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THE MODELING OF STARTUP ECOSYSTEMS IN CENTRAL AND EASTERN EUROPE BASED ON SOCIO-ECONOMIC INDICATORS

The article solves the problem of building a model to describe the development of the startup ecosystem in Central and Eastern Europe (CEE) based on the analysis of a set of indicators. The European experience in developing startup ecosystems has been analyzed. Structural components of the startup ecosystem have been outlined, their role in the functioning of the system and interconnections has been defined. The functioning of startup ecosystems in European countries has been described. Possible directions for the application of European experience in the development of startup ecosystems in Ukraine have been studied. A model has been built to determine the dependence of the ecosystem value on the influence of a set of significant indicators, namely: the number of unicorns, future unicorns, VC funding, the number of exits, employees. The developed model allows predicting the development of the startup ecosystem of the countries of the world.

Keywords: ecosystem, startup ecosystem, entrepreneurial ecosystem, unicorn startups, ecosystem value, VC funding, unicorn, number of exits, number of funding rounds
JEL classification: ***O3, M2, E26***

Стаття присвячена вирішенню проблеми розвитку стартап-екосистем у країнах Центральної та Східної Європи (зокрема українського підприємництва після здобуття Україною незалежності) шляхом переорієнтації їхньої економіки на ринкову економіку та проведення її на засадах сталого розвитку, етики та соціальної відповідальності. Виявлено, що у досліджуваних країнах велика кількість механізмів і процедур не повністю адаптована до здійснення підприємницької діяльності на основі системності, комплексності та взаємодії; присутні лише точкові елементи, а ефективність їх взаємодії в процесі підприємницької діяльності досить низька. При цьому спостерігається стрімкий розвиток екосистем стартапів. Визначення цього поняття в статті розглядається з точки зору науковців як «поєднання локалізованих культурних поглядів, соціальних мереж, інвестиційного капіталу, університетів та активної економічної політики, що створює середовище, яке підтримує інноваційний бізнес, і Startup Genome, який трактує екосистему стартапів як «набір ресурсів (політики, акселератори, інкубатори, коворкінги, навчальні заклади та групи фінансування), які здебільшого розташовані в радіусі 100 кілометрів навколо центральної точки в певному регіоні, за кількома винятками, заснованими на місцевих реаліях». Встановлено, що на даний момент теоретична концепція підприємницької екосистеми є недостатньо розробленою, що не дозволяє однозначно трактувати її склад, а також визначити вплив на розвиток стартапів. Виявлено, що центральним рушієм екосистем стартапів найчастіше вважають університети як центри освіти та рушійні сили інноваційного зростання. Саме інновації визначаються як джерело розвитку підприємництва. Вищевикладене стало основою для розгляду та можливого вирішення проблеми побудови моделі, що описувала б розвиток стартап-екосистеми країн Центральної та Східної Європи на основі аналізу набору показників, що характеризують стартап-екосистему за методологією Dealroom.co, де найпопулярніші та ті, що мають екосистемне значення є найповнішим описом розвитку екосистеми стартапу. Проаналізовано європейський досвід розвитку стартап-екосистем. Відображено структурні компоненти екосистеми стартапів, визначено їх роль у функціонуванні системи та їх взаємозв’язки. Описано функціонування екосистем стартапів у країнах Європи. Досліджено можливі напрямки застосування європейського досвіду розвитку стартап-екосистем в Україні. Водночас уряд України вважає пріоритетами у подальшому розвитку IT-індустрію та військові технології (високотехнологічне озброєння), що особливо актуально під час військових дій. Дослідження було перевірено на екосистемі стартапів Греції, і було виявлено, що найбільш суттєвими проблемами, які впливають на успішний розвиток стартапів, є проблеми на державному рівні, що пов’язані з податковими пільгами та прискоренням процедур стартапів.. Побудовано модель, яка визначає залежність вартості екосистеми від дії набору значущих факторів.

Ключові слова: екосистема, стартап екосистема, підприємницька екосистема, стартапи-єдинороги, цінність екосистеми, фінансування VC, єдиноріг, кількість виходів, кількість раундів

JEL classification: ***O3, M2, E26***

General statement of the problem and its relation to important scientific or practical tasks.

Ukrainian entrepreneurship has gone through a difficult path of development since the country gained independence. The bitter legacy of the planned administrative command economy and paternalistic policy, when entrepreneurial culture, understanding of market mechanisms and entrepreneurial thinking were almost destroyed, is still reflected in the specifics of doing business. Only with Ukraine’s independence did its economy begin to be market oriented. For 30 years, Ukrainian entrepreneurship has gone from a business closely associated with criminal activity to one that is based on sustainable development, ethics and social responsibility. This path has not been completed to the end - a large number of mechanisms and procedures are not fully adapted for the implementation of entrepreneurial activities on the basis of consistency, complexity and interaction; only point elements are observed, the effectiveness of their interaction in the process of entrepreneurial activity is quite low. At the same time, it is worth noting a rapid development of the startup ecosystem, which took place before the war in Ukraine, and its sustainability during military operations. It should be noted that the platform Advantage Ukraine [1], which presents promising projects for investment in Ukraine, highlights innovative technologies, represented by more than 2,000 start-up market players and an investment potential of $11 billion. In addition, the Ukrainian government singles out the IT-industry and military-tech (high-tech weapons) as priorities for further development. In this regard, the study of the state, features and trends in the development of startup ecosystems in Central and Eastern Europe (CEE) during the war years is an important and relevant scientific task.

Analysis of recent research and publications in which the solution of this problem was initiated and on which the authors rely.

