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EFFECT OF EDUCATION ON EASE OF DOING BUSINESS IN CONDITIONS OF INNOVATION DEVELOPMENT: FACTOR ANALYSIS AND MULTIPLE REGRESSION**Anastasiia Samoilikova,**  **ORCID ID:** <https://orcid.org/0000-0001-8639-5282>

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Abstract: Education accelerates changes and transformations in social life, as well as one of the main factors of progress and development in general and business. The article substantiates and formalises the relationships between indicators of the level of education (taking into account its innovative development) and the ease of doing business based on evidence from 28 world countries and the data from the World Bank, the United Nations, Tufts University and Standard & Poor's Ratings Services. The article aims to find indicators of innovative education that most significantly contribute to the ease of doing business. For this, cognitive analysis of statistical data is carried out, and with the help of descriptive analysis tools, a statistically significant characteristic space of indicators is formed. Checking the density and direction of the relationship is carried out by calculating the values of the Pearson correlation coefficients. The multidimensionality of input feature space is reduced to the four most significant indicators from nine investigated ones (digital development indicator; human development index; digital trust, financial literacy index) using the procedure of principal component analysis and orthogonal transformation using the Varimax method in the Statgraphics Centurion 19 software. The quality of the factorisation is confirmed by Kaiser-Meier-Olkin testing and Bartlett's sphericity testing. As a result of the developed multiple econometric models, which describe the dependence of ease of doing business and the above indicators, and the Backward Stepwise Selection hard screening procedure in Statgraphics 19, a statistically significant model of the effect of digital development on ease of doing business is built. It shows that with the value increase of digital development by 1%, ease of doing business will also increase by 0.79%. The obtained results can be useful to scientists for further research, as well as to change-makers in education and business and all stakeholders in the direction of «business–education» competition.

Keywords: academic staff, business, digital evolution, digital trust, expenditure, financial literacy, human development, school, tertiary education.

JEL Classification: I23, M21, O32.

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Introduction. Today education is an important precondition for the future in which we will live. Education and experience are catalysts for all scientific and technical discoveries, innovations, and the progress of humanity in general. Everything around them changes quickly, and any innovative solution can radically affect an entire industry, the economic direction, or the sphere of people's lives (Bilas, 2020). The influence of education on economic growth is a widespread issue (Hanushek and Woßmann, 2007, Barro, 2013, Canals, 2017).

In turn, education affects business in at least two ways: it creates a basis for the development of human potential (critical thinking, project thinking, creativity, openness to innovation, ability to lifelong learning, etc.) and forms the future class of consumers, and provides new knowledge through research and observation, which leads to innovation development, the emergence of innovative solutions, opening a new business, economic growth, national and business competitiveness (Bilas, 2020).

All the above potential benefits of education, both for country and business levels, are especially important in modern conditions of countries' transition and integration processes, urbanisation, industrialisation, economic recession, labour migration, etc. (Stojanov et al., 2011; Jiroudkova et al., 2015; Li et al., 2019). Special challenges arise for education and business during war, pandemics, and other emergencies.

However, despite the seemingly logical conclusion about the value of education when creating a business, entrepreneurs have a diametrically opposite attitude to education: some of them say that a good education is a good foundation for a successful business, while others follow Mark Zuckerberg, saying that education is not the most important thing without which business cannot be built (Shveda, n.d.).

That is why the issue of the effect of education on ease of doing business in conditions of innovation development is timely and relevant. The article aims to find indicators of innovative education that most significantly contribute to the ease of doing business.

Achieving the goal involves carrying out research in the following stages:

1. Literature review and bibliometric analysis based on VosViewer soft.
2. Formation of indicators sample.
3. Description of statistical significance and feature space quality (descriptive statistics).
4. Data standardisation.
5. Analysis of the main components and factor analysis (building a regression model).

Literature Review. When searching for scientific papers in the scientometric database Scopus using the words «business» and «education», 63,618 scientific papers were found from 1965 to 2022. Only in the last seven years (from 2016 to 2022) 21,648 scientific works dedicated to studying the relationship between education and business were indexed, emphasising the extreme importance and relevance of the research topic.

