $t_{calculated}$=0.000522 is less than the value of the $t_{tabular}$=2.20, therefore the significance level of the equation is less than 0.05.

3.5. Selection of endogenous variables lags, checking the significance of autocorrelation coefficients using the Ljung-Box Q-test

No significant autocorrelation was found in the endogenous y_t^1, y_t^2, y_t^3, y_t^4, therefore, the lags of the variables will not be included in the equations.

The study revealed the same form of dependence between the endogenous and exogenous variables of the G7 and E7 countries. Therefore, the model for predicting the quality of life in the G7 and E7 countries has a single form.

3.6. Writing a system of equations in a structural form, converting the structural form of the model to the reduced form

The structural form of the model after performing the stages of selecting exogenous variables, i.e. after removing some exogenous variables from the analysis, took the following form:

$$\begin{cases} y_t^1 = f(X_t^1) \\ y_t^2 = f(X_t^1;\ X_t^3) \\ y_t^3 = f(X_t^3;\ X_t^4) \\ y_t^4 = f(X_t^1) \end{cases}$$

The system of ADL-equations took the following form:

$$\begin{cases} Y_t^1 = a_{10} + e_{11}X_t^1 \\ Y_t^2 = a_{20} + e_{21}X_t^1 + g_{23}X_t^3 \\ Y_t^3 = a_{30} + g_{23}X_t^3 + h_{34}X_t^4 \\ Y_t^4 = a_{40} + e_{41}X_t^1 \end{cases}$$

Such a form of the model is final.

3.7. Identifiability of the system of equations

Moving from the reduced form of the model to the structural one, the problem of identification arises. Identification is the uniqueness of the correspondence between the structural and reduced forms of the model. It is revealed that all the equations are superidentifiable, since the number of exogenous variables contained in the system, but not included in the final equation, exceeds the number of endogenous variables in the system.

The extended matrix of the model equations system is shown in Table 8.

Table 8. Matrix of coefficients of model variables.

	Y_1	Y_2	Y_3	Y_4	X_1	X_3	X_4
The equation 1	-1	0	0	0	e_{11}	0	0
The equation2	0	-1	0	0	e_{21}	g_{23}	0
The equation 3	0	0	-1	0	0	g_{23}	h_{34}
The equation 4	0	0	0	-1	e_{41}	0	0

From the matrix follows that a sufficient identifiability condition for the equations is satisfied, since their determinant is not zero. As a result, a two-step OLS method was used to determine the coefficients.

3.8. Determining the coefficients of each equation of the model

The coefficients of the equations were determined using the SPSS program, they are shown in Table 9.

Table 9. Coefficients of the model describing the impact of technological development on the quality of life.

	Y_t^1	Y_t^2	Y_t^3	Y_t^4
Const.	-0.009	41.302	3.573	79.936
X_t^1	3.334E-8	-2.106E-6	-	0.001
X_t^3	-	0.003	-0.002	-
X_t^4	-	-	-2.480E-11	-

As a result of all the transformations, the system of the equations took the following form:

$$\begin{cases} Y_t^1 = -0.009 + 3.334E - 8 * X_t^1 \\ Y_t^2 = 41.302 - 2.106E - 6 * \mathrm{X}_t^1 + 0.003 * X_t^3 \\ Y_t^3 = 3.573 - 0.002 * \mathrm{X}_t^1 - 2.480E - 11 * X_t^4 \\ Y_t^4 = 79.936 - 0.001 * X_t^1 \end{cases}$$

The following dependencies in the system of equations are revealed:

- The number of patent applications affects the Human Development Index – the higher the number of patent applications, the higher the HDI, the Gini Index – the higher the number of patent applications, the lower the Gini Index; the Consumer Price Index – the higher the number of patent applications, the higher the CPI.

- The number of grants for technical cooperation has a negligible impact on endogenous variables in the system.
- The number of technical specialists involved in R&D affects the Gini Index – the greater the number of technical specialists involved in R & D, the higher the Gini Index, and the International Poverty Line – the greater the number of technical specialists involved in R&D, the lower the IPL.
- The change in high-tech exports showed a high impact on the International Poverty Line, the higher the export level, the higher the IPL.