Ecosystem theory stems from biological sciences. It appeared in the economic space in the late 20th century, when James Moore [9] introduced the term "entrepreneurial ecosystem". The peculiarity of the ecosystem approach in the economy as a whole and entrepreneurship in particular is that the agents of the national economy are considered not only as competitors but also as partners, whose interaction is appropriate and mutually beneficial, creates synergy and allows for sustainable development. Also, the ecosystem approach is based on a combination of the internal and external environment that should promote the development of national economic agents and ensure rapid growth of entrepreneurship. Currently, the concepts of entrepreneurial ecosystem and startup ecosystem as a component of an entrepreneurial ecosystem are widely used.

Its understanding is ambiguous and is considered both at the scientific and at more practical levels. For example, in the works [13, 15], the authors define a startup ecosystem as "a union of localized cultural outlooks, social networks, investment capital, universities, and active economic policies that create environments supportive of innovation-based business". Startup Genome interprets a startup ecosystem as "a shared pool of resources, usually located within a 60-mile (100 km) radius of a central point in a given region, with some exceptions based on local reality. Resources typically include policymakers, accelerators, incubators, coworking spaces, educational institutions, and funding groups [11]".

It can be stated that at the moment the theoretical concept of entrepreneurial ecosystem is not sufficiently developed and does not allow for an unambiguous interpretation of its composition, as well as determination of its impact on the development of startups. Most often, universities are considered the central driver of startup ecosystems as centers of education and driving forces for innovative growth. It is innovations that are considered to be the source of entrepreneurship development [12]. Accordingly, the key role in the theory of startup ecosystems is played by the triple helix model, which is based on the assertion that innovations are generated and implemented by academia (the university), industry, and government [5, 6]. The model was extended by Carayannis, E. G.; Campbell, D. F considering the role of culture, civil society and the media [2]. The so-called Quadruple Helix Model was reflected and expanded in the study [15], which singled out the following components: funding, government intervention, networking and support, human research, education and research. The study was tested on the Greek startup ecosystem and showed that the most significant factors affecting the startup successful development are governmental issues, such as tax incentives and acceleration of startup procedures, availability of financing opportunities, stakeholder communication, entrepreneurial education, previous startup experience, incubator support, and mentorship.

Research [14] proves that the functioning of the ecosystem affects the entrepreneurship productivity. The authors identify 10 components of the entrepreneurial ecosystem, including 3 – formal institutions, culture, networks – that are the basis for another 7: physical infrastructure, demand, intermediaries, talent, knowledge, leadership, finance.

These approaches are based on the consideration of startup ecosystems in individual countries and combine qualitative and quantitative research methods.

The study of international indices that characterize the startup ecosystem, e. g., Global Startup Ecosystem Index 2022 developed by StartupBlink [10], indicates the presence of several components (quantitative, qualitative ones, and business environment) described by a set of various indicators the composition of which is not fixed and changes from year to year.

Another company – Dealroom.co – a global provider of data on startups and technology ecosystems, uses a set of indicators to describe startup ecosystems, including: number of startups, number of unicorns, future unicorns, number of funding rounds, VC funding, exit volume, employees, ecosystem value, new funds [4]. This resource is constantly updated, which allows for obtaining up-to-date data, and has a consistent methodology for measuring indicators.

Description of the startup ecosystem according to this method requires a more complete disclosure of the essence of the following indicators:

− ecosystem value is a measure of economic impact and is calculated as the value of exits and startup valuations; economic impact of ecosystem in turn is calculated as the total exit valuation and startup valuations over two-and-a-half-years.

− VC financing at the expense of venture capital;

− unicorn is a company with a valuation of more than $1B;

− exit is *the amount of money that an investor would receive if the company were to be sold or go public*;

− number of funding rounds is *rounds that have been funded*. Startups are financed in stages, in separate rounds, which allows evaluating the results of financing and making an informed decision.

It is the value of the ecosystem that is the most popular indicator used to analyze the success of startup ecosystems. The researchers say that each ecosystem is unique, and, in the previous studies [8], the author and co-authors determined certain patterns of development of startup ecosystems and conditions for their growth.

Identification of previously unresolved parts of the general problem considered in the article.

Despite the high scientific interest in this topic and the relevance of research, it should be noted that the indicators that influence the development of startup ecosystems at different levels – international, national, etc. – and the models to describe them are not fully defined.

Formulation of the purpose of the article (problem statement).

The purpose of the article is to build a model to describe the development of the startup ecosystem in Central and Eastern Europe based on the analysis of a set of indicators.

Presentation of the main research material with a full justification of the scientific results obtained.

According to a study by Dealroom.co and Google for Startups and Atomico [4], the total aggregate value of all Ukrainian startups in 2022 is estimated at €23.3B (compared to €27.1B in 2021). An analysis of the CEE region in terms of startups shows a rapid increase in their value (Table 1). In general, it should be noted that CEE is one of the fastest-growing regions in terms of VC funding in Europe, which has increased 7.6 times since 2017 (from €5.3B to €40.28B).

The analysis of the enterprise value of startups shows an average 3.3-fold increase over 5 years (from 2017 to 2022), with Europe as a whole showing a below-average growth, and the CEE region showing a 4-fold growth above the global and European average – from €47B to €190 B. The start-up value trend across the region indicates that Croatia, Lithuania and Ukraine posted the fastest growth in total enterprise value since 2017. It should be noted that the higher the value of start-ups in countries in 2017, the lower the growth over the last 5 years studied. For example, Poland, with an enterprise startup value of €11.8B, showed a 3.2-fold growth, and, in 2022, the value of its startups amounted to €36.8B (the highest figure among CEE countries). Estonia, where in 2017 the corporate value of startups was even higher than in Poland (€11.8B), showed

Table 1

Growth of enterprise value of startups (built based on [4])

Country / region	2017	2022	Growth (times)
Global average (excluding China), $K	6.9	22.8	3.3
Europe average, $K	1.1	3.4	3.1
Nordics, $B	129	468	3.6
Central and Eastern Europe, €B	47	190	4.0
1 Lithuania, €B	0.6	10	16.6
2 Croatia, €B	0.3	4.7	15.7
3 Ukraine, €B	2.5	23.3	9.3
4 Bulgaria, €B	0.6	4.8	8.0
5 Romania, €B	1.2	8.1	8.8
6 Hungary, €B	1.4	7.6	5.4
7 Czechia, €B	6.9	30.2	4.4
8 Poland, €B	11.4	36.8	3.2
9 Estonia, €B	11.8	36.3	3.1
10 Rest of CEE, €B	2.6	7.8	3.0

a lower (3.1-fold) growth rate, and, in 2022, demonstrated a value lower than Poland's (€36.8B).

