# The paradigm of emergent qualities of education management as a scientific and technological platform for sustainable development



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**Abstract.** In this paper the factors influencing sustainable development were identified. The influence of emergent qualities of education management on stable development is highlighted. The analysis of the rating of countries by the level of education, the human development index was carried out. A cognitive map-review of systematized factors of influence on the development of education in the modern socio-economic environment has been constructed. Economic-mathematical models that describe trends in indicators of the impact of emergent qualities of education management on sustainable development and testify to a fairly stable relationship between the factors influencing the stable development of education management have been constructed. It is proved that the emergent qualities of education management have a direct impact on the creation of a scientific and technological platform in Ukraine as an effective mechanism for partnership and interaction between education, science and business.

## 1. Introduction

The global disruption in education caused by the COVID-19 pandemic is unparalleled and its impact on learning is very serious. The crisis has halted the education system around the world: school closures have forced more than 1.6 billion pupils to study independently. Although almost every country in the world offered distance learning opportunities for pupils and students, the quality and coverage of such initiatives varied greatly and at best partially replaced full-time education. Now educational institutions remain closed to millions of children and young people, and millions of applicants for education at different levels will never return to education. Evidence of the detrimental impact of the closure of educational institutions demonstrates a terrible reality: learning losses are significant, which affects the most marginalized children and young people.

UNESCO called for a new public contract in the field of education as part of a historic report on the future of education. The practical experience that humanity has gained as a result of the global pandemic has shown that teachers, pupils, students and their parents were not prepared for such challenges. At this time, the issue of new education, education that transforms people who can transform society and build a better future, is becoming urgent.

UNESCO has called for the conclusion of a new social contract in the field of education as part of the historical report on future education [1].

Together, educators should strive to transform education systems so that pupils of all ages receive support, so that they can take care of each other and the planet, and create more peaceful, just and sustainable societies.

Ukraine is the largest European country by area with a population estimated by the state statistics service 41,588,354 people as of January 1, 2021. Today about 70% of Ukrainian residents have a higher education. However, the potential of higher education is not fully used by society and the economy. So, according to the overall rating "The Good Country Index", which indicates how much each of the 153 countries does good for the planet and the human race through their policies and behavior, in 2020 Ukraine ranked 76th, while the closest geographical neighbors and countries that are direct competitors in the educational services market are significantly higher, namely Poland – 31st, and Germany – 5th.

It should be noted that this is not the first time that Ukraine ranks 1st in the "Contribution to the Development of Science and Technology" component of this rating, Poland – on the 13th place, Germany – on the 23rd, and Great Britain – on the 5th, but it should be noted that such a high place of Ukraine is explained by a significantly lower level of GDP per person than the results of the development of science and technology [2]. Higher education is in high demand and this is confirmed by the indicator of high-tech employment, which is a component of the global innovation index [3]. Analysis of sources [2-4] showed that in 2020 the global innovation indicator of Ukraine was 37.3% and Ukraine ranked 32nd. However, a number of European countries have a significantly higher indicator of this index. The UK ranks 7th with the Global Innovation Index at 49.2%, Germany is 17th with 45.2%, and Poland is 28th with 39.5%.

## 2. Critical review of the literature

The integration of the national economy, in particular domestic energy companies, into the global economic space is a complex and unpredictable process, because it is difficult to ensure its effective functioning, especially sustainable development. Research on the conceptual foundations of sustainable development of energy companies is an extremely relevant issue today. The unpredictability of socio-economic phenomena, global turbulence and the emergentness of the national economy complicate the solution of this problem.

It is necessary to identify and monitor the latent manifestations of emergent qualities of education management as a scientific and technological platform for sustainable development, the formation of which takes place in the context of constant and not always effective reforms. The modern socio-economic environment is characterized by turbulence, the presence of economic threats and dangerous socio-economic phenomena that simultaneously threaten their sustainable development.