From the keyword relationship map (Figure 1), it is possible to clearly distinguish the 80 most used keywords: human, education, students, adults, experiment, men, women, engineering, cross-sectional study, psychology, decision-making, online learning, covid, university, commerce, awareness, leadership, economics, learning systems, knowledge, organisation and management, employment, social media, business, motivation, financial management, innovation, etc.

All these keywords are connected by different links, forming four clusters of multidisciplinary research, as the following:

- 1) «red» cluster – education, e-learning, personal training, decision-making, entrepreneurship, business, employment, sustainable development, innovation, artificial intelligence, big data, etc.
- 2) «green» cluster – knowledge, university, cross-sectional studies, students, men, females, psychology, etc.
- 3) «blue» cluster – human, health, workplace, organisation and management, pandemic, covid-19, etc.
- 4) «yellow» cluster – leadership, skill, perception, human experiment, etc.

The formed clusters reflect the most common areas of interdisciplinary research on education and business, which are of the greatest scientific interest.



A cognitive analysis of statistical data was carried out, and with the help of descriptive analysis tools, a statistically significant characteristic space of indicators was formed. Checking the density and direction of the relationship was carried out by calculating the values of the Pearson correlation coefficients. The multidimensionality of input feature space was reduced to the clearest indicators from all investigated ones using principal component analysis and orthogonal transformation based on the Varimax method in the Statgraphics Centurion 19 software. The quality of the factorisation was confirmed by the Kaiser-Meier-Olkin test (Kaiser, 1974; Cattell, 1966) and Bartlett's sphericity test (Bartlett, 1955).

Multiple econometric models were developed, which describe the dependence on ease of doing business and determined indicators (digital development indicator; human development index; digital trust, financial literacy index). Due to the Backward Stepwise Selection hard screening procedure in Statgraphics 19, a statistically significant model of the effect of digital development on ease of doing business was built.

The information base involved data from the World Bank, Eurostat, and Index Mundi for the sample from 28 countries of the world in 2020 according to the following indicators: ease of doing business; school enrolment, primary; enrolment in tertiary education, all programs; higher education, teachers; digital evolution score; human development index; the number of registered businesses; digital trust; financial literacy index; government expenditure on education, % of GDP.

Results. Research is conducted in the four stages to determine indicators of innovative education that most significantly contribute to the ease of doing business.

1. Formation of a sample of indicators.

For evaluation, a sample of statistical data from the World Bank, Human Development Report Office of the United Nations, Tufts University (Digital Planet project) and Standard and Poor's Ratings Services for 28 countries for 2020 was formed, in particular, the input sample of the study consisted of the following indicators:

- k1 – ease of doing business (overall score) (World Bank, n.d.d);
- k2 – school enrolment, primary (World Bank, n.d.e);
- k3 – enrolment in higher education (enrolment in tertiary education, all programs) (World Bank, n.d.a);
- k4 – tertiary education, academic staff (World Bank, n.d.f);
- k5 – an indicator of digital development (digital evolution score) (Tufts University, n.d.a);
- k6 – human development index (UNDP, n.d.);
- k7 – number of new businesses registered (World Bank, n.d.c);
- k8 – digital trust (Tufts University, n.d.b.);
- k9 – financial literacy index (S&P Ratings Services, n.d.; Klapper et al., 2020);
- k10 – government costs on education as % of GDP (World bank, n.d.b).

The countries of the study were: Switzerland, Sweden, Germany, Denmark, the Netherlands, Austria, Spain, the United Kingdom, Singapore, France, Italy, Turkey, Poland, Portugal, Romania, Brazil, Colombia, Egypt, Israel, Malaysia, Indonesia, New Zealand, Ukraine, Saudi Arabia, Thailand, Vietnam, the United Arab Emirates, the Philippines.

2. Description of statistical significance and quality of feature space.

Table 1 presents the obtained results of the descriptive statistics analysis.

