СВІТОВЕ ГОСПОДАРСТВО

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THE INTERPLAY BETWEEN VENTURE INVESTING AND INNOVATION COMPETITIVENESS OF EU MEMBER-STATES

The purpose of the article is to reveal the interplay between venture investing and innovation development of selected EU member-states based on global innovation index, the World Bank's data on population, as well as OECD's information on venture investing in 2013–2019. The paper sheds light on general tendencies of venture investing and innovation competitiveness in the EU.

We have applied the Spearman's rank correlation coefficient to determine the strength and direction of connection between venture investing per capita and national innovation competitiveness of abovementioned countries. We have calculated the critical point of the two-sided critical region with the significance level α equaling 0.05 and compared it with the table value to determine that the rank correlation coefficient of venture investing per capita and innovation indices of EU member-states is statistically significant and the rank correlation between the scores for two tests is significant.

Key words: EU member-states, innovation competitiveness, innovation development, innovation index, venture investing, venture investing per capita.

Метою статті є розкриття взаємозв'язку між венчурними інвестиціями та інноваційним розвитком окремих країн – членів ЄС на підставі глобального індексу інновацій, даних Світового банку про чисельність населення, а також інформації ОЕСР щодо венчурних інвестицій у 2013–2019 рр. У статті висвітлено загальні тенденції венчурного інвестування та інноваційної конкурентоспроможності в ЄС.

Середній рівень венчурних інвестицій на душу населення серед вибраних держав – членів ЄС у 2013–2019 рр. зріс з 10 до 19,5 дол. США. Отже, більшість досліджуваних країн показала зростання у венчурному інвестуванні на душу населення із середнім показником зміни у 9,6 дол. США, проте Литва була єдиним винятком, відчувши падіння в розмірі 2,5 дол. США за той самий період. Лідерами венчурного інвестування в 2019 р. були Данія, Фінляндія, Ірландія, Швеція, Бельгія, Франція та Нідерланди з показником венчурного інвестування на душу населення в межах 33,4–58,8 дол. США, у той час як серед аутсайдерів були Болгарія, Румунія та Литва з рівнем венчурного інвестування на душу населення нижче 2 дол. США.

Тим часом середній бал індексів інновацій серед вибраних країн – членів ЄС знизився з 49,7 до 49,3 у 2013–2019 рр. Тринадцять країн мали негативні результати, а саме Ірландія, Люксембург, Австрія, Бельгія, Естонія, Іспанія, Італія, Португалія, Угорщина, Латвія, Словацька Республіка, Болгарія та Румунія, тоді як Швеція та Нідерланди лідирували з оцінкою, що перевищувала 60 балів у 2019 р.

Ми застосували коефіцієнт рангової кореляції Спірмена, щоб визначити силу та напрям зв'язку між венчурними інвестиціями на душу населення та національною інноваційною конкурентоспроможністю вищезазначених країн. Ми розрахували критичну точку двосторонньої критичної області з рівнем значущості α, що дорівнює 0,05, і порівняли її зі значенням таблиці,

щоб визначити, що коефіцієнт рангової кореляції венчурного інвестування на душу населення та індекси інновацій країн – членів ЄС є статистично значущими, і кореляційна оцінка між балами за двома тестами є значущою.

Ключові слова: країни – члени ЄС, інноваційна конкурентоспроможність, інноваційний розвиток, інноваційний індекс, венчурне інвестування, венчурне інвестування на душу населення.

Introduction. Nowadays, the innovation competitiveness determines the general development tendencies of the global economy in general, as well as success or failure of national economic systems. There is the controversy surrounding the issue of disclosing factors influencing innovation activity on micro-, macro- and global levels, including the discussion on their significance and real impact. The Covid-pandemic significantly decreased the number of successful businesses and revealed shortcomings in the design of the global economic order with its archaic emphasis on resources and labor force. The increasing rates of unemployed all over the world and the need for creating self-sufficient innovative business models raise the issue of impact of venture investing on innovations and vice versa.