The study of the theoretical foundations of manifestations of unpredictable directions of sustainable development of subjects of entrepreneurial activity and business, the economic nature of which is determined by the formation and activation of emergent qualities of education management, forms organizational and economic support for quantitative and qualitative changes in the strategic aspect. Timely identification of emergent negative qualities of education management of subjects of economic processes and systems and their effective direction will enable their sustainable development. Elucidating the emergentness characteristics and features of non-additive (emergent) qualities of education management will become the basis for social development and the development of the educational environment for identifying and timely directing strategic guidelines for sustainable development. Determining the

effectiveness of the direction of emergent qualities of education management in the national economy and the economic system at the microlevel will be a prerequisite for a model forecast of the functional potential of these systems.

The methodology of sustainable development processes is the object of research by a significant number of domestic and foreign scientists.

Many factors affect sustainable development, among which special attention should be paid to the quality of education management.

In the literature on management, commercial activity and marketing, it is classically customary to divide it into factors of internal and external environment, as well as factors of direct and indirect influence [5-9]. In modern conditions, the number of factors and their nature is being transformed. For example, with the development of information technology and logistics, each organization has the ability to increase or decrease the impact of individual factors.

Both the external and internal environment include many different components. Thus, the internal environment includes, according to M. Mescon, M. Albert and F. Hedowry [11], the goals of the organization, material and labor resources, size, horizontal and vertical division of labor, technical equipment, internal information, organizational culture and other elements. G. Levitt has the same opinion paying attention to the systemic nature of the organization and formulating the concept of "Levitt's Diamond", which lays in the relationship of four components: tasks and missions; technologies; structure; people [12].

For the effective functioning of the enterprise, the implementation of tasks is related to the set goals, which requires providing employees with specialties and qualifications. The sustainable development of companies is constrained by the lack of the necessary professionals. The main concern of a modern enterprise is the selection of professionals and the help of capable managers.

It should be noted that without high-quality education management, there will be no professionals in any field of activity, and therefore it is necessary to pay special attention to the emergent qualities of education management as a scientific and technological platform for sustainable development.

Analysis of literature sources has shown that today much attention is paid to complex systems that are characterized by emergentness, as a manifestation of the property of system integrity in the brightest form, that is, the presence of any system of such properties that are not inherent in any of its elements, considered separately outside the system. In general, emergentness (from the English ‘emergent’ – suddenly appearing, suddenly popping up) is the appearance of properties of a whole that are not additive to the properties of the parts included in it, that is, properties that do not follow from the properties of its parts. However, as practice shows, today there is no single definition of the concept of "emergentness", different scientists interpret it following no particular pattern [6-12].

It is most appropriate to define emergentness as a result of the occurrence between the elements of the system of the ability to tune in to a more productive, efficient nature of work and respond in time to respond to changes in both the external and internal environment, which provide a significant increase in the overall effect than the sum of the effects of individual independent elements of the system.

Emergent qualities of education management are manifested in the form of the feature of innovation and innovative features. The feature of the innovation has versatile and diverse characteristics that lead to rapid changes in both products, goods produced by enterprises and educational services provided by teachers, or there is a gradual improvement of these results of enterprises' activities. Due to the emergent features of innovations, the company gains relative stability for the purposes of sustainable mass production. An innovative feature is characterized as a breakthrough in the main product technology, through innovative processing that solves the main issues of development and processing. Due to emergent innovative features, society experiences technological normality through goods and services, or the compliance of technologies

with modern requirements of life and business model. Innovative processing in the concept of circular economy is also considered [9].

The processes of activation of emergent properties are a driving force for the mechanism of innovation introduction and promotion, which allows companies to select and measure the needs of the market and consumer at each stage of the life cycle for the expediency, timeliness, clarity and compliance of innovations [10].