Table 1. The obtained results of the descriptive statistics analysis

| Indicator | Coefficient of variation | Coefficient of kurtosis (Std. kurtosis) | Asymmetry coefficient (Std. skewness) |
|-----------|--------------------------|--|--|
| k1 | 9,36595% | 0,605458 | -1,79414 |
| k2 | 30,7039% | -0,984239 | -1,09999 |
| k3 | 24,4477% | -1,13488 | 0,1508 |
| k4 | 152,413% | 14,5156 | 7,49225 |
| k5 | 8,49774% | 4,80746 | 2,29197 |
| k6 | 31,1825% | -0,121725 | 0,652495 |
| k7 | 13,1771% | 0,717654 | 0,875067 |
| k8 | 9,90225% | -0,947547 | -1,47752 |
| k9 | 38,1504% | -1,56122 | 0,692392 |
| k10 | 30,2502% | -0,0852232 | 0,988791 |

Sources: developed by the authors based on Statgraphics.

The variation coefficient informs about the relative dispersion of the data set. The indicator is significant if the coefficient of variation is more than 5%, so from the obtained results, all indicators are statistically significant, and it is possible to conduct research with them. The asymmetry coefficient is a numeral indicator of the probability distribution of a valid random variable. The kurtosis coefficient shows the steepness of the distribution curve's rise compared to the normal one.

Kurtosis and asymmetry coefficients should range from -2 to 2, so attention should be paid to indices for which standardised coefficients' values go beyond this interval. Depending on the aim of model development

and applying certain multivariate statistical analysis methods to interpret obtained results, there may be more than these coefficients to satisfy the corresponding testing. In this case, these are k4 (higher education, teachers) and k5 (development indicator).

Figure 2 shows a means of visualising groups of numerical data in descriptive statistics through their quantiles – a swing chart, boxplot, or «box with whiskers». Quantiles cut off within a series a certain part of its members. A boxplot may also have lines that extend vertically out of the box («whiskers»), indicating the amount of variability outside the upper and lower quantile limits. Emissions can be plotted as points.

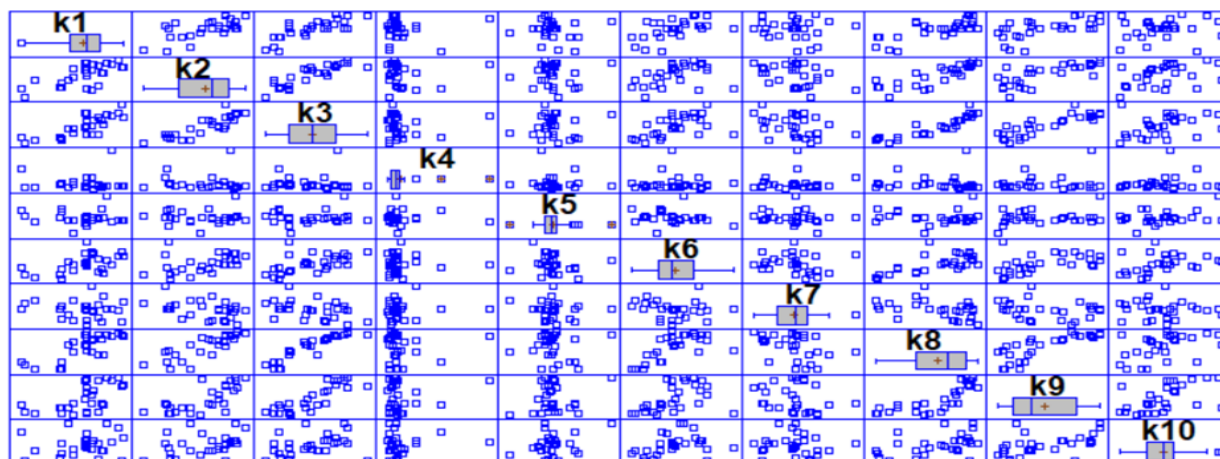


Figure 2. Box graph («box with whiskers»)

Sources: developed by the authors using the Statgraphics program.