In 2022, 4 CEE countries received more than 70 % of the total VC funding (Estonia – €1.4B, Czech Republic – €1.1B, Croatia – €865M, Poland – €550M). Ukraine ranked 6th with €246M. In 2022, compared to 2020, the startup ecosystem of Ukraine increased 3.3 times – from €7.0B to €23.3B (compared to 2017 (€2.5B) – 9.3 times). In the previous period of 2017-2022, the leaders in VC funding (without mega rounds) were: Poland (€2.3B); Estonia (€2.1B), Czech Republic (€1.3B) and Croatia, which ranked 7th (€550M+).

It should be noted that in the Startup Blink ranking of startup ecosystems in 2022 [10], the positions of Ukraine and the CEE countries have changed compared to the previous ones. Among the 100 countries represented in the ranking, Estonia took the highest position – 13th place – and this position did not change compared to 2021. Lithuania, which showed the highest growth among CEE countries in the ranking, dropped by 1 point and ranked 17th in 2022. The Czech Republic held its position at 32nd for two years, unlike Poland, which lost 3 points and ranked 33rd. Bulgaria ranked 36th in 2022 with a loss of 1 point compared to 2021. At the same time, Romania, which showed an increase of 2 points in 2022, was 39th in the ranking. Croatia, which ranked 2nd in terms of startup growth in CEE countries, fell 8 points in the overall ranking and ranked 45th in 2022. The largest drop (-16 points) was experienced by Ukraine's startup ecosystem due to russia's military aggression and dropped to 50th place. in the ranking. In the same year, Hungary ranked 51st due to a 2-point drop from its position in the 2021 rankings.

This shows that the growth of startup ecosystems is driven not only by funding, but also by other indicators such as mentorship, business environment, etc.

An analysis of the CEE startup ecosystem is presented in Table 2.

From the analysis of startup ecosystems of CEE countries, it can be seen that Poland is the leader. Its ecosystem is valuated at $43.0B and it has 11 unicorn startups with the VC funding of $2.2B (less than Estonia with $3.3B).

To summarize, we can state that, among CEE countries, Poland takes a leading position due to the cumulative effect, but, based on the results of the last year, its growth has been slowing down. In the overall ranking of enterprise value of startups, it ranks 8th (compared to 2017, it shows a 3.2-fold growth, which is lower than the average for CEE countries – a 4-fold growth).

Table 2

Analysis of the most promising CEE ecosystems (as of March 7, 2023)

Country	Number of startups	Number of unicorns	Future unicorns	Number of funding rounds	VC funding, mln. $	Amount of exits, $	Employees	Ecosystem value, $	New funds, $
Poland	3283	11	3	1788	2200	18700	48000	40300	1300
Czech Republic	1646	4	1	883	2200	18600	17000	25600	1800
Romania	1572	0	1	392	666	934	24000	3500	136
Estonia	1490	2	2	716	3300	701	12000	14600	765
Hungary	1471	0	2	486	677	6700	15000	2600	871
Ukraine	1459	0	0	376	245	4	17000	823	115
Lithuania	1082	3	4	512	1300	1800	16000	10000	356
Greece	938	2	2	269	1000	7200	7198	8000	455
Bulgaria	799	0	0	384	345	2000	7229	1200	351
Slovenia	601	0	0	117	181	625	6678	656	–
Latvia	587	0	1	337	342	17.7	4106	1000	206
Slovakia	432	0	1	175	369	110	3822	1300	13.2
Belarus	337	0	0	60	70.6	13.2	3842	257	–
Albania	149	0	0	9	10.1	–	359	52.8	–
Moldova	87	0	0	18	14.2	15	277	109	–
North Macedonia	77	0	0	24	13.5	–	272	58.5	–
Bosnia and Herzegovina	73	0	0	6	330	–	1330	1.6	–
Kosovo	30	0	0	9	9.3	–	303	35.1	–
Montenegro	17	0	0	2	13.8	–	219	69	

The Ukrainian startup ecosystem demonstrates resilience and a significant growth potential: the 3rd place in the ranking of enterprise value of startups for 2017-2022; the 6th place in the ranking of VC funding in 2022; the 7th place in the ranking of startup ecosystems by country.

To determine the impact and significance of various quantitative indicators of startup ecosystems on ecosystem value (as a resulting indicator), it was proposed to apply methods of economic and mathematical modeling. The calculations were carried out using the SPSS Statistics software.

Regression analysis is appropriate for making predictions, testing hypotheses, and identifying hidden relationships in the data.

The equation of the linear regression model is as follows:

$$y = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k + u \quad (1)$$

where y is the dependent variable;

$(x_1, x_2, ..., x_n)$ are the independent variables;

u is a random error whose distribution generally depends on the independent variables, but whose mathematical expectation is zero.

Using Automatic Linear Modeling, we can determine the overall significance, possible variations with different criteria, and the weighting of the predictors of the future mathematical model.

Having built an economic and mathematical model, where the dependent value is represented by the value of the ecosystem, and the independent ones are represented by all other indicators, we obtain the accuracy of the proposed model at the level of 99.5% (Fig. 1).