## 3. Methodology and results

Currently, higher education in Ukraine is publicly available and the level of higher education coverage of the population of the traditional official age of study reaches 83 %, which allowed Ukraine to take the 14th place in the Global Innovation Index 2020, while according to this component of the Global Innovation Index, Great Britain ranks 34th and the indicator is 60%, Germany is on the 28th place (70.2%), Poland has the value of this component at the level of 67.8% and occupies the 34th place. Most researchers believe that a significant advantage of Ukraine is equal access to education for both women and men. The share of working women with higher education and scientific degrees in the total number of employees in Ukraine is one of the largest in the world-30.4 % (the 3rd place). In other countries selected for comparison, this indicator is much lower. So in the UK – 23.4% of working women have higher education and a scientific degree and it ranks 16th, Poland ranks 25th, since 21.1% of working women have higher education and a scientific degree – 21.1 % (25th), Germany-13.5 % (51st) [3].

Analysis of the data in Figure 1 shows that 47 countries have a high level of education among the countries studied, out of which 15 countries, namely: Germany, Norway, Great Britain, Finland, Iceland, New Zealand, Australia, Ireland, Denmark, Sweden, the Netherlands, Slovenia, Belgium, Switzerland, the United States of America have an index of 0.9 or higher.

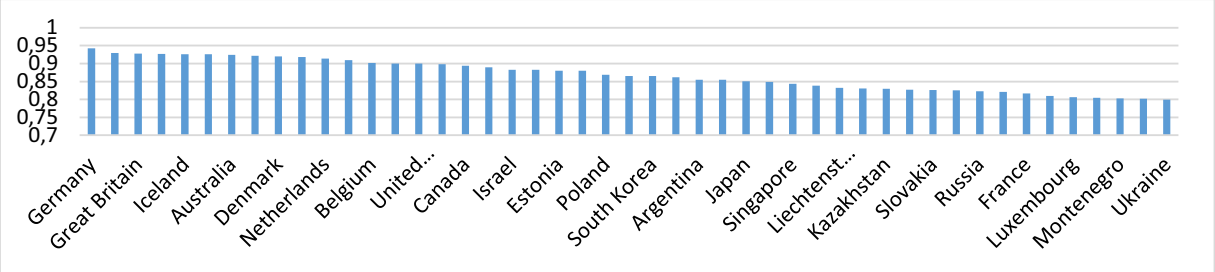


**Figure 1.** Rating chart of a country with a high level of education.

Countries with an education index of 0.8 to 0.9 include Lithuania, Canada, the Czech Republic and other countries. It should be noted that Ukraine closes this list with an indicator of 0.8.

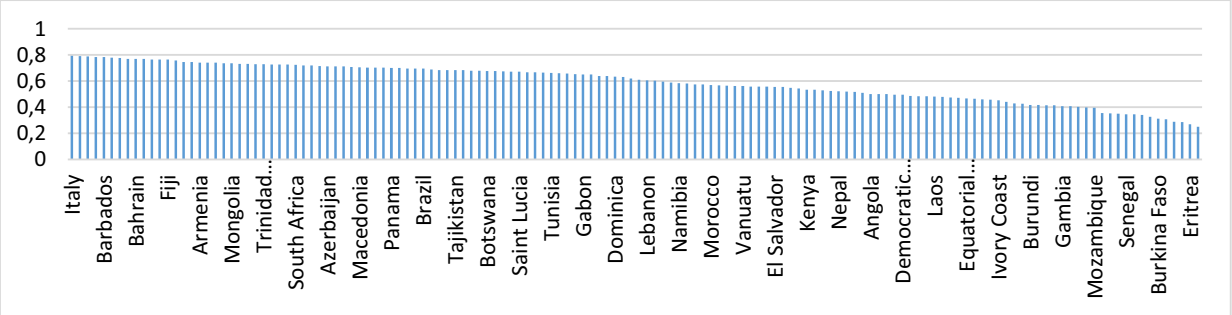


**Figure 2.** Rating graph of countries with medium and low levels of education.

Analysis of the indicators in Figure 2 showed that Italy, which is a highly developed country and is among the 10 most developed countries in the world, has an education index of 0,793 and Cuba of 0.79. The lowest indicators are in such countries as Mali (0.286), Eritrea (0.269), Niger (0.249).