Some indicators have anomalous values (shown by squares outside the line corresponding to the input range of values); for example: for k1 (ease of doing business), the value for the country Brazil (59.10) is anomalous, as this value is the smallest among of all countries; for k5 (digital development indicator), there are three outliers for countries such as Sweden (133.86) and Romania (82.85), which are the highest and lowest of all countries, respectively; for the indicator k10 (state spending on education as a % of GDP), the value for the country of Saudi Arabia is abnormal, since this indicator is the largest for this country, etc.

The next indicator of descriptive statistics that must be considered is the Pearson correlation coefficient (Figure 3).

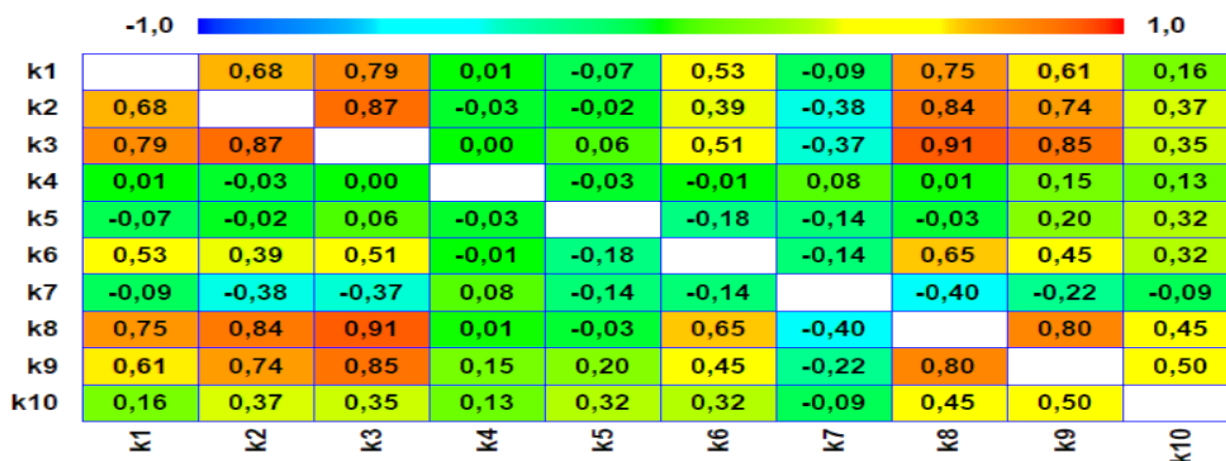


Figure 3. Pearson correlation results

Sources: developed by the authors based on Statgraphics.

Based on Figure 3, the following conclusions can be made. A high level of positive correlation, direct influence (from 0.5 to 1.0) exists between indicators of ease of conducting business and school enrolment, ease of conducting business and enrolment in higher education, ease of conducting business and human development, ease of conducting business and digital trust, ease of conducting business and financial literacy; school enrolment and enrolment in tertiary education, school enrolment and digital trust, school enrolment

and financial literacy; enrolment in tertiary education and human development, enrolment in tertiary education and digital trust, enrolment in higher education and financial literacy; human development and digital trust; digital trust and financial literacy; financial literacy and government expenditure on education.

A high level of negative correlation and inverse influence (from -1.0 to -0.5) does not exist between any indicators.

Medium level of positive correlation, direct influence (from 0.3 to 0.5) exists between school enrolment and human development, school enrolment and government costs on education; enrolment in higher education and government costs on education; an indicator of digital development and government costs on education; human development and financial literacy, human development and government costs on education; digital trust and government costs on education.

The average level of negative correlation, reverse influence (from -0.5 to -0.3), takes place between school enrolment and the number of new businesses registered, enrolment in higher education and number of new businesses registered, number of new businesses registered and digital trust.