3.9. Forecast

The forecast values of the indicators for the G7 group of countries are shown in Table 10. The forecast is depicted in Figure 1.

Table 10. The values of the forecast indicators of the quality of life for the group of G7.

Year	HDI	Gini	IPL	CPI
2019	0.9104772	34.568556	17.055495	113.22282
2020	0.9118575	34.643429	16.757272	114.5637
2021	0.9132378	34.718302	17.092948	115.90459
2022	0.9146181	34.793176	17.238519	117.24548
2023	0.9159984	34.868049	17.394037	118.58636
2024	0.9173787	34.942922	17.095814	119.92725
2025	0.918759	35.017795	17.43149	121.26813

Figure 1. The values of the forecast indicators of the quality of life for the group of G7

The analysis showed that by 2025, all the studied endogenous indicators for the G7 will increase.

The forecast values of the indicators for the E7 group of countries are shown in Table 11. The forecast is depicted in Figure 2.

Table 11. The values of the forecast indicators of the quality of life for the group of E7.

Year	HDI	Gini	IPL	CPI
2019	0.7646461	41.57043	15.855653	166.19163
2020	0.771211	41.584292	15.439889	174.08522
2021	0.7777759	41.598155	15.024125	181.97881
2022	0.7843408	41.612018	14.608361	189.8724
2023	0.7909058	41.625881	14.192596	197.76599
2024	0.7974707	41.639744	13.776832	205.65958
2025	0.8040356	41.653607	13.361068	213.55316

Figure 2. The values of the forecast indicators of the quality of life for the group of E7

The E7 analysis showed that further growth of HDI and CPI is predicted, nevertheless, the Gini Index and IPL tend to decrease.

Comparison of the values of the quality of life indicators G7 and E7 is depicted in Figure 3.

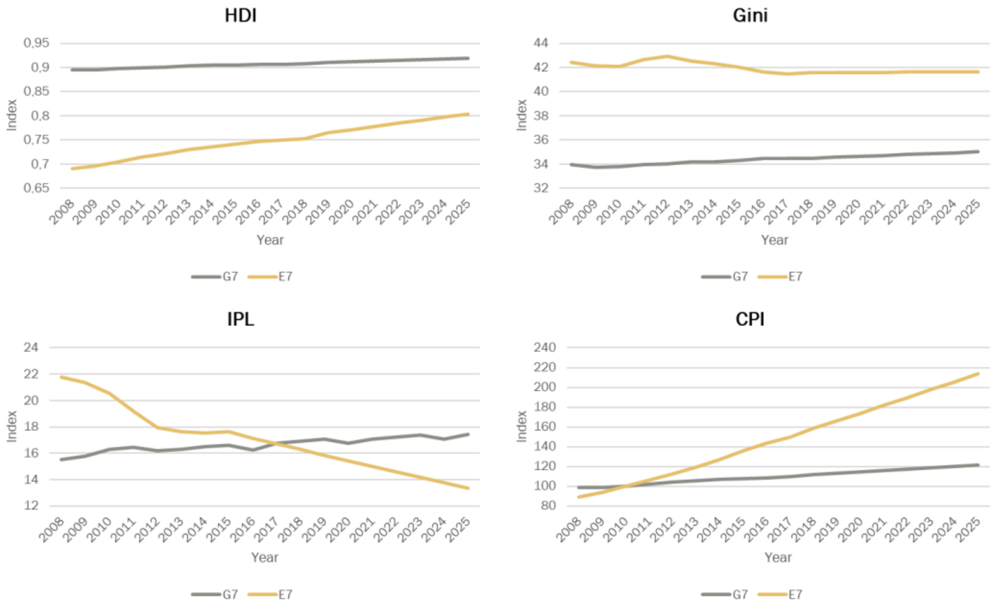

Figure 3. Comparison of G7 and E7 quality of life indicators

A comparison of G7 and E7 indicators led to the following conclusions:

- Further growth of HDI is predicted in both groups of countries, but the growth rate of HDI in E7 exceeds the rate of G7.
- The level of Gini Index in the E7 is higher, but tends to fall, while in G7 there is an increase.
- The index of IPL in E7 is falling. IPL for G7 has the opposite trend and already exceeds the value of E7.
- The value of the CPI in both groups of countries is growing, the growth rate of the index in the E7 countries exceeds its growth rate in the G7.