The choice of the optimal model is carried out on the basis of a set of proposed possible variations, taking into account the information criterion (preferably the minimum value of the indicator, since models with this indicator are better suited) and ranking the indicators according to the degree of influence on the resulting one (Table 3).

The method of model building implies choosing the best subsets according to the information criterion. A check mark means that this effect is present in the model.

The target field, where the importance of the most significant predictors – number of unicorns, future unicorns, VC funding, amount of exits, employees – is presented in relation to the ecosystem value indicator in Fig. 2.

This figure shows that the most important indicator is number of unicorns, the significance of which is almost 60 %. The dependence of the indicators of number of unicorns and ecosystem value is quite high, so it is advisable to graphically display their dependence using a scatter plot (Fig. 3).

Based on the results obtained from aggregating the data of the models, taking into account the set of information criteria and the plot demonstrating the weights of predictors, we can build a linear regression model where the predictors are VC funding, employees, future unicorns, number of exits, number of unicorns and the dependent variable is ecosystem value.

Thus, Model 1 of the proposed options is the most attractive, as it has the lowest value of the information criterion and contains all the most significant input components. With the help of the linear regression, using SPSS Statistics application we calculate: the

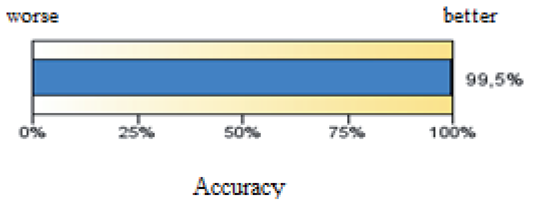

Fig.1. Information on the model quality
(built by the authors based on calculations in SPSS Statistics)

Table 3

Matrix of possible variations of the models built using Automatic Linear Modeling
(built by the authors based on calculations in SPSS Statistics)

Names	1	2	3	4	5	6	7	8	9	10
Information criterion	264.4	267.3	268.7	269.4	269.4	269.4	269.6	269.8	270.4	272.3
Number of unicorns	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Future unicorns	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
VC funding	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Amount of exits	✔		✔	✔	✔	✔	✔			
Employees	✔	✔	✔	✔		✔				✔
New funds		✔				✔		✔	✔	✔
Number of startups			✔				✔		✔	✔
Number of funding rounds				✔						

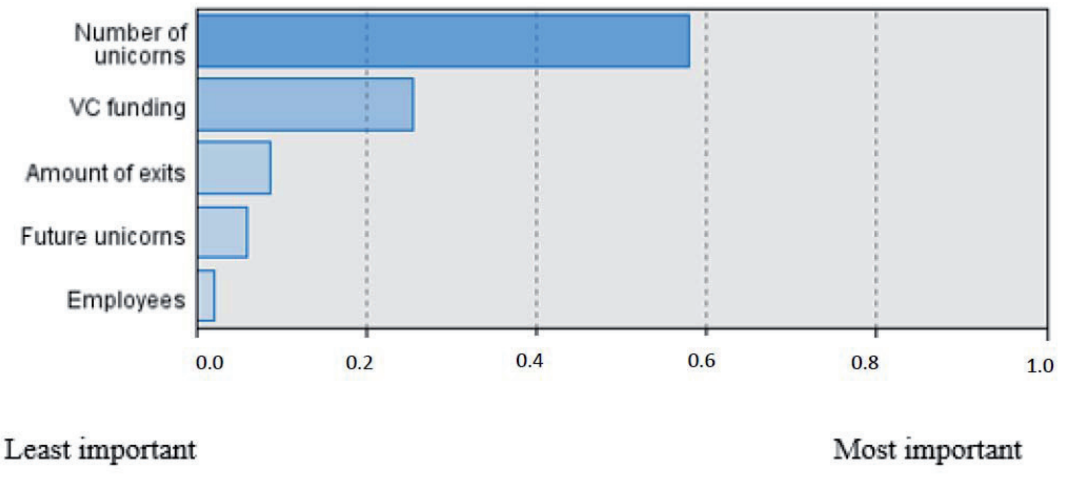

Fig.2. The weight of model predictors with the resulting indicator of ecosystem value
(built by the authors based on calculations in SPSS Statistics)