Low level of positive correlation, direct influence (from 0.1 to 0.3) there is between ease of doing business and government costs on education, higher education (academic staff) and financial literacy, tertiary education (academic staff) and government costs on education, an indicator of digital development and financial literacy.

A low level of negative correlation, reverse influence (from -0.3 to -0.1) exists between the indicator of digital development and human development, an indicator of digital development and new businesses number, human development and some new businesses registered, new businesses number and financial literacy.

There is no correlation at all (from -0.09 to 0; from 0 to 0.09) between indicators of ease of doing business and tertiary education (academic staff), ease of doing business and indicator of digital development, ease of doing business and number of new businesses registered, school enrolment and tertiary education (academic staff), school enrolment and indicator of digital development, enrolment in higher education and tertiary education (academic staff), enrolment in higher education and indicator of digital development, tertiary education (academic staff) and indicator of digital development, tertiary education (academic staff) and human development, tertiary education (academic staff) and number of new businesses registered, tertiary education (academic staff) and digital trust, an indicator of digital development and digital trust, number of new businesses registered and government expenditure on education.

3. Data standardisation.

Since the input data are measured in different scales, reflecting both absolute and relative values of the characteristics, for accuracy and adequacy of the further development of regression models, it was necessary to carry out their normalisation procedure using the data standardisation procedure in the Statistica software.

4. Factor analysis. Analysis of the main components.

Factor analysis aims to receive a small sample of variables that mostly explain the variability in 10 investigated factors. Using principal component analysis, the most influential factors were identified. A factor is significant if the Kaiser statistic (Eigenvalue) is greater than 1. The first three factors give the result of the entire sample (Table 2).

Table 2. Factor analysis results

| Factor Number | Eigenvalue | Per cent of Variance | Cumulative Percentage |
|---------------|------------|----------------------|-----------------------|
| 1 | 4,84551 | 48,455 | 48,455 |
| 2 | 1,36566 | 13,657 | 62,112 |
| 3 | 1,14785 | 11,479 | 73,590 |
| 4 | 0,861498 | 8,615 | 82,205 |
| 5 | 0,736635 | 7,366 | 89,571 |
| 6 | 0,505188 | 5,052 | 94,623 |
| 7 | 0,257941 | 2,579 | 97,203 |
| 8 | 0,147966 | 1,480 | 98,682 |
| 9 | 0,078399 | 0,784 | 99,466 |
| 10 | 0,0533573 | 0,534 | 100,000 |

Sources: developed by the authors based on Statgraphics.

So, three factors were determined because they were equal to or more than 1.0. They cover 73.59% of data variability. Because the method of principal components was chosen, initial estimations were adjusted to suppose that widespread factors caused all data variability.

Table 3 shows the factor loading matrix after Varimax rotations.

Table 3. Factor capacity matrix after rotations

| | Factor 1 | Factor 2 | Factor 3 | Estimated Communalities | Specific Variance |
|------------|-----------|-----------|-------------|-------------------------|-------------------|
| k1 | 0,84669 | -0,118381 | -0,00703817 | 0,730948 | 0,269052 |
| k2 | -0,151642 | 0,860307 | -0,151296 | 0,786013 | 0,213987 |
| k3 | 0,70641 | -0,154746 | 0,0928117 | 0,531576 | 0,468424 |
| k4 | -0,278346 | -0,276233 | 0,629398 | 0,549924 | 0,450076 |
| k5 | 0,927061 | 0,182366 | -0,155342 | 0,91683 | 0,0831702 |
| k6 | 0,95214 | 0,134842 | -0,111442 | 0,937172 | 0,0628275 |
| k7 | 0,067033 | 0,169059 | 0,774814 | 0,633411 | 0,366589 |
| k8 | 0,859829 | 0,157759 | -0,196094 | 0,802647 | 0,197353 |
| k9 | 0,818927 | 0,388939 | 0,0782907 | 0,828045 | 0,171955 |
| k10 | 0,387844 | 0,654283 | 0,252867 | 0,642451 | 0,357549 |

Sources: developed by the authors based on Statgraphics.

