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University of Novi Sad, Faculty of Economics in Subotica
9 - 11 Segedinski put, Subotica 24000, Serbia
Tel: +381 24 628 000
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e-mail: smjournal@ef.uns.ac.rs

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Strategic approach to the territorial distribution of EAFRD projects

Alexandru Sin
National Institute for Economic Research "Costin C. Kiriţescu", Romanian Academy, Bucharest, Romania
https://orcid.org/0000-0003-1814-0602

Czesław Nowak
University of Applied Sciences in Tarnów, Tarnów, Poland
https://orcid.org/0000-0002-6693-4039

Yanwen Tan
South China Agricultural University, Guangzhou, Guangdong, China
https://orcid.org/0000-0001-9479-956X

Abstract
Background: The implementation of the Common Agricultural Policy of the European Union aims at a balanced territorial development and economic convergence of the rural areas. However, in some cases, EU rural funding didn't manage to reduce the gaps between regions, but quite the contrary, the wealthiest regions attracted most of the resources.
Purpose: The main objective of the paper was to assess whether EAFRD funding reached the most vulnerable areas. This is a measure of the contribution of CAP to economic convergence.
Study design/methodology/approach: Cluster analysis was performed on Galaţi County in Romania. The analysis was performed at LAU level, considering four variables: population, poverty, agricultural area and the value of implemented EAFRD projects.
Findings/conclusions: The analysis concluded five clusters, with poorer areas receiving less funding, calling for better development strategies, focused on the central, northern and north-eastern parts of the county, where these areas are concentrated. Also, territorial reorganization of rural areas may be necessary in some cases, in order to address the uneven development and poverty.
Limitations/future research: The present research focused only on EAFRD funding related to agricultural exploitations. For more precise conclusions and recommendations, further research will also need to include other EAFRD submeasures.

Keywords
EAFRD, agriculture, rural development, uneven territorial distribution, cluster analysis, rural poverty, economic convergence

Introduction

Homogeneous development of rural areas is one of the objectives of the Common Agricultural Policy of the European Union (CAP), and economic convergence represents the most important contribution to the achievement of this objective. On the other hand, the persistence and deepening of development gaps between regions, counties and localities, is one of the drawback factors and increase internal migration.

As an important part of the CAP, the Second Pillar, implemented through the European Agricultural Fund for Rural Development (EAFRD), aims at a balanced territorial development of rural economies and communities. The Second Pillar focuses on rural development and had an allocated budget of approx. 95.6 billion euros for the 2014-2020 timeframe. Its

implementation contributes positively to resilience, risk prevention, climate change adaptation and economic convergence (Tijanic & Korent, 2019).

A more detailed analysis, at Local Administrative Unit (LAU) level, can reveal potential territorial differences within the same county, regarding the distribution of EU funds. Cluster analysis has proven its usefulness in identifying and contextualizing these differences, by considering other aspects as well, such as poverty, population or agricultural potential. Thus, this study aimed to analyse, considering the above variables, the territorial distribution in the absorption of EU funds for rural development, at the level of local communities in Galați County in Romania.

1. Literature review

Disparities in rural development have been observed in rural areas all over the world and economic convergence in target areas needs prioritization of underdeveloped communities (Singh & Kumar, 2022).

Previous studies highlighted important differences between countries and development regions regarding absorption of EU rural development funds, with most funding being absorbed by the most developed areas (Cárdenas Alonso & Nieto Masot, 2017; Sin, Nowak & Burlacu, 2020; Beluhova-Uzunova & Hristov, 2020; Kiryluk-Dryjska, Beba & Poczta, 2020; Dax, Machold & Roberts, 2022).

In many cases, even if Pillar II contributed to economic development of rural areas, implementation of EAFRD projects failed to achieve all of CAP's goals, most importantly economic convergence, and support the engagement of small farms in market activities in a relevant manner (Sin, 2014; Popescu, 2018; Sodano & Gorgitano, 2021). Beside an overall low absorption rate (Marin, 2019), the extremely unequal territorial distribution across the Romanian business environment (Chivu, 2019) played a part in this outcome as well.