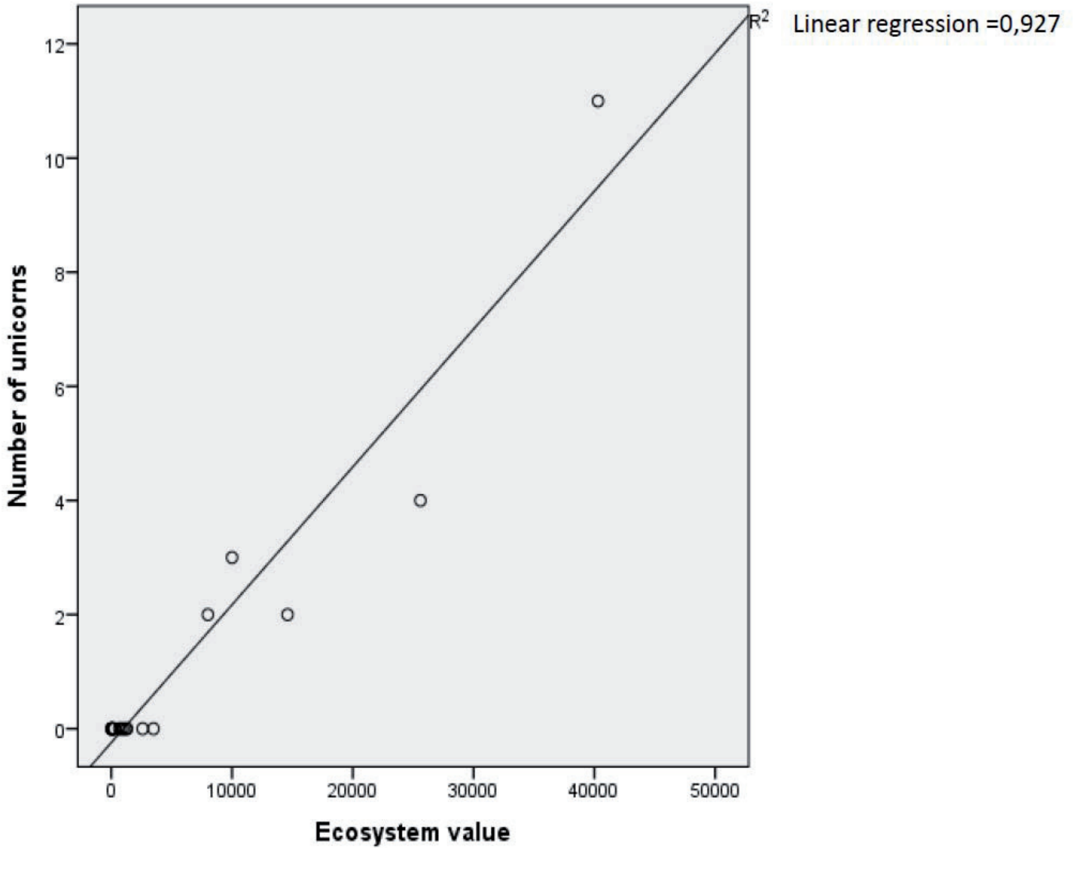

Fig. 3. Scatter plot
(built by the authors based on calculations in SPSS Statistics)

coefficient of determination, which explains the degree of dispersion of the resultant input values; Fisher's statistic to obtain an estimate of the significance of indicators and their interaction; Durbin-Watson (DW) statistics for autocorrelation analysis (Table 4).

The coefficient of determination (R^2) for the model of dependence of the random variable *y* on the indicator *x* is calculated as follows:

$$R^2 = 1 - \frac{D[y|x]}{D[y]} = 1 - \frac{\sigma^2}{\sigma_y^2}, \quad (2)$$

where $D[y] = \sigma_y^2$ is the variance of the random variable;

$D[y|x] = \sigma^2$ is the conditional (by indicator *x*) variance of the dependent variable.

In the case of a linear regression model with a constant, we have the following expression:

$$R^2 = \frac{SS_{reg}}{SS_{tot}}, \quad (3)$$

The explained sum of squares is

$$SS_{reg} = \sum_{i=1}^{n} (\hat{y}_i - \underline{y})^2, \quad (4)$$

The total sum of squares is

$$SS_{tot} = \sum_{i=1}^{n} (y_i - \underline{y})^2 = n\hat{\sigma}_y^2, \quad (5)$$

$$\underline{y} = \frac{1}{n}\sum_{i=1}^{n} y_i, \quad (6)$$

where y_i, $\hat{y}_i$ are actual and estimated value of the explanatory variable.

The adjusted coefficient of determination is used to compare the model with a different number of indicators, so that the number of these indicators will not affect the R^2:

$$\underline{R}^2 = R_{adj}^2 = 1 - \frac{\frac{SS_{reg}}{n-k}}{\frac{SS_{tot}}{n-1}} = 1 - (1 - R^2)\frac{n-k}{n-1} \le R^2 \quad (7)$$

In general terms, the Fisher's criterion is used to compare the variance of two random samples with a normal distribution according to the formula:

$$F = \frac{D_1}{D_2} \quad (8)$$

where D_1 is the higher variance;

D_2 is the lower variance.

The Durbin-Watson statistic is a test for the autocorrelation in the first-order residuals from a regression model, calculated using the following formula:

$$d = \frac{\sum_{t=2}^{n} (\epsilon_t - \epsilon_{t-1})^2}{\sum_{t=1}^{n} \epsilon_t^2} \approx 2(1 - p_1), \quad (9)$$

where $\epsilon\epsilon$ is the regression residual;

p is the first-order autocorrelation coefficient.

There is no autocorrelation if the following condition is met:

$$d1 < DW \text{ та } d2 < DW < 4 - d2 \quad (10)$$

We can use an approximate rule and assume that there is no autocorrelation in the residuals if $1.5 < DW < 2.5$.

The R and R^2 values tend to 1 (0.998 and 0.995, respectively), demonstrating a high correlation (according to the Chaddock scale, the values within 0.9-0.99 indicate a very strong correlation). Consequently, the data provided by the model will be reliable, since 99.5 % of the change in the output variable is determined by the influence of input variables. The Durbin-Watson statistic is used to test the null hypothesis for autocorrelation in the residual vector of the regression model. The value of the index tends to 2, which indicates the absence of autocorrelation. The Fisher coefficient has a rather high value F = 558.680, which also characterizes the developed model positively.

The model developed on the basis of the multiple regression and tested according to the Fisher statistic, is adequate and characterizes the influence of these indicators on the final result.

Thus, we proceed directly to the calculation of the coefficients needed to determine the equation of the linear regression model (Table 5).

To calculate the empirical value of the t-criterion (Student's t-test) for testing the hypothesis about the differences between two dependent samples (e.g., two samples of the same test with a time interval) the following formula is applied:

$$t = \frac{|M_d|}{\frac{\sigma_d}{\sqrt{N}}}, \quad (11)$$

where $|M_d|$ is the mean difference in the values;

σ_d is the standard deviation of the difference between the values.