The authors investigated an up-to-date (periodically updated in accordance with the latest research results) list of countries of the world and administrative territories without state status, ordered by the Human Development Index. Current data is presented as of 2019 and published in December 2020. Figures 3-6 show the ranking of countries classified into four categories according to the accepted gradation shown above.

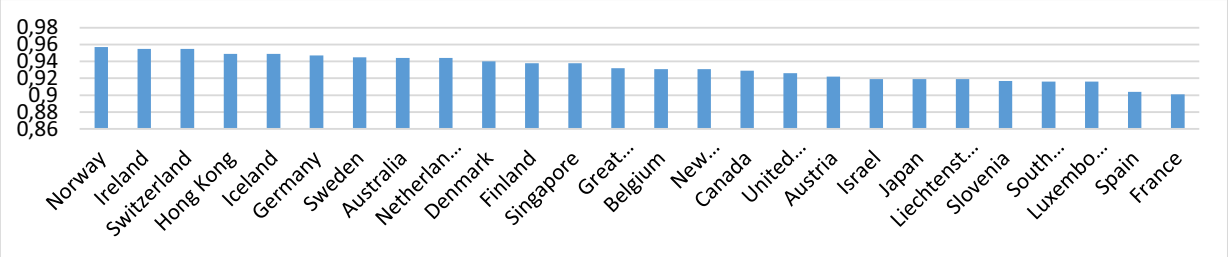


**Figure 3.** Ranking of countries with a very high level of the Human Development Index.

Analysis of the Human Development Index of countries that have a very high level showed that no country has this indicator at the level of the maximum value of 1. Norway, Iran, Switzerland have the highest level. According to this gradation, such countries as Luxembourg, Spain, and France have the lowest level among countries that have a very high level of the Human Development Index.

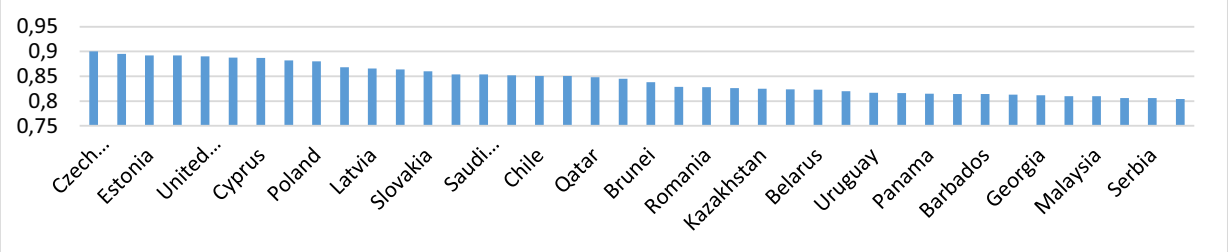


**Figure 4.** Rating of countries with a high level of the Human Development Index.

Analysis of the Human Development Index of countries with a high level showed that the Czech Republic, Estonia, and the United Arab Emirates have the highest level. According to this gradation, such countries as Georgia, Malaysia, and Serbia have the lowest level among countries with a high level of the Human Development Index.