Analysis of recent achievements and publications. There is an abundant literature on both venture investing and innovation development. For example, Kuzmina-Merlino and Kublina [1] analyze venture capital as the financial basis for innovation entrepreneurship and independent market economy constituent, while D. Teker, S. Teker and Ö. Teraman [2] define it as the support for entrepreneurial talents via transforming science and ideas into new services and products.

R. Nanda, S. Samila and O. Sorenson [3] found that additional IPOs of VC companies' first ten investments result in 8% higher IPO rate on their following investments, but this effect disappears with time as VC firms lose the contact with reality, namely investing in time and at right places. H. Lahr and A. Mina [4] discovered that venture investors tend to finance companies possessing know-how, but it does not guarantee the effective patent output.

Meanwhile, E. Litsareva [5] revealed that the key factors of effective innovation development of South Korea, Taiwan Province of China, Singapore, Malaysia, and Thailand are government support, public and foreign investments. U.A. Rumina, A.S. Balandina and K.A. Bannova [6] highlighted the necessity to introduce tax incentives for stimulating innovations in business with consideration of the degree of tax burden relief and state interests in budget revenues. Conversely, Daniluk [7] pointed out that surveyed Polish companies showed little or no interest in cooperation with business environment institutions. Finally, Szopik-Depczyńska, Cheba, Bąk, Kędzierska-Szczepaniak, Szczepaniak, and Ioppolo [8] substantiated a new approach for evaluating innovation level of EU regions, namely the estimation includes classifying objects based on different groups of indicators overcoming disadvantages of concentrating only on mean values.

Taking into account different aspects revealed in publications devoted to innovation development and venture investing, as well as considering the meaning of venture investing for innovative transformations and Ukraine's European integration inspirations, the experience of EU member-states is worth further investigating.

The research purpose and relevance. The purpose of the article is to reveal the interplay between venture investing and innovation development of selected EU member-states based on global innovation index, the World Bank's data on population, as well as OECD's information on venture investing in 2013–2019. The paper sheds light on general tendencies of venture investing and innovation competitiveness in the EU.

Statement of the primary research material. As the global competition became more and more severe, the problem of stimulating innovations by any means arose. Venture investments create the necessary environment for implementing business ideas, especially for small and medium enterprises, as well as start-ups. Table 1

indicates that most EU member-states had the positive change in volume of venture investments in 2013–2019, but the bulk of venture investments declined in Lithuania and Portugal for unknown reasons. The maximum value was registered in France ($2,320.3 million), and Latvia accounted for the minimum value ($4.1 million) in 2019.

Table 2 present data on population changes in selected EU member states in 2013–2019. The population decreased in Bulgaria, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, and Romania.

Table 3 shows that the average value of venture investing per capita among selected EU member states appreciated from $10 to 19.5 in 2013–2019, therefore, most investigated countries showed the increase in venture investing per capita with the average value change of $9.6, while Lithuania was the only exception experiencing the decrease equaling $2.5. The detected leaders in venture investing in 2019 were Denmark, Finland, Ireland, Sweden, Belgium, France and Netherlands with venture investing per capita values within $33.4–58.8 range, while outsiders were Bulgaria, Romania, and Lithuania with venture investing per capita below $2.