Creating jobs in rural areas proved to be a good driver of rural development, EU funding having a positive effect on a significant number of cases (Loizou, Karelakis, Galanopoulos & Mattas, 2019; Unay-Gailhard & Bojnec, 2019; Castaño, Blanco & Martinez, 2019). Thus, some countries prioritized measures targeting non-agricultural activities, but for most cases, funding targeted the farmers, limiting the effect on reducing economic disparities, while high administrative requirements for small farmers reduced the effectiveness of the programme (Schuh, Brkanovic, Gaugitsch et al., 2021; Balodis & Pilvere, 2021; Grodzicki & Jankiewicz, 2022). Also, in some cases, the employment increased in non-agricultural industries and services at the expense of agricultural labour (Zawalińska, 2019).

The impact of EU funding on diversification towards non-agricultural activities and labour structure in rural areas proved to be questionable (Garrone, Emmers, Olper & Swinnen, 2019; Galluzzo, 2020; Lillemets, Fertő & Viira, 2022). However, in assessing that issue, local structure of rural economy needs to be taken into consideration. Funding non-agricultural activities in areas where agriculture is predominant did not generate the desired growth, but the same approached worked well where the importance of agriculture was relatively low (Hyytiä, 2014).

Cluster analysis has proven to be an effective tool in assessing the level of socio-economic development of rural areas in general and for analysing the results of CAP's implementation in particular (Popescu, Dragomir, Popescu, Horablaga & Chis, 2016; D'Urso, Manca, Waters & Girone, 2019; Shcherbak, et al., 2020; Okereke & Wojciechowska, 2022). From the scientific point of view, cluster analysis is an exploratory method based on an unsupervised classification of data into groups. The characteristics of these groups are not determined in advance, but are an expression of the natural positioning of the analysed data. The formed groups contain objects (instances) with a maximum degree of similarity between them and a maximum degree of dissimilarity to the objects belonging to the other groups. This analysis, however, focuses more on group homogeneity than on differences between groups (Hennig, Meila, Murtagh & Rocci, 2015). Cluster analysis is useful for identifying patterns, to provide insights into the underlying structure of data, and studying significant relationships between data (Rotariu, Culic, Bădescu, Mezei & Mureșan, 2006; Kim, Kim & Cho, 2020).

In partition cluster analysis, the similarity between two objects is defined by their distance, which can be measured as Euclidean distance. The partition divides the analysed objects (instances) into k groups. The most widely used method for partitioning cluster analysis is the k-means method (Lucke & Forster, 2019). The advantages of this method are the ability to process large volumes of data and the flexibility of the analysis regarding the

belonging of objects to groups (Govender & Sivakumar, 2020).

2. Materials and method

The efficiency of evaluation methods for CAP implementation are still being discussed, but they should focus on evidence-based policy-making and good governance (Thoyer & Préget, 2019). The tools for analysing if the implemented policies generated the expected outcomes should be orientated more towards development actors and the people living within the target area, and less towards academics (Cagliero, Licciardo & Legnini, 2021). For this study, data expressing the potential, development state and financial aid for the target areas was used: population, relative poverty rate, available agricultural area and EAFRD spending.

K-means clustering method was used to analyse data corresponding to all LAUs in Galați County, Romania. The aim was to relevantly partition the 65 LAUs into clusters, based on four variables.

For a more accurate identification of the optimal number of clusters, three methods were used: Elbow, Silhouette and Dunn.

The Elbow method uses the sum of squares (WCSS) as a function of the number of clusters. The internal mean sum of squares is defined as the average distance between points within a cluster:

$$WCSS_k = \sum_{r=1}^{k} \frac{1}{n_r} D_r$$

where k is the number of clusters, n_r the number of points in cluster r and Dr the sum of distances between all points in cluster r. As the number of clusters increases, the score decreases. This is because the points will be closer to the centroids they are assigned to. The Elbow method aims to identify the k value, for which the score drops the fastest, before the graphic representation (the curve) reaches a plateau. Increasing the number of clusters beyond this value will not further improve the analysis and will not lead to further relevant conclusions (David & Vassilvitskii, 2007).