Table 4

Aggregate quality indicators of the developed economic and mathematical model

Indicator	Value
R	0.998[a]
R^2	0.995
Adjusted R^2	0.994
F	558.680
Durbin-Watson (DW)	1.590

Table 5

Coefficients of the regression equation

Model	Non-standardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
	B	Std. error	Beta			Tolerance	VIF
(Constant)	-148.123	273.731		-0.541	0.598		
Number of unicorns	2369.953	178.311	0.595	13.291	0.000	0.445	2.250
Future unicorns	-895.604	251.948	-0.101	-3.555	0.004	0.178	5.616
VC funding	3.441	0.331	0.299	10.397	0.000	0.298	3.351
Amount of exits	0.409	0.062	0.227	6.558	0.000	0.327	3.057
Employees	0.046	0.028	0.054	1.648	0.23	0.430	2.325

Only those regression coefficients that are statistically significant (t-value) can be accepted in the equation. Standardized regression coefficients (Beta) are measures of the contribution of each variable to the regression model.

It should be noted that the value of Variance Inflation Factor (VIF) for each independent variable is less than 10, i.e., the effect of multicolinearity is not observed, and the regression model is acceptable for further work.

Based on the results, we have the following linear regression equation:

$$y = 2369.953x_1 - 895.604x_2 + 3.441x_3 + 0.409x_4 + 0.046x_5 - 148.123,$$

where y is the ecosystem value, $M;

x_1 is the number of unicorns;

x_2 is the future unicorns;

x_3 is the VC funding;

x_4 is the amount of exits;

x_5 is employees.

As can be seen from the equation, number of unicorns has the greatest positive impact on ecosystem value. This means that conditions must be created in the country to ensure the launching of startups and their development to the market capitalization of $1B. VC funding, number of exits, and employees also have a positive impact on ecosystem value. It should be noted that future unicorns exert a rather strong and negative impact on ecosystem value.

The proposed model was tested for all CEE countries (Table 1) and showed its relevance only for those countries in which the indicator of the number of unicorns does not have zero values. Thus, it can be concluded that the presence of unicorn startups in a country plays a crucial role in increasing its ecosystem value and developing the ecosystem as a whole.

Accordingly, different scenarios of startup ecosystem development should be used for countries with and without unicorn startups.

Based on the linear regression equation, it is possible to calculate the estimated ecosystem value for different CEE countries. Let us consider, for example, the calculations made for the leaders in terms of startup ecosystem indicators, at a possible increase in the input values by 2 %, 5 % and 10 % (Table 6).

In accordance with the calculated data presented in Table 6, we can build graphs of the forecast change in the ecosystem vale (Fig.4).

Table 6

Forecast trends in the share of ecosystem value
(calculated and built by the authors)

Names	Reference value	Increase by			
		2 %	5 %	10 %	20 %
	Poland				
Number of unicorns	11	11.22	11.55	12.1	13.2
Future unicorns	3	3.06	3.15	3.3	3.6
VC funding	2200	2244	2310	2420	2640
Amount of exits	18700	19074	19635	20570	22440
Employees	48000	48960	50400	52800	57600
Ecosystem value (calculated according to the model)	40300	41477.23	42701.51	44741.97	48822.88
	Czech Republic				
Number of unicorns	4	4.08	4.2	4.4	4.8
Future unicorns	1	1.02	1.05	1.1	1.2
VC funding	2200	2244	2310	2420	2640
Amount of exits	18600	18972	19530	20460	22320
Employees	17000	17340	17850	18700	20400
Ecosystem value (calculated according to the model)	24395.69	24886.56	25622.88	26850.07	29304.45
	Estonia				
Number of unicorns	2	2.04	2.1	2.2	2.4
Future unicorns	2	2.04	2.1	2.2	2.4
VC funding	3300	3366	3465	3630	3960
Amount of exits	701	715.02	736.05	771.1	841.2
Employees	12000	12240	12600	13200	14400
Ecosystem value (calculated according to the model)	14994.58	15297.44	15751.72	16508.85	18023.13
	Lithuania				
Number of unicorns	3	3.06	3.15	3.3	3.6
Future unicorns	4	4.08	4.2	4.4	4.8
VC funding	1300	1326	1365	1430	1560
Amount of exits	1800	1836	1890	1980	2160
Employees	16000	16320	16800	17600	19200
Ecosystem value (calculated according to the model)	9324.82	9514.28	9798.47	10272.11	11219.41
	Greece				
Number of unicorns	2	2.04	2.1	2.2	2.4
Future unicorns	2	2.04	2.1	2.2	2.4
VC funding	1000	1020	1050	1100	1200
Amount of exits	7200	7344	7560	7920	8640
Employees	7.2	7.34	7.56	7.92	8.64
Ecosystem value (calculated according to the model)	9186.71	9373.40	9653.448	10120.19	11053.67

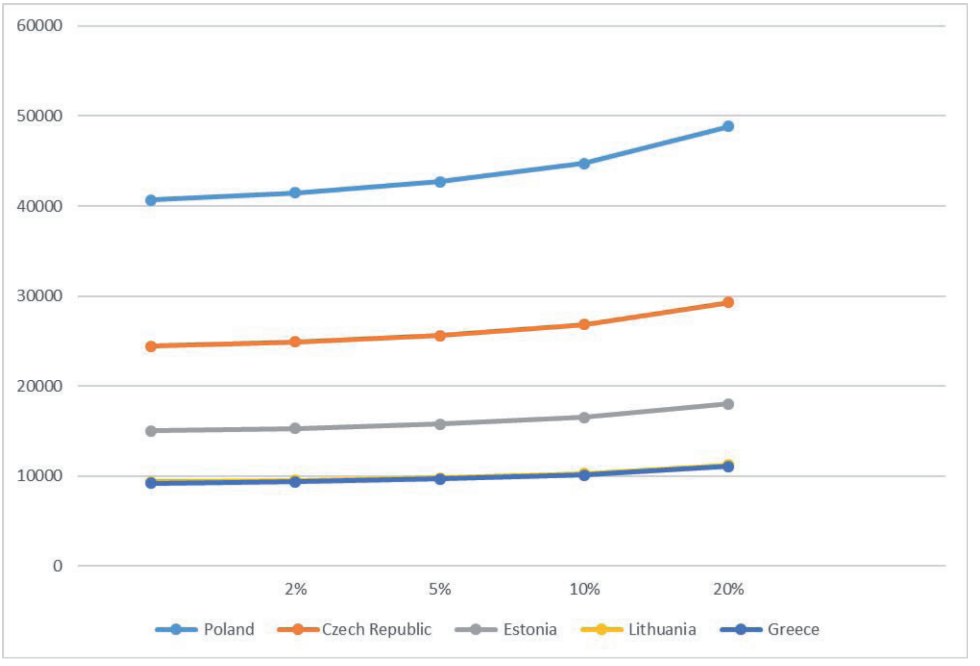

Fig.4, Forecast trends in the share of ecosystem value by individual CEE countries
(calculated and built by the authors)

Conclusions from this study and the prospects for further research in this direction.