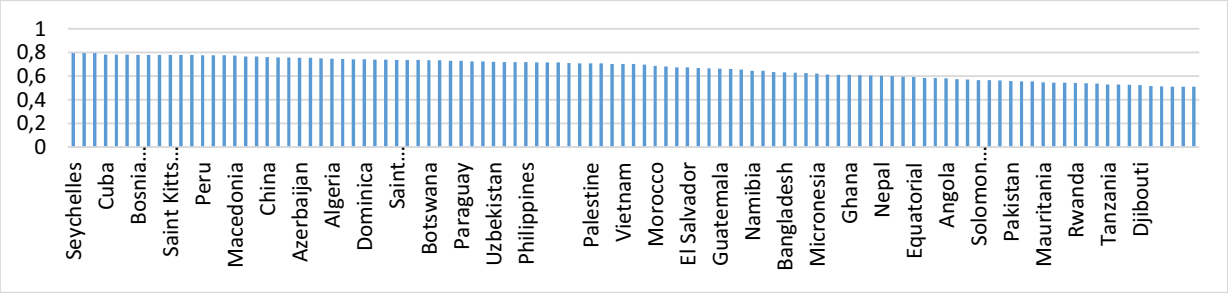


**Figure 5** – Ranking of countries with an average level of the Human Development Index.

The studies have shown that most of the countries studied have an average level of Human Development Index, namely Cuba, Albania, Iran, Sri Lanka and others. It should be noted that the part of the data provided by national statistical organizations is not always reliable, as some governments knowingly embellish the situation in their countries, and the statistics shown in Figure 4 are somewhat questionable.

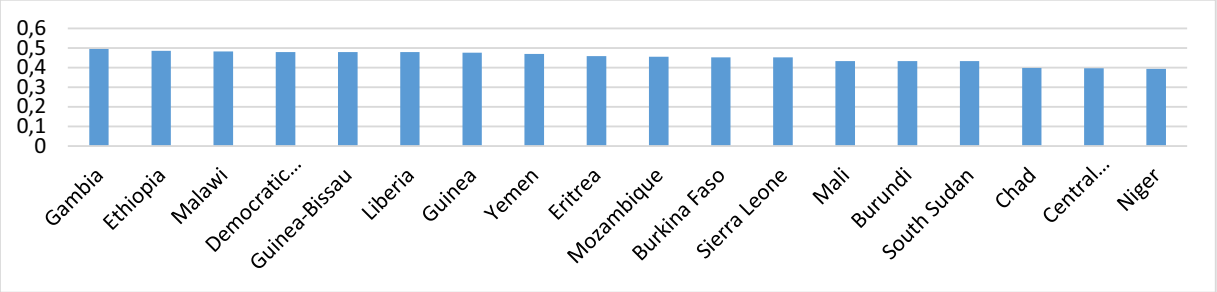


**Figure 6.** Rating of countries with a low level of the Human Development Index.

The studies have shown that countries such as The Gambia, Ethiopia, the Democratic Republic of the Congo, Guinea-Bissau, Liberia and others have a low level of Human Development Index.

So, the studies have shown that modern world socio-economic processes indicate an increasing role of education in all spheres of public life, including having a significant impact on sustainable development.

Without any exaggeration we can say that education plays and will play a crucial role in sustainable development. It is due to education that a modern information society is formed, as well as an integral system of resource conservation of social production.

In modern conditions, the sustainable development of the energy industry is determined by an increase in the scientific and technological component, the development of intellectual capital, and a high level of competitiveness due to the widespread introduction of innovations.

Today, the development of Ukraine is impossible without a conscious acceptance of the priority of ensuring an effective balance of economic, environmental and social development. The energy industry is one of the key global changes in this direction, since the progressive increase in capacity based on outdated technologies and worn-out fixed assets leads to an increase in the negative impact on the ecology of regions and countries, and the qualitative restructuring of the sector structure is long-term and investment-intensive. Ukraine, as a state, supports the course of building a circular economy and ensuring inclusive development.

Recently, the importance of education and the level of its management have significantly increased, which is advisable to understand the system of making managerial decisions that will ensure the high-quality functioning of an educational institution in modern environmental conditions. At the same time, it is important that management allow the educational institution to adapt or counteract certain factors that affect the development of education and its competitiveness. It is clear that educational institutions are fundamentally different from enterprises. However, in our opinion, they can significantly increase the efficiency of their activities if they adopt management tools. Figure 7 shows a cognitive map overview of systematized factors influencing the development of educational institutions on those that contribute to the development of educational institutions, and those that slow it down.