The Silhouette method is based on cluster quality analysis. This is measured by calculating the degree of objects' membership to the clusters that contain them. A high value of the Silhouette index indicates good agglomeration. Thus, the optimal number of clusters (k) is the one that maximizes the indicator over a range of possible values for k (Kaufman & Rousseeuw, 2005).

The global Silhouette index is defined as:

$$S = \frac{1}{n} \sum_{i=1}^{n} S_i$$

Where Si represents the Silhouette index of one point:

$$s(i) = \frac{b(i) - a(i)}{\max(a(i), b(i))}$$

Whereas a(i) is the average distance between point i and all other points belonging to the same cluster and b(i) is the average distance between point i and all other points belonging to the nearest cluster.

The "Dunn" method aims to identify clustering solutions that provide compact and well-separated clusters. Clusters must be far enough apart but with little variation between points belonging to the same cluster. The Dunn index is defined by:

$$DI_m = \frac{\min\limits_{1 \le i < j \le m} \delta(C_i, C_j)}{\max\limits_{1 \le k \le m} \Delta_k}$$

where δ(Ci,Cj) is the distance between clusters i and j (measured as the distance between their closest points), Δk is the distance within the cluster (measured as the distance between the most distant points within the cluster) and m is the number of clusters. The higher the Dunn index value, the better the clustering, so the number of clusters that maximize the Dunn index is considered as the optimal number of clusters (Dunn, 1974).

The k-means algorithm uses a list of d-dimensional points as input values, performing data grouping in order to minimize the objective function, considering the Euclidean distance in d-dimensional space and being defined as:

$$J(X, S) = \sum_{k=1}^{K} \sum_{x \in S_k} dist(x, m_k)$$

The centres are first randomly initiated and are subject to change, with new centres being assigned, until the membership function doesn't change anymore (Aggarwal & Reddy, 2013).

2. Research and results

Collected data for all 65 LAUs in Galați County was analysed by k-means clustering. Analysed data referred to four variables: total population by residence (A), relative poverty rate (B), agricultural area per population (C) and total value of implemented EU agricultural projects per population (D), as represented in Table 1.

Table 1 Analysed dataset for Galați county, Romania

#	LAU	A	B	C	D
1	GALAȚI	306.617	8.9	0.04	20
2	ȘENDRENI	5.215	14.5	0.75	0
3	VÂNĂTORI	6.445	23.1	0.59	246
4	TECUCI	45.917	10.1	0.16	82
5	DRĂGĂNEȘTI	6.694	46.9	0.80	109
6	MUNTENI	7.641	30.6	1.09	724
7	BEREȘTI	3.131	63.4	1.00	99
8	BEREȘTI-MERIA	3.480	47.9	2.39	29
9	TÂRGU BUJOR	7.171	23.5	0.91	185
10	BARCEA	6.470	29.3	0.76	110
11	BĂLĂBĂNEȘTI	1.928	55.5	2.06	194
12	BĂLĂȘEȘTI	2.205	61.5	2.38	0
13	BĂLENI	2.245	48.2	2.77	18
14	BĂNEASA	2.050	63.9	2.65	51
15	BRANIȘTEA	4.386	47.2	1.12	133
16	BRĂHĂȘEȘTI	10.074	41.4	0.30	12
17	BUCIUMENI	2.429	51.0	1.11	6
18	CAVADINEȘTI	2.845	58.8	3.09	47
19	CERȚEȘTI	2.311	37.8	2.37	35
20	COROD	7.459	47.3	1.30	166
21	CORNI	2.109	67.0	2.35	109
22	COSMEȘTI	6,568	44.8	0.46	120
23	COSTACHE NEGRI	2,716	45.5	0.95	139
24	CUCA	2.085	41.1	1.79	7
25	CUDALBI	7.346	60.8	1.87	60
26	DRĂGUȘENI	5.682	41.8	1.06	8
27	FÂRȚĂNEȘTI	5.048	24.4	1.38	20
28	FOLTEȘTI	3.162	50.1	1.83	441
29	FRUMUȘIȚA	5.378	24.2	1.77	131
30	FUNDENI	3.765	39.0	0.85	20
31	GHIDIGENI	6.924	24.4	0.78	311
32	GOHOR	3.245	43.8	1.33	173
33	GRIVIȚA	3.730	62.6	1.01	83
34	INDEPENDENȚA	4.614	31.8	1.20	0
35	IVEȘTI	10.114	19.8	0.68	21
36	JORĂȘTI	1.772	21.3	2.64	0
37	LIEȘTI	10.856	46.3	0.67	34
38	MATCA	12.300	28.7	0.65	680
39	MĂSTĂCANI	4.683	55.5	1.10	78
40	MOVILENI	3.358	40.0	0.63	78
41	NĂMOLOASA	2.038	21.0	2.87	257
42	NICOREȘTI	3.997	22.6	1.22	132
43	OANCEA	1.667	56.2	2.60	0
44	PECHEA	11.092	24.6	0.97	31
45	PISCU	4.747	31.4	1.06	126
46	PRIPONEȘTI	2.097	39.9	2.33	14
47	REDIU	2.016	36.5	1.71	763
48	SCÂNTEIEȘTI	2.392	40.6	1.79	170
49	SCHELA	3.839	49.8	1.06	230
50	SLOBOZIA CONACHI	4.163	64.0	1.36	0
51	SMÂRDAN	5.849	26.9	2.29	3
52	SMULȚI	1.370	38.0	3.54	47
53	SUCEVENI	1.607	45.9	3.21	19
54	TUDOR VLADIMIRESCU	5.068	20.1	0.86	8
55	TULUCEȘTI	7.578	61.6	0.78	2
56	ȚEPU	2.372	43.8	1.29	344
57	UMBRĂREȘTI	7.057	28.5	0.80	299
58	VALEA MĂRULUI	3.593	44.1	1.35	155
59	VÂRLEZI	1.971	60.3	3.97	264
60	VLĂDEȘTI	2.561	41.9	1.85	81
61	RĂDEȘTI	1.447	37.1	1.95	0
62	NEGRILEȘTI	2.583	43.3	1.40	416
63	POIANA	1.726	58.8	1.09	0
64	CUZA VODĂ	2.681	29.9	0.74	72