Factor 1, which characterises the quality of business and its development from indicators, is considered in more detail, and three significant models can be used. Table 3 gives the equation's estimated total coefficients after rotation performed to simplify the factors explanation. The first returned factor has the equation:

$$\text{Factor 1} = 0,84669 * k1 - 0,151642 * k2 + 0,70641 * k3 - - 0,278346 * k4 + 0,927061 * k5 + 0,95214 * k6 + 0,067033 * k7 + + 0,859829 * k8 + 0,818927 * k9 + 0,387844 * k10 \quad (1)$$

The variables' values are standardised by subtracting their averages and dividing them by standard deviations. In addition, the obtained results were confirmed by the following tests: the Kaiser-Meier-Olkin sampling adequacy measure and Bartlett's sphericity test. The Kaiser-Meyer-Olkin testing allows us to determine how well data fit for factor analysis and measures sampling adequacy for each model variable and the entire model. The obtained values, according to Kaiser-Meyer-Olkin testing from 0.5 to 1, indicate the adequacy of the factor analysis; values up to 0.5 mean that factor analysis cannot be used for these input samples. Bartlett's sphericity test is used to check whether the correlations of the studied indicators are different from 0. If the value of the correlation coefficient is close to zero, then the selected variable is not interconnected with others. A significance of less than 0.05 indicates that the factor analysis is acceptable.

The test results (KMO = 0.768882; Chi-square = 179,298; DF = 45; P-value = 0.0) confirmed the quality of the factor analysis.

The next step is to build a multiple regression that describes independent indicators' impact on the performance indicator – ease of doing business. In order to determine which indicators are the most influential, the accumulated variance (Estimated Communalities) was analysed. Accordingly, four indicators with the largest variance were selected: k5 (digital development indicator) – 0.91683, k6 (human development index) – 0.937172, k8 (digital trust) – 0.802647, k9 (financial literacy index) – 0.828045.

The multiple regression was built with dependent variables – k1 (ease of doing business) and independent variables – k5 (digital development index), k6 (human development index), k8 (digital trust), and k9 (financial literacy index). As a result of constructing the regression model, the following equation was obtained:

$$k1 = 4,60422E - 11 + 0,821542 * k5 + 0,271888 * k6 - - 0,0761361 * k8 - 0,252757 * k9 \quad (2)$$

Indicators k8 (digital trust) and k9 (index of financial literacy) have an inversely proportional (inverse) relationship with the resulting indicator k1 (ease of doing business). However, based on the logical content of indicators k8 (digital trust) and k9 (index of financial literacy), it is obvious that the dependence should be directly proportional, so let us check for multicollinearity in the regression model using the Backward Stepwise Selection hard screening procedure in the Statgraphics 19 software.

Multicollinearity was found between indicators k8 (digital trust) and k9 (index of financial literacy), so the regression equation for indicator k1 (ease of doing business) takes the following form (Tables 4-5):

$$k1 = 2,8077E - 11 + 0,786154 * k5 \quad (3)$$

Table 4 presents multiple regression results.

Table 4. Multiple regression results

| Variable | Estimation | Standard Error | t-statistic | p-value | 95.0% confidence interval | |
|----------|------------|----------------|-------------|---------|---------------------------|----------|
| Const. | 2,8077E-11 | 0,119022 | 2,35898E-10 | 1,0000 | -0,244653 | 0,244653 |
| k5 | 0,786154 | 0,121206 | 6,48611 | 0,0000 | 0,537012 | 1,0353 |

Sources: developed by the authors based on Statgraphics.

Table 5 shows an analysis of variance results.

Table 5. Analysis of variance results (ANOVA)

| Sources | Squares sum | Df | Square mean | f-ratio | p-value |
|---------------|-------------|----|-------------|---------|---------|
| Model | 16,687 | 1 | 16,687 | 42,07 | 0,0000 |
| Residual | 10,313 | 26 | 0,396653 | | |
| Total (Corr.) | 27,0 | 27 | | | |

Sources: developed by the authors based on Statgraphics.