The priorities of the functioning of the innovative economy are the availability of highly educated employees capable of innovative work [16, 22-28]. To solve the tasks set for the effective development of educational institutions, it is necessary to use the tools of modeling processes. The main stages of economic modeling are:

- defining the essence of the economic process and setting the task;
- choosing a method for solving the problem;

- analysis of quantitative and qualitative parameters of the task set in relation to the object of research;
- study of relationships between model elements;
- building an economic model, solving the problem;
- analysis of model results, implementation of forecasts [17].

Econometric models are a type of economic and mathematical models that are used to estimate the parameters of the research object using mathematical statistics methods.

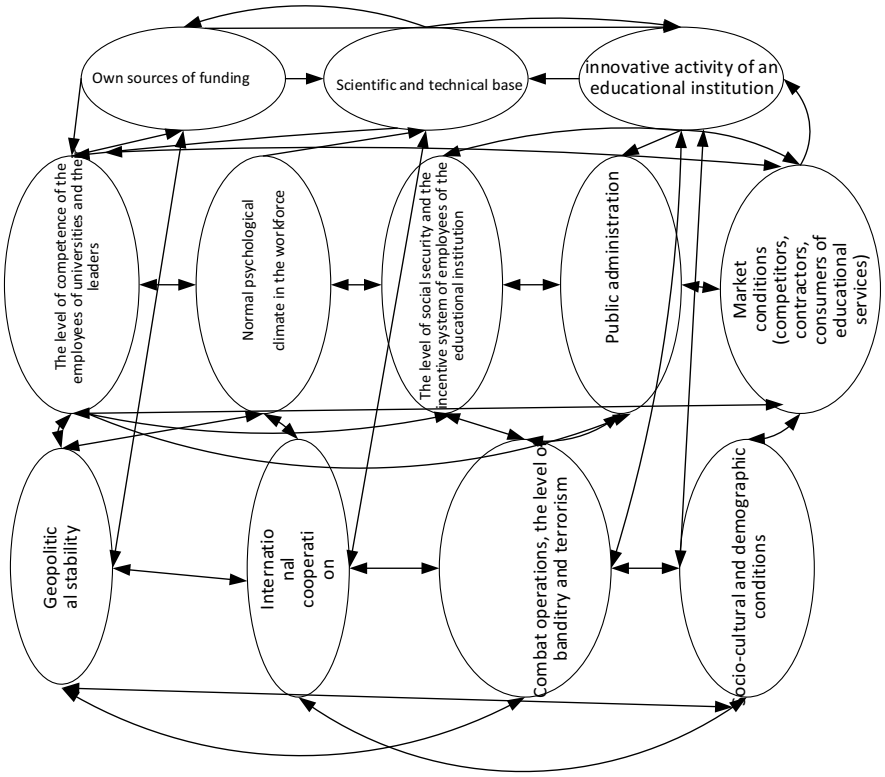


**Figure 7.** Cognitive map overview of systematized factors influencing the development of education in the modern socio-economic environment.

In the econometric model, one of the main approaches to studying the relationship between factors of influence is correlation-regressive analysis. It is a set of methods that determine the type of equation for the factors under study and calculate their parameters (regressive analysis). Regression models establish a linear relationship between variables. The tightness of the relationship between variables in an equation or equations and their significance is also determined using correlation analysis [18].

In order to study the processes and factors of influence of emergent qualities of education management on sustainable development, it is advisable to apply methodological developments of scientists and economists on the construction of Trend models for predicting the main development processes [19]. According to the State Statistics Service of Ukraine [20], the Ministry of Finance of Ukraine [21], a certain number of indicators that have an impact on sustainable development were selected for the study. From the

presented array of statistical data, indicators of the most significant impact of emerging qualities of education management on sustainable development are selected for further research (Table 1).