Source: the authors, based on INS, INCE and AFIR data

For three of the variables, calculations were made based on the latest available data: population by residence on 01.07.2020 and available agricultural area, both sourced from the Romanian National Institute of Statistics (INS, 2022), and total value of implemented EU rural development projects on 27.06.2022, sourced from the Agency for Financing Rural Investments (AFIR, 2022).

Total value of implemented EU agricultural projects referred to all EAFRD projects implemented for agricultural exploitations, in all agricultural areas: cultivation of cereals, legumes and oilseeds plants, vegetables, melons, grapes and fruit trees and bushes, as well as pigs, cattle, sheep, goats, birds and other animals farming (EAFRD submeasures 4.1, 4.1A, 6.1, and 6.3)

One of the objectives of the research was to find out if rural funding was properly directed to where it was needed the most, i.e. poorer areas. Thus, when including the variable referring to the relative poverty rate, the situation at the beginning of the implementation of the 2014-2020 CAP was considered most relevant, more specifically data

corresponding to the year 2016, when actual financing the 2014-2020 EAFRD projects began. Data was sourced from the results of SIPOCA4 research project (INCE, 2019).

The dataset was standardized based on the mean and standard deviation results (Table 2).

Table 2 Standardized dataset

#	LAU	z-scores			
		A	B	C	D
1	GALAȚI	7.91	-2.14	-1.70	-0.64
2	ȘENDRENI	-0.12	-1.76	-0.86	-0.76
3	VÂNĂTORI	-0.09	-1.17	-1.05	0.71
4	TECUCI	0.96	-2.06	-1.56	-0.27
5	DRĂGĂNEȘTI	-0.08	0.45	-0.80	-0.11
6	MUNTENI	-0.05	-0.66	-0.46	3.56
7	BEREȘTI	-0.17	1.58	-0.57	-0.17
8	BEREȘTI-MERIA	-0.17	0.53	1.09	-0.58
9	TÂRGU BUJOR	-0.07	-1.15	-0.67	0.34
10	BARCEA	-0.09	-0.75	-0.85	-0.10
11	BĂLĂBĂNEȘTI	-0.21	1.04	0.69	0.40
12	BĂLĂȘEȘTI	-0.20	1.45	1.07	-0.76
13	BĂLENI	-0.20	0.54	1.53	-0.65
14	BĂNEASA	-0.20	1.61	1.38	-0.45