Table 1

Venture investments in EU member-states in 2013–2019, $ million

Country	2013	2014	2015	2016	2017	2018	2019	Change	Average
Austria	78.8	79.3	124.7	63.0	121.8	102.0	90.2	11.5	94.2
Belgium	157.8	164.4	109.2	167.4	230.8	343.3	418.3	260.5	227.3
Bulgaria	4.7	2.8	9.2	6.2	5.0	8.3	4.8	0.1	5.8
Czech Republic	5.9	7.4	2.8	5.0	6.8	18.0	26.4	20.5	10.3
Denmark	113.3	89.7	80.6	102.5	114.2	363.3	342.2	228.9	172.2
Estonia	6.6	14.1	4.2	8.0	1.8	17.9	39.7	33.1	13.2
Finland	169.7	163.9	121.3	143.7	156.8	265.5	323.8	154.2	192.1
France	880.4	798.4	942.6	960.6	1,423.6	1,751.7	2,320.3	1,439.9	1,296.8
Germany	972.5	910.6	969.8	1,212.8	1,459.8	1,772.3	2,142.7	1,170.2	1,348.7
Greece	17.3	12.7	34.8	12.4	9.7	44.7	27.1	9.7	22.7
Hungary	29.1	58.5	67.5	46.9	42.7	87.0	135.2	106.1	66.7
Ireland	158.9	99.8	97.9	240.1	140.1	352.4	208.5	49.6	185.4
Italy	112.0	73.1	76.7	87.6	119.1	221.1	273.6	161.7	137.6
Latvia	2.1	8.7	8.2	8.7	1.5	3.7	4.1	2.1	5.3
Lithuania	12.2	12.9	10.4	3.4	4.1	3.3	4.6	–7.6	7.3
Luxembourg	9.2	5.7	6.5	4.4	18.8	18.7	17.3	8.1	11.5
Netherlands	267.0	242.5	190.1	250.0	394.6	489.6	578.2	311.2	344.6
Poland	21.7	31.7	33.8	50.6	55.3	43.8	111.4	89.7	49.8
Portugal	51.8	72.9	65.1	23.0	29.2	42.7	44.1	–7.7	47.0
Romania	4.0	7.0	2.0	3.3	6.3	3.6	19.5	15.5	6.5
Slovak Republic	0.1	9.2	11.6	12.6	3.1	4.9	17.4	17.3	8.4
Spain	229.8	376.1	477.8	487.9	619.0	632.1	617.4	387.6	491.4
Sweden	324.2	382.6	193.1	261.6	279.7	517.1	403.5	79.4	337.4

Source: own calculations and compilation based on [9].

Table 2

Population in EU member-states in 2013–2019, millions

Country	2013	2014	2015	2016	2017	2018	2019	Change
Austria	8.480	8.546	8.643	8.737	8.798	8.841	8.877	0.397
Belgium	11.159	11.209	11.274	11.331	11.375	11.427	11.484	0.325
Bulgaria	7.265	7.224	7.178	7.128	7.076	7.025	6.976	-0.289
Czech Republic	10.514	10.525	10.546	10.566	10.594	10.630	10.670	0.155
Denmark	5.615	5.643	5.683	5.728	5.765	5.794	5.819	0.204
Estonia	1.318	1.315	1.315	1.316	1.317	1.322	1.327	0.009
Finland	5.439	5.462	5.480	5.495	5.508	5.516	5.520	0.081
France	65.999	66.312	66.548	66.724	66.864	66.966	67.060	1.061
Germany	80.646	80.983	81.687	82.349	82.657	82.906	83.133	2.487
Greece	10.965	10.892	10.821	10.776	10.755	10.733	10.716	-0.249
Hungary	9.893	9.866	9.843	9.814	9.788	9.776	9.770	-0.123
Ireland	4.624	4.658	4.702	4.755	4.807	4.867	4.941	0.318
Italy	60.234	60.789	60.731	60.627	60.537	60.422	60.297	0.063
Latvia	2.013	1.994	1.978	1.960	1.942	1.927	1.913	-0.100
Lithuania	2.958	2.932	2.905	2.868	2.828	2.802	2.787	-0.171
Luxembourg	0.543	0.556	0.570	0.582	0.596	0.608	0.620	0.077
Netherlands	16.804	16.865	16.940	17.030	17.131	17.232	17.333	0.528
Poland	38.040	38.012	37.986	37.970	37.975	37.975	37.971	-0.069
Portugal	10.457	10.401	10.358	10.325	10.300	10.284	10.269	-0.188
Romania	19.984	19.909	19.816	19.702	19.587	19.473	19.357	-0.627
Slovak Republic	5.413	5.419	5.424	5.431	5.439	5.447	5.454	0.041
Spain	46.620	46.481	46.445	46.484	46.593	46.798	47.077	0.457
Sweden	9.600	9.696	9.799	9.923	10.058	10.175	10.285	0.685

Source: own calculations and compilation based on [10].