**Table1.** Factors of influence of emergent qualities of education management on sustainable development.

| Name | Influence factors |
|---|---|
| X1 | Number of population, thousand people |
| X2 | Average life expectancy at birth, both sexes, years |
| X3 | Expenditures of the consolidated budget for the development of the state, UAH bln. |
| X4 | Consolidated budget expenditures on education, UAH bln |
| X5 | Graduates of specialists in ZVO III-IV levels of accreditation, thousand people |
| X6 | Trained (graduated) skilled workers, thousand people |
| X7 | Number of scientists, persons |
| X8 | Amount of organizations performing research and development, number of organizations |
| X9 | Share of enterprises implementing innovations, % |
| X10 | Economically active population aged 15-70, thousand people |
| X11 | Employed population aged 15–70, thousand people |
| X12 | Unemployed population aged 15-70, thousand people |
| X13 | Average monthly salary, UAH |
| X14 | Labor productivity of human funds, USD/person |
| X15 | Population migration between Ukraine and other states, increase (decrease), thousand people |
| X16 | Expected duration of study, years |
| X17 | GDP of Ukraine, million USD |
| X18 | GDP per capita in USA, USD |

Note: formed by the authors on the basis of data (the State Statistics Service of Ukraine. Economic activity of the population of Ukraine, 2020; the Ministry of Finance of Ukraine, 2020) [20, 21]

For certain factors of influence of emergent qualities of education management on sustainable development, trend lines are constructed using various types of approximating dependence (linear; logarithmic; polynomial of the 2nd, 3rd and 4th degree; power). The forecast values were calculated using the Microsoft Excel package. The selection of trend models was carried out taking into account the value of the coefficient of determination ($R^2$). For further studies, the following factors of influence and their predictive values were selected, which had high values of the coefficient of determination in the range of 0.8-0.9.

In general, a multi-factor correlation and regression model that reflects the relationship of factor features to the resulting indicator (Y) and is used for economic analysis has the following form:

$$Y = f(X) + u, \quad (1)$$

$$Y = a0 + a1*X1 + a2\ X2 + a3\ *X3 + \ldots + an\ *\ Xn + u, \quad (2)$$

where Y - dependent variable;

X – independent variable;

a0, a1,… an – unknown parameters of the regression model (a coefficient that determines the strength of influence of factors, i.e. independent variables on the Y indicator;

u – a vector of random variables (errors) [18].

In general matrix form the econometric model is presented as follows:

$Y = AX+u$,

where A is a matrix of model parameters of size m×n
Y – a dependent variable parameter matrix;
X – a matrix of parameters of independent variables;
u – a matrix of random variables.

Table 2 shows models describing trends in indicators of the impact of emerging qualities of education management on sustainable development

**Table 2.** Models describing trends in indicators of the impact of emerging qualities of education management on sustainable development.