15	BRANIȘTEA	-0.14	0.47	-0.42	0.04
16	BRĂHĂȘEȘTI	0.01	0.08	-1.39	-0.68
17	BUCIUMENI	-0.19	0.74	-0.43	-0.72
18	CAVADINEȘTI	-0.18	1.27	1.92	-0.47
19	CERȚEȘTI	-0.20	-0.17	1.05	-0.55
20	COROD	-0.06	0.48	-0.21	0.23
21	CORNI	-0.20	1.83	1.03	-0.11
22	COSMEȘTI	-0.08	0.31	-1.20	-0.04
23	COSTACHE NEGRI	-0.19	0.36	-0.62	0.07
24	CUCA	-0.20	0.06	0.37	-0.71
25	CUDALBI	-0.06	1.40	0.47	-0.40
26	DRĂGUȘENI	-0.11	0.11	-0.49	-0.71
27	FÂRȚĂNEȘTI	-0.12	-1.09	-0.11	-0.64
28	FOLTEȘTI	-0.17	0.67	0.42	1.87
29	FRUMUȘIȚA	-0.11	-1.10	0.35	0.03
30	FUNDENI	-0.16	-0.09	-0.74	-0.64
31	GHIDIGENI	-0.07	-1.08	-0.82	1.09
32	GOHOR	-0.17	0.24	-0.17	0.27
33	GRIVIȚA	-0.16	1.52	-0.56	-0.26
34	INDEPENDENȚA	-0.13	-0.58	-0.33	-0.76
35	IVEȘTI	0.01	-1.40	-0.95	-0.63
36	JORĂȘTI	-0.21	-1.30	1.37	-0.76
37	LIEȘTI	0.03	0.41	-0.95	-0.55
38	MATCA	0.07	-0.79	-0.97	3.30
39	MĂSTĂCANI	-0.13	1.04	-0.45	-0.29
40	MOVILENI	-0.17	-0.02	-1.00	-0.29
41	NĂMOLOASA	-0.20	-1.31	1.65	0.78
42	NICOREȘTI	-0.15	-1.21	-0.30	0.03
43	OANCEA	-0.21	1.09	1.33	-0.76
44	PECHEA	0.04	-1.07	-0.60	-0.57
45	PISCU	-0.13	-0.60	-0.50	0.00
46	PRIPONEȘTI	-0.20	-0.02	1.01	-0.67
47	REDIU	-0.20	-0.26	0.27	3.79
48	SCÂNTEIEȘTI	-0.19	0.02	0.37	0.26
49	SCHELA	-0.16	0.65	-0.50	0.61
50	SLOBOZIA CONACHI	-0.15	1.63	-0.13	-0.76
51	SMÂRDAN	-0.10	-0.91	0.97	-0.74
52	SMULȚI	-0.22	-0.16	2.44	-0.47
53	SUCEVENI	-0.21	0.38	2.06	-0.65
54	TUDOR VLADIMIRESCU	-0.12	-1.38	-0.73	-0.71
55	TULUCEȘTI	-0.06	1.46	-0.82	-0.75
56	ȚEPU	-0.19	0.24	-0.22	1.30
57	UMBRĂREȘTI	-0.07	-0.81	-0.80	1.03
58	VALEA MĂRULUI	-0.16	0.26	-0.15	0.17
59	VÂRLEZI	-0.21	1.37	2.95	0.82
60	VLĂDEȘTI	-0.19	0.11	0.45	-0.28
61	RĂDEȘTI	-0.22	-0.21	0.56	-0.76
62	NEGRILEȘTI	-0.19	0.21	-0.09	1.72
63	POIANA	-0.21	1.27	-0.46	-0.76
64	CUZA VODĂ	-0.19	-0.71	-0.87	-0.33
65	SUHURLUI	-0.22	-0.94	-0.33	-0.50

Source: the authors

Elbow, Silhouette and Dunn analysis were performed, in order to identify the optimal number of clusters. Data was processed using Jupyter application on Phyton platform.