Therefore, when the value of the k5 indicator increases by 1% (digital development indicator), the result indicator of k1 (ease of doing business) will also increase by 0.79% on average.

The coefficient of determination for the model has a value of 61.8038; that is, it covers 61.80% of the dependent indicator variability (ease of doing business). The built model accepts well with original data. Also, the p-value is less than 0.05. Accordingly, there is a significant dependence on the 95.0% confidence interval.

Thus, digital development is the most important of the considered triggers for improving the business process.

Conclusions. Indicators of innovative education that most significantly contribute to the ease of doing business were identified based on data samples from 28 world countries and applying the complex research methods including descriptive, correlation, factor, and regression analysis, special tests for quality and significance confirmation and specific program software.

Firstly, the four most influential factors from the nine investigated were singled out: digital development indicator, human development index, digital trust, and financial literacy index. At the same time, the analysis of the developed multiple econometric models describing the dependence of the above indices and the performance indicator of ease of doing business revealed signs of multicollinearity between independent variables. So secondly, due to the hard screening procedure, a statistically significant model of the effect of digital development indicators on the ease of doing business was built. It was grounding that ease of doing business will increase by 0.79% with an increase in the value of digital development by 1%.

However, the obtained results have certain limitations because of the number of sample countries and the period, which should be expanded in the future, as well as the number and list of factors selected for analysis, to which other variables can also be added in the future.

Nevertheless, the obtained results can be useful to scientists for further research, as well as to change-makers in the field of education and business and to all stakeholders in the direction of 'business–education' cooperation.

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Вплив освіти на легкість ведення бізнесу в умовах інноваційного розвитку: факторний аналіз та множинна регресія

Освіта є вагомим прискорювачем змін і перетворень у суспільному житті, а також одним із головних факторів прогресу та розвитку як загалом, так і у сфері бізнесу, зокрема. У статті обґрунтовуються та формалізуються взаємозв'язки між показниками рівня освіти (з урахуванням її інноваційного розвитку) та легкості ведення бізнесу на основі вибірки з двадцяти восьми країн світу та даних Світового банку, Організації Об'єднаних Націй, Університету Тафтса та рейтингових служб Standard & Poor's. Метою статті є визначення показників інноваційної освіти, які найбільш суттєво сприяють полегшенню ведення бізнесу. Для цього здійснюється когнітивний аналіз статистичних даних і за допомогою засобів описативного аналізу формується статистично значущий ознаковий простір показників. Перевірка щільності та спрямованості зв'язку здійснюється шляхом обчислення значень коефіцієнтів кореляції Пірсона. Багатовимірність простору вхідних ознак зводиться до чотирьох найвпливовіших показників із дев'яти досліджуваних факторів (індикатор цифрового розвитку; індекс людського розвитку; цифрова довіра, індекс фінансової грамотності) шляхом застосування процедури аналізу головних компонент та ортогонального перетворення за допомогою методу Varimax у пакеті програмного забезпечення Statgraphics Centurion 19. Якість факторизації підтверджується тестом Кайзера-Майєра-Олкіна та критерієм сферичності Бартлетта. У результаті розроблених декількох економетричних моделей, які описують залежність легкості ведення бізнесу від вищезазначених показників, і процедури жорсткого відбору Backward Stepwise Selection у Statgraphics 19, будується та описується статистично значуща модель впливу цифрового розвитку на легкість ведення бізнесу із перевіркою на її адекватність. Виявляється, що зі збільшенням показника оцінки цифрового розвитку на 1% легкість ведення бізнесу також збільшується в середньому на 0,79%. Отримані результати можуть бути корисними науковцям для подальших досліджень, а також законотворцям у сфері освіти та бізнесу, та всім стейкхолдерам у напрямку коопетиції «бізнес – освіта».

Ключові слова: бізнес, викладачі, витрати, вища освіта, людський розвиток, фінансова грамотність, цифрова довіра, цифрова еволюція, школа.