| Influence factors | Models | Determination coefficient R2 | Estimated values, years 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|---|
| Number of population, thousand people | Y1=-345,1X+49783 | 0,95 | 41231 | 41100 | 40878 | 40581 | 40121 |
| Average life expectancy at birth, both sexes, years | Y2=9E-05X4-0,0012x3+0,059x2-0,7985x+68,387 | 0,92 | 71,88 | 72,05 | 72,34 | 72,54 | 72,61 |
| Expenditures of the consolidated budget for the development of the country, UAH bln | Y3=1,1124x3-17,99x2+128,5x-0,1198 | 0,97 | 2765,5 | 3382,7 | 3456,27 | 3512,83 | 3582,47 |
| Consolidated budget expenditures on education, UAH bln | Y4=0,14689x3-2,989x2+16,999x-3,898 | 0,96 | 403,15 | 462,32 | 482,1 | 501,20 | 543,83 |
| Specialists graduated from universities of III-IV levels of accreditation, thousand people | Y5=-0,79852x2+37,954x+3,1212 | 0,92 | 360,53 | 348,68 | 345,81 | 331,32 | 328,24 |
| Trained (graduated) skilled workers, thousand people | Y6=0,0029x4-0,25341x3+7,121x2-49,787x+573,01 | 0,92 | 120,44 | 119,21 | 117,99 | 117,24 | 116,88 |
| Number of scientists, thousand people | Y7=-8159ln(x)+325315 | 0,97 | 47009 | 45483 | 43124 | 42024 | 41545 |
| Amount of organizations performing research and development | Y8=-2,141x2+48141x+1198,8 | 0,87 | 567 | 462 | 354 | 256 | 198 |
| Economically active population aged 15-70, thousand people | Y10=-498,98x+20194 | 0,85 | 14297 | 14392 | 13985 | 13002 | 12878 |
| Average monthly salary, UAH | Y13=108,1x2-301,29x+13,992 | 0,92 | 16128 | 17958 | 18450 | 18342 | 19450 |
| Expected duration of study, years | Y16=-0,03011x2+0,2698x+14,725 | 0,93 | 15,6 | 14,6 | 14,3 | 13,1 | 13 |

As we can see in Table 2, in the near future, when calculating forecast values, some indicators are characterized by a downward trend, which will negatively affect the development of education.

**Table 3.** Econometric models of education management development.

| Models | Correlation coefficient R | Determination coefficient R2 | Normalized R-square | Fisher's criterion F | Approximation error |
|---|---|---|---|---|---|
| Y1=0,1583+0,1872X1+0,2402X8+0,1968X10+ 0,1005X13+0,2705X16 | 0,968 | 0,815 | 0,723 | 10,1 | 0,012 |
| Y2=0,15041+0,5238X7+0,2781X12+0,4239X1 3+0,3728X17+ 0,1105X18 | 0,951 | 0,811 | 0,711 | 11,2 | 0,017 |
| Y3=0,3717+0,1658X2+0,5362X8+0,51708X11 +0,4101X15+0,3471X17 | 0,810 | 0,671 | 0,651 | 12,1 | 0,018 |
| Y4=0,2357+0,3453X1+0,2061X4+0,4753X7+0, 2443X10+0,1763X13 | 0,929 | 0,713 | 0,645 | 10,1 | 0,016 |
| Y5=0,15484+0,17584X1+0,04578X4+0,26183 X11+0,1956X15+05748X14 | 0,899 | 0,715 | 0,671 | 10,0 | 0,015 |

This indicates the need to step up state regulation and improvement measures efficiency of reproduction and development of the country's education management. High values of the coefficient of determination $R^2$ indicate a significant close relationship between the dependent variable Y and the independent variable X. The results of calculations using standard MS Excel software are shown in Table 3. Econometric modeling of the influence of factors on the development of educational management is carried out and correlation and regression models are constructed.

## 4. Conclusion

The paper defines the factors of influence of emergent qualities of education management on sustainable development, on the basis of which economic and mathematical models are constructed that describe trends in indicators of the influence of emergent qualities of education management on sustainable development. Economic and mathematical models of education management development are also constructed. The constructed economic and mathematical models indicate a fairly stable relationship between factors affecting the development of education management. The authors came to the conclusion that the emergent qualities of education management have impact on the creation of scientific platforms in Ukraine as an effective mechanism for partnership and interaction between education, science and business, which in the future will make it possible: improve the competitiveness of the main sectors of the economy; to combine education, science and business in the process of creating and developing advanced technologies; to concentrate state and private sector funds on solving the problems of scientific and technological and innovative development; to identify future needs in the field of training highly professional personnel in demand by the market; to encourage the participation of business structures to act as customers of

educational and scientific institutions and research organizations, as well as investors in promising scientific and technological developments.

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