Results were conclusive, as all three methods identified an optimum number of five clusters (Fig.1, Fig.2 and Fig.3). Thus, a number of five clusters were chosen for further analysis.

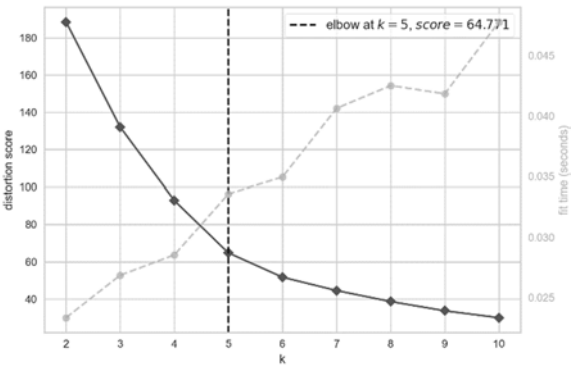

Figure 1 The Silhouette score graph results
Source: the authors

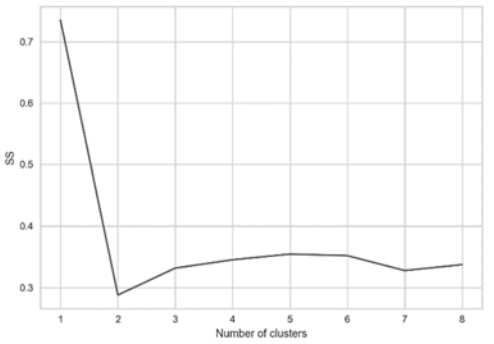

Figure 2 The Davies–Bouldin method graph results
Source: the authors

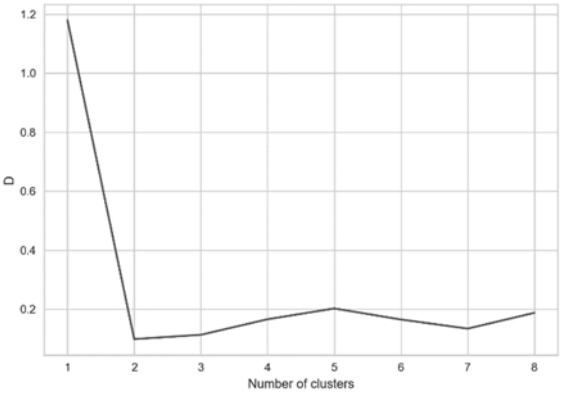

Figure 3 The Dunn method graph results
Source: the authors

The algorithm started with five random observations and was replayed until no further improvement was possible and the best clustering solution was reached, based on the minimum total value of distances between observations and centres (Table 3).