1) It was found that the startup ecosystems of Central and Eastern Europe show higher growth than the global and European average.

2) According to the Dealroom.co methodology, a set of indicators that characterize the startup ecosystem was identified. It was proved that ecosystem value is the most popular among them and provides a fuller description of the development of the startup ecosystem.

3) The regression and correlation analysis of a set of indicators (number of unicorns, future unicorns, VC funding, number of exits, employees, new funds, number of startups, number of funding rounds) made it possible to identify five of them, which are the most important for the ecosystem value of the country.

4) A model has been built that determines the dependence of the value of the ecosystem on the action of many significant factors, including: the number of unicorns, future unicorns, VC funding, the number of exits, employees. This allows predicting the development of the country's startup ecosystem. The adequacy and effectiveness of the proposed model was confirmed for a country with non-zero values of the indicator of the number of unicorns. This demonstrates the importance of creating an environment that ensures startup capitalization to the level of unicorns, which is the primary condition for the growth of a country's ecosystem value. Accordingly, all countries with non-zero values of this indicator are in the upper part of the rating. For other countries, other models should be used and, accordingly, other strategies for developing the country's startup ecosystem.

Bibliography

1. Advantage Ukraine (2023). Available at: https://advantageukraine.com/ (accessed 15 March 2023).

2. Carayannis, E.G.; Campbell, D.F. *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters: A Comparative Systems Approach across the*

United States, Europe, and Asia [Greenwood Publishing Group]. Santa Barbara, CA, USA, 2006.

3. Central and Eastern European startups (2022). Available at: https://dealroom.co/uploaded/2022/11/Dealroom-GoogleAtomicCredo-CEE-2022.pdf (accessed 15 March 2023).

4. Dealroom (2023). Available at: https://dealroom.co/about (accessed 15 March 2023).

5. Etzkowitz, H. *Innovation in Innovation: The Triple Helix of University-Industry-Government Relations,* [Соц. Sci. Інф.], 2003 , no. *42* , pp. 293–337.

6. Etzkowitz, H.; Leydesdorff, L. T*he Triple Helix–University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development*. [EASST Rev.], 1995, vol. 14, pp. 14–19

7. Global Startup Ecosystem Index (2022). Available at: https://www.startupblink.com/startupecosystemreport (accessed 15 March 2023).

8. Kyzym, M., Dymchenko, O., Smachylo, V., Rudachenko, O., Dril, N. (2023). *Cluster Analysis Usage as Prerequisite for Implementing Strategies of Countries Startup Ecosystems Development.* [In: Arsenyeva, O., Romanova, T., Sukhonos, M., Tsegelnyk, Y. (eds) Smart Technologies in Urban Engineering. STUE 2022. Lecture Notes in Networks and Systems], 2023, vol 536. Springer, Cham, pp. 290-301. https://doi.org/10.1007/978-3-031-20141-7_27

9. Moore J. F. *Predators and prey: a new ecology of competition.* [Harvard business review], 1993, vol.71, no. 3, pp. 75-86

10. StartupBlink: Global Startup Ecosystem Index. (2022). Available at: https://www.startupblink.com/blog/reports/ (accessed 15 March 2023).

11. Startupgenome (2023). Available at: https://startupgenome.com/glossary. (accessed 15 March 2023).

12. Сергеєва О.Р., Орлова В.М.. Кузьменко О.В. *Щодо інноваційної діяльності вітчизняного малого та середнього підприємництва.* [АКАДЕМІЧНИЙ ОГЛЯД], 2021, vol. 1 (54), pp. 5-12. doi: 10.32342/2074-5354-2021-1-54-1. Available at: https://acadrev.duan.edu.ua/images/PDF/2021/1/2.pdf (accessed 15 March 2023).

13. Spigel, B. *The Relational Organization of Entrepreneurial Ecosystems.* [Entrep. Theory Pract], 2017, no. *41*, pp. 49–72.

14. Stam, E., & Van de Ven, A. *Entrepreneurial ecosystem elements.* [Small Business Economics], 2021, vol. 56(2), pp. 809–832. https://doi.org/10.1007/s11187-019-00270-6

15. Ziakis C, Vlachopoulou M, Petridis K. Start-Up Ecosystem (StUpEco): A Conceptual Framework and Empirical Research. *Journal of Open Innovation: Technology, Market, and Complexity*, 2022, vol. 8(1):35. https://doi.org/10.3390/joitmc8010035. Available at: https://startupgenome.com/glossary

References

1. Advantage Ukraine (2023). Available at: https://advantageukraine.com/ (accessed 15 March 2023).

2. Carayannis, E.G.; Campbell, D.F. *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters: A Comparative Systems Approach across the United States, Europe, and Asia* [Greenwood Publishing Group]. Santa Barbara, CA, USA, 2006.

3. Central and Eastern European startups (2022). Available at: https://dealroom.co/uploaded/2022/11/Dealroom-GoogleAtomicCredo-CEE-2022.pdf (accessed 15 March 2023).