Table 3

Venture investments in EU member-states in 2013–2019, $ million

Country	2013	2014	2015	2016	2017	2018	2019	Change	Average
Austria	9.3	9.3	14.4	7.2	13.8	11.5	10.2	0.9	10.8
Belgium	14.1	14.7	9.7	14.8	20.3	30.0	36.4	22.3	20.0
Bulgaria	0.6	0.4	1.3	0.9	0.7	1.2	0.7	0.0	0.8
Czech Republic	0.6	0.7	0.3	0.5	0.6	1.7	2.5	1.9	1.0
Denmark	20.2	15.9	14.2	17.9	19.8	62.7	58.8	38.6	29.9
Estonia	5.0	10.7	3.2	6.1	1.3	13.5	29.9	25.0	10.0
Finland	31.2	30.0	22.1	26.1	28.5	48.1	58.7	27.5	35.0
France	13.3	12.0	14.2	14.4	21.3	26.2	34.6	21.3	19.4

End of table 3

Country	2013	2014	2015	2016	2017	2018	2019	Change	Average
Germany	12.1	11.2	11.9	14.7	17.7	21.4	25.8	13.7	16.4
Greece	1.6	1.2	3.2	1.2	0.9	4.2	2.5	0.9	2.1
Hungary	2.9	5.9	6.9	4.8	4.4	8.9	13.8	10.9	6.8
Ireland	34.4	21.4	20.8	50.5	29.2	72.4	42.2	7.8	38.7
Italy	1.9	1.2	1.3	1.4	2.0	3.7	4.5	2.7	2.3
Latvia	1.0	4.3	4.2	4.5	0.8	1.9	2.2	1.1	2.7
Lithuania	4.1	4.4	3.6	1.2	1.5	1.2	1.7	–2.5	2.5
Luxembourg	17.0	10.2	11.5	7.5	31.5	30.8	27.9	10.9	19.5
Netherlands	15.9	14.4	11.2	14.7	23.0	28.4	33.4	17.5	20.1
Poland	0.6	0.8	0.9	1.3	1.5	1.2	2.9	2.4	1.3
Portugal	5.0	7.0	6.3	2.2	2.8	4.2	4.3	-0.7	4.5
Romania	0.2	0.4	0.1	0.2	0.3	0.2	1.0	0.8	0.3
Slovak Republic	0.0	1.7	2.1	2.3	0.6	0.9	3.2	3.2	1.5
Spain	4.9	8.1	10.3	10.5	13.3	13.5	13.1	8.2	10.5
Sweden	33.8	39.5	19.7	26.4	27.8	50.8	39.2	5.5	33.9
Average	10.0	9.8	8.4	10.1	11.5	19.1	19.5	9.5	12.6

Source: own calculations based on [9; 10].

Meanwhile, the average score of innovation indices among selected EU member states decreased from 49.7 to 49.3 in 2013–2019. There were thirteen countries with negative results, namely Ireland, Luxembourg, Austria, Belgium, Estonia, Spain, Italy, Portugal, Hungary, Latvia, Slovak Republic, Bulgaria, and Romania (Table 4), while Sweden and Netherlands were leaders with the score exceeding 60 points in 2019.

We apply Spearman's rank correlation coefficient to determine the strength and direction of connection between venture investing per capita and national innovation competitiveness of abovementioned countries. Firstly, we assign ranks (Table 5) to attribute Y (average innovation indices) and factor X (average values of venture investing per capita).

Since the matrix contains related ranks (the same rank number), we re-form them without changing the importance of the rank (Table 6).