4. Discussion and Conclusion

The analysis allows to conclude that among the factors affecting the quality of life, one of the key positions is occupied by scientific and technical development. During the study, a model of the impact of technological development on the quality of life was developed. Given that our results show following:

- The change in the number of patent applications has a positive effect on the Human Development Index and Consumer Price Index, and a negative effect on the Gini Index. The connection of the indicator with HDI is explained by the fact that the introduction of innovations leads to an improvement in the comfort of the population, opens up new opportunities for development, education, communications and increases the well-being of the population due to leadership positions in the world.

  At the initial stage of their life cycle, technological innovations usually have a higher cost compared to substitutes. This leads to an increase in the cost of living, which explains the connection of patent applications with CPI.

  The number of patent applications has a negative impact on the Gini Index. The decrease in the Gini

Index is interpreted as a decrease in inequality in society, thus, in the conditions of an increase in the number of registered patents, a modern progressive society is growing, which leads to a decrease in differentiation.

- Grants for technical cooperation have a negligible impact on the quality of life.
- The change in the number of technicians in R & D has a positive effect on the Gini Index and a negative effect on the International Poverty Line. This impact is explained by the fact that technical specialists engaged in the development of innovations have a higher income level, which leads to an increase in the differentiation of the population and a decrease in the number of people living below the poverty line.
- An increase in the export of high technologies has a positive effect on the International Poverty Line. An increase in the export of expensive technical means entails attracting additional money supply and increasing the number of workplaces, which increases prosperity and reduces the number of people living below the poverty line.
- The study revealed that the selected factors have the same effect on the results for G7 and E7, therefore, the resulting model was used to describe the process of changing quality of life indicators in both countries.

During the study a forecast was made for the G7 and E7 groups of countries. Forecast results show that the overall level of well-being of the G7 will grow despite the increase in social inequality of the population. The number of people living below the poverty line is also forecasted to grow. The reasons can be the forecasted increase in the cost of living, as well as the growing flow of migrants due to the growing attractiveness of life in the G7 countries.

The E7 forecast showed that the overall level of well-being in these countries will grow in the conditions of a slightly decreasing indicator of social inequality of the population and with a decrease in the number of people living below the poverty line. However, the value of the cost of living will continue to grow because of a relatively high level of inflation in the developing E7 countries.

In the article compared the blocks of the G7 and E7 countries in the period from 2008 to 2025. As a result of the comparison, the following conclusions were made:

- Further growth of HDI is predicted in both groups of countries, but the growth rates of the population welfare of the seven developing countries are significantly higher than the growth of the G7.
- The population differentiation in the E7 is much higher than in the G7, however, in the E7 countries the gap between rich and poor is constantly decreasing and in the G7 countries the situation is the opposite.
- The number of people living below the poverty line in the E7 countries is decreasing, in the G7 countries it is growing and is already above the level of the E7 countries.
- The rate of inflation growth in developing countries remains high, which leads to a more rapid increase in the cost of life in the E7 compared to the G7.

Eventually, the forecast for the E7 countries turned out to be more optimistic than in the G7. The only exception is the continued growth in the value of the cost of living in E7.

Thus, the goal of the work was achieved: to identify the degree of influence of the selected factors of technological development on the level and quality of life in comparison with the E7 and G7 countries by constructing an

ADL model.

The results of the study, namely the model of the technological development impact on the quality of life and the resulting forecast of quality of life indicators, can be used within the framework of social development strategies by the governments of the G7 and E7 countries to improve the quality of life.

The analysis has certain limitations inherent to the available statistical data and related to a huge number of factors that can have an impact on the quality of life. Nevertheless, this opens possibilities to future research lines. In further studies, the range of both exogenous and endogenous variables can be expanded to prove the influence of new indicators of technological development that have not been considered in the work.

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