4. Dealroom (2023). Available at: https://dealroom.co/about (accessed 15 March 2023).

5. Etzkowitz, H. *Innovation in Innovation: The Triple Helix of University-Industry-Government Relations,* [Соц. Sci. Інф.], 2003 , no. *42* , pp. 293–337.

6. Etzkowitz, H.; Leydesdorff, L. T*he Triple Helix–University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development*. [EASST Rev.], 1995, vol. 14, pp. 14–19

7. Global Startup Ecosystem Index (2022). Available at: https://www.startupblink.com/startupecosystemreport (accessed 15 March 2023).

8. Kyzym, M., Dymchenko, O., Smachylo, V., Rudachenko, O., Dril, N. (2023). *Cluster Analysis Usage as Prerequisite for Implementing Strategies of Countries Startup Ecosystems Development.* [In: Arsenyeva, O., Romanova, T., Sukhonos, M., Tsegelnyk, Y. (eds) Smart Technologies in Urban Engineering. STUE 2022. Lecture Notes in Networks and Systems], 2023, vol 536. Springer, Cham, pp. 290-301. https://doi.org/10.1007/978-3-031-20141-7_27

9. Moore J. F. *Predators and prey: a new ecology of competition.* [Harvard business review], 1993, vol.71, no. 3, pp. 75-86

10. StartupBlink: Global Startup Ecosystem Index. (2022). Avaliable at: https://www.startupblink.com/blog/reports/ (accessed 15 March 2023).

11. Startupgenome (2023). Available at: https://startupgenome.com/glossary. (accessed 15 March 2023).

12. Serheieva O.R., Orlova V.M., Kuz`menko O.V. *Schodo innovatsijnoi diial`nosti vitchyznianoho maloho ta seredn`oho pidpryiemnytstva* [Akademichnyj ohlyad], 2021, vol. 1 (54), pp. 5-12. doi: 10.32342/2074-5354-2021-1-54-1. Available at: https://acadrev.duan.edu.ua/images/PDF/2021/1/2.pdf (accessed 15 March 2023).

13. Spigel, B. *The Relational Organization of Entrepreneurial Ecosystems.* [Entrep. Theory Pract], 2017, no. *41*, pp. 49–72.

14. Stam, E., & Van de Ven, A. *Entrepreneurial ecosystem elements.* [Small Business Economics], 2021, vol. 56(2), pp. 809–832. https://doi.org/10.1007/s11187-019-00270-6

15. Ziakis C, Vlachopoulou M, Petridis K. Start-Up Ecosystem (StUpEco): A Conceptual Framework and Empirical Research. *Journal of Open Innovation: Technology, Market, and Complexity*, 2022, vol. 8(1):35. https://doi.org/10.3390/joitmc8010035. Available at: https://startupgenome.com/glossary

THE MODELING OF STARTUP ECOSYSTEMS IN CENTRAL AND EASTERN EUROPE BASED ON SOCIO-ECONOMIC INDICATORS

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JEL classification: ***O3, M2, E26***

The article is devoted to solving the problem of the development of startup ecosystems in the countries of Central and Eastern Europe (including Ukrainian entrepreneurship since Ukraine gained independence) by reorienting their economy to a market economy and conducting it based on sustainable development, ethics, and social responsibility. It has been found that in the countries a large number of mechanisms and procedures are not fully adapted to the implementation of entrepreneurial activity based on systematicity, complexity, and interaction; only point elements are present, and the effectiveness of their interaction in the process of entrepreneurial activity is quite low. At the same time, the rapid development of startup ecosystems is observed. The definition of this concept in the article is considered from the point of view of scientists as “a combination of localized cultural views, social networks, investment capital, universities, and active economic policies that create an environment that supports innovative business” and Startup Genome. This allows for the interpreting of a startup ecosystem as “a set of resources (policies, accelerators, incubators, co-working spaces, educational institutions, and funding groups) that are mostly located within a radius of 100 kilometers around a central point in a given region, with a few exceptions based on local realities”. It has been established that at the moment the theoretical concept of entrepreneurial ecosystems is insufficiently developed, which does not allow unambiguously interpreting its composition, as well as determining the impact on the development of startup. It has been revealed that the central driver of start-up ecosystems is most often considered by universities as centers of education and driving forces of innovative growth. It is innovations that are determined as a source of entrepreneurship development. The above was the basis for consideration and a possible solution to the problem of building a model that would describe the development of the startup ecosystem of the countries of Central and Eastern Europe based on the analysis of a set of indicators that characterize the startup ecosystem according to the Dealroom.co methodology, where the most popular and those that Ecosystem value is the most complete description of the development of the startup ecosystem. The European experience in the development of startup ecosystems has been analyzed. The structural components of the startup ecosystem have been reflected, and their role in the functioning of the system and their interrelationships has been defined. The functioning of startup ecosystems in European countries has been described. Possible directions of application of the European experience in the development of startup ecosystems in Ukraine have been studied. At the same time, the government of Ukraine considers the IT industry and military tech (high-tech weapons) as priorities in further development, which is especially relevant during military operations. The study was tested on the Greek startup ecosystem and found that the most significant issues affecting the successful development of startups are issues at the state level, which are related to tax incentives and acceleration of start-up procedures, the availability of financing opportunities, communication between interested parties, entrepreneurial education, previous startup experience, incubator support, and mentoring. A regression-correlation analysis of a set of five indicators (Number of unicorns, Future unicorns, VC funding, Number of exits, Employees, New funds, Number of startups, Number of funding rounds), which have the greatest significance for the Ecosystem value of the country, has been carried out. A model has been built that determines the dependence of Ecosystem value on the action of a set of significant factors: Number of unicorns, Future unicorns, VC funding, Number of exits, and Employees, which allows predicting the development of the startup ecosystem of the countries of the world.

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