Table 4

Innovation Indices of EU member-states in 2013–2019, points

Country	2013	2014	2015	2016	2017	2018	2019	Change	Average
Austria	9.3	9.3	14.4	7.2	13.8	11.5	10.2	0.9	10.8
Belgium	14.1	14.7	9.7	14.8	20.3	30.0	36.4	22.3	20.0
Bulgaria	0.6	0.4	1.3	0.9	0.7	1.2	0.7	0.0	0.8
Czech Republic	0.6	0.7	0.3	0.5	0.6	1.7	2.5	1.9	1.0
Denmark	20.2	15.9	14.2	17.9	19.8	62.7	58.8	38.6	29.9
Estonia	5.0	10.7	3.2	6.1	1.3	13.5	29.9	25.0	10.0

End of table 4

Country	2013	2014	2015	2016	2017	2018	2019	Change	Average
Finland	31.2	30.0	22.1	26.1	28.5	48.1	58.7	27.5	35.0
France	13.3	12.0	14.2	14.4	21.3	26.2	34.6	21.3	19.4
Germany	12.1	11.2	11.9	14.7	17.7	21.4	25.8	13.7	16.4
Greece	1.6	1.2	3.2	1.2	0.9	4.2	2.5	0.9	2.1
Hungary	2.9	5.9	6.9	4.8	4.4	8.9	13.8	10.9	6.8
Ireland	34.4	21.4	20.8	50.5	29.2	72.4	42.2	7.8	38.7
Italy	1.9	1.2	1.3	1.4	2.0	3.7	4.5	2.7	2.3
Latvia	1.0	4.3	4.2	4.5	0.8	1.9	2.2	1.1	2.7
Lithuania	4.1	4.4	3.6	1.2	1.5	1.2	1.7	-2.5	2.5
Luxembourg	17.0	10.2	11.5	7.5	31.5	30.8	27.9	10.9	19.5
Netherlands	15.9	14.4	11.2	14.7	23.0	28.4	33.4	17.5	20.1
Poland	0.6	0.8	0.9	1.3	1.5	1.2	2.9	2.4	1.3
Portugal	5.0	7.0	6.3	2.2	2.8	4.2	4.3	-0.7	4.5
Romania	0.2	0.4	0.1	0.2	0.3	0.2	1.0	0.8	0.3
Slovak Republic	0.0	1.7	2.1	2.3	0.6	0.9	3.2	3.2	1.5
Spain	4.9	8.1	10.3	10.5	13.3	13.5	13.1	8.2	10.5
Sweden	33.8	39.5	19.7	26.4	27.8	50.8	39.2	5.5	33.9
Average	10.0	9.8	8.4	10.1	11.5	19.1	19.5	9.5	12.6

Source: own calculations and compilation based on [11].

Table 5

Ranking of attribute Y and factor X

X	Y	Rank X, dx	Rank Y, dy
10.8	52.5	14	15
20	51.1	18	13
0.8	41.6	2	5
1	49.8	3	12
29.9	58.2	20	20
10	51.1	12	13
35	59.7	22	21
19.4	53.6	16	16
16.4	57.3	15	18
2.1	39	6	2
6.8	44.3	11	7
38.7	57.7	23	19
2.3	46.7	7	10
2.7	44.4	9	8

End of table 5

X	Y	Rank X, dx	Rank Y, dy
2.5	41.5	8	4
19.5	56.3	17	17
20.1	61.4	19	22
1.3	40.9	4	3
4.5	45.7	10	9
0.3	38.3	1	1
1.5	42.4	5	6
10.5	48.9	13	11
33.9	62.9	21	23

Source: own calculations.

Table 6

Ranking matrix

Rank X, dx	Rank Y, dy	$(dx - dy)^2$
14	15	1
18	13.5	20.25
2	5	9
3	12	81
20	20	0
12	13.5	2.25
22	21	1
16	16	0
15	18	9
6	2	16
11	7	16
23	19	16
7	10	9
9	8	1
8	4	16
17	17	0
19	22	9
4	3	1
10	9	1
1	1	0
5	6	1
13	11	4
21	23	4

Source: own calculations.