Table 3 Clustering solution (Sol.) based on the minimum total distances

#	1	2	3	4	5	Min.	Sol.
1	79.99	84.70	68.16	73.67	0.00	0.00	5
2	9.04	20.02	1.23	5.81	65.26	1.23	3
3	9.10	8.74	1.02	3.55	67.04	1.02	3
4	15.10	18.89	3.65	9.06	48.34	3.65	3
5	3.79	14.84	3.03	0.17	71.58	0.17	4
6	21.00	0.00	12.81	13.73	84.70	0.00	2
7	4.03	19.00	7.91	1.30	80.67	1.30	4
8	0.00	21.00	5.31	2.65	79.99	0.00	1
9	6.77	10.64	0.25	2.79	66.55	0.25	3
10	5.60	13.56	0.53	1.70	66.81	0.53	3
11	1.39	14.24	6.19	1.69	82.70	1.39	1
12	0.89	25.49	9.60	3.82	86.28	0.89	1
13	0.21	23.17	6.89	4.29	83.28	0.21	1
14	1.29	24.70	11.05	4.80	89.37	1.29	1
15	2.65	13.73	2.84	0.00	73.67	0.00	4
16	6.36	19.44	3.37	1.63	67.36	1.63	4
17	2.37	20.32	4.37	0.65	75.48	0.65	4
18	1.25	25.67	11.32	6.35	90.11	1.25	1
19	0.49	19.46	3.26	2.93	77.09	0.49	1
20	2.36	12.44	2.91	0.09	73.27	0.09	4
21	1.93	21.94	11.05	3.98	89.23	1.93	1
22	5.57	14.48	3.12	0.64	70.44	0.64	4
23	3.37	13.29	2.56	0.06	73.38	0.06	4
24	0.75	19.51	2.61	1.37	74.85	0.75	1
25	1.19	20.81	7.61	1.85	80.79	1.19	1
26	2.69	18.84	2.32	0.70	70.70	0.70	4
27	4.03	17.95	0.50	2.98	68.10	0.50	3
28	6.49	5.43	7.47	4.12	83.98	4.12	4
29	3.56	13.35	0.44	3.08	70.04	0.44	3
30	3.71	18.05	1.89	0.87	70.15	0.87	4
31	9.05	6.39	1.43	3.71	68.55	1.43	3
32	2.40	11.72	2.19	0.17	74.08	0.17	4
33	3.80	19.43	7.62	1.21	79.91	1.21	4
34	3.25	18.68	1.02	1.74	68.98	1.02	3
35	7.86	18.36	0.91	4.24	63.43	0.91	3
36	3.43	22.42	3.44	6.98	76.02	3.43	1
37	4.20	18.34	3.42	0.66	69.10	0.66	4
38	21.10	0.37	11.37	12.59	79.25	0.37	2
39	2.70	17.74	5.18	0.43	76.43	0.43	4
40	4.74	15.58	2.01	0.69	70.30	0.69	4
41	5.56	12.62	4.38	8.02	79.61	4.38	3
42	5.31	12.81	0.00	2.84	68.16	0.00	3
43	0.41	24.94	8.57	4.07	85.52	0.41	1
44	5.41	17.27	0.50	2.81	64.27	0.50	3
45	4.11	12.72	0.40	1.17	68.80	0.40	3
46	0.31	20.52	3.64	2.80	77.57	0.31	1
47	20.42	0.77	15.39	15.12	92.79	0.77	2
48	1.48	12.09	2.02	0.88	75.34	0.88	4
49	3.95	10.44	3.84	0.37	75.79	0.37	4
50	2.72	24.01	8.68	2.04	81.50	2.04	4
51	2.11	20.61	2.30	4.45	72.73	2.11	1
52	2.32	24.97	8.90	8.84	87.13	2.32	1
53	0.97	25.15	8.57	6.61	86.40	0.97	1
54	6.94	18.84	0.76	4.08	65.98	0.76	3
55	4.54	23.19	8.00	1.75	77.15	1.75	4
56	5.31	6.04	3.73	1.68	77.23	1.68	4
57	7.94	6.57	1.41	2.77	68.95	1.41	3
58	2.15	12.50	2.21	0.14	73.92	0.14	4
59	6.17	23.33	17.89	12.80	101.8	6.17	1
60	0.67	16.18	2.41	0.98	75.35	0.67	1
61	0.85	19.92	2.36	2.07	74.84	0.85	1
62	6.81	4.29	4.92	3.02	79.17	3.02	4
63	2.96	22.40	6.77	1.27	79.06	1.27	4
64	5.41	15.31	0.69	1.73	68.31	0.69	3
65	4.16	16.63	0.36	2.31	69.37	0.36	3

Source: the authors

Corresponding to the best clustering solution, the six resulting clusters included the following LAUs:

- Cluster 1: Berești-Meria, Bălăbănești, Bălășești, Băleni, Băneasa, Cavadinești, Certești, Corni, Cuca, Cudalbi, Jorăști, Oancea, Priponești, Rădești, Smârdan, Smulți, Suceveni, Vârlezi and Vlădești.
- Cluster 2: Munteni, Matca and Rediu.

- Cluster 3: Șendreni, Vânători, Tecuci, Târgu Bujor, Barcea, Fârțănești, Frumușița, Ghidigeni, Independența, Ivești, Nămoloasa, Nicorești, Pechea, Piscu, Tudor Vladimirescu, Umbrărești, Cuza Vodă and Suhurlui.
- Cluster 4: Drăgănești, Berești, Braniștea, Brăhășești, Buciumeni, Corod, Cosmești, Costache Negri, Drăgușeni, Foltești, Fundeni, Gohor, Grivița, Liești