We verify the correctness of the matrix using the checksum calculation:

$$\sum x_{ij} = \frac{(1+n)n}{2} = \frac{(1+23)23}{2} = 276$$

The sum of the columns of the matrix and checksum are equal; hence, the matrix is composed correctly. There are several identical values among x and y resulting in associated ranks, therefore, we calculate the Spearman coefficient as follows:

$$\rho = 1 - 6\frac{\sum 6d^2 + A + B}{n^3 - n}$$

Where:

$$A = \frac{1}{12}\sum\left(A_j^3 - A_j\right)$$

$$B = \frac{1}{12}\sum\left(B_k^3 - B_k\right)$$

j – numbers of bundles in order for the attribute x;

A_j – the amount of identical ranks in the j-th bundle in x;

k – numbers of bundles in order for the attribute y;

B_k – the amount of identical ranks in the kth bundle in y.

B = (23 – 2)/12 = 0.5

$$\rho = 1 - \frac{6 \times 217.5 + 0.5}{23^3 - 23} = 0.892$$

Therefore, the connection between attribute Y and factor X is direct and strong.

Now, we calculate the critical point:

$$T_{critical} = t(\alpha, k) \times \sqrt{\frac{1-\rho^2}{n-2}}$$

Where:

n – the sample size;

ρ – the Spearman's rank correlation coefficient;

$t(\alpha, k)$ – the critical point of the two-sided critical region, which is found from the table of critical points of the Student's distribution, according to the significance level α and the number of degrees of freedom $k = n - 2$.

If $|\rho| < T_{critical}$, then we do not reject the null hypothesis, and the rank correlation is not significant. If $|\rho| > T_{critical}$, then the null hypothesis is rejected, and the rank correlation is significant. According to the Student's table, we find $t(\alpha/2, k) = (0.05/2;$

$$T_{critical} = 2.414 \times \sqrt{\frac{1-0.892^2}{23-2}} = 0.24$$

$T_{critical} < \rho$, we reject the null hypothesis.

Conclusions. Our calculations have shown that the rank correlation coefficient of venture investing per capita and innovation indices of EU member-states is statistically significant and the rank correlation between the scores for two tests is significant. Therefore, there is a direct and strong connection between venture investing per capita and innovation competitiveness of EU member-states. The prospects of future research include estimating the elasticity of innovation competitiveness on venture investing per capita, and determining measures needed to boosting venture activity in Ukraine considering the efficient EU experience.

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THE INTERPLAY BETWEEN VENTURE INVESTING AND INNOVATION COMPETITIVENESS OF EU MEMBER-STATES

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Key words: EU member-states, innovation competitiveness, innovation development, innovation index, venture investing, venture investing per capita.

The purpose of the article is to reveal the interplay between venture investing and innovation development of selected EU member-states based on global innovation index, the World Bank's data on population, as well as OECD's information on venture investing in 2013–2019. The paper sheds light on general tendencies of venture investing and innovation competitiveness in the EU.

The average value of venture investing per capita among selected EU member states appreciated from $10 to 19.5 in 2013–2019, therefore, most investigated countries showed the increase in venture investing per capita with the average value change of $9.6, while Lithuania was the only exception experiencing the decrease equaling $2.5. The detected leaders in venture investing in 2019 were Denmark, Finland, Ireland, Sweden, Belgium, France and Netherlands with venture investing per capita values within $33.4–58.8 range, while outsiders were Bulgaria, Romania, and Lithuania with venture investing per capita below $2.

Meanwhile, the average score of innovation indices among selected EU member states decreased from 49.7 to 49.3 in 2013–2019. There were thirteen countries with negative results, namely Ireland, Luxembourg, Austria, Belgium, Estonia, Spain, Italy, Portugal, Hungary, Latvia, Slovak Republic, Bulgaria, and Romania, while Sweden and Netherlands were leaders with the score exceeding 60 points in 2019.

We have applied the Spearman's rank correlation coefficient to determine the strength and direction of connection between venture investing per capita and national innovation competitiveness of abovementioned countries. We have calculated the critical point of the two-sided critical region with the significance level α equaling 0.05 and compared it with the table value to determine that the rank correlation coefficient of venture investing per capita and innovation indices of EU member-states is statistically significant and the rank correlation between the scores for two tests is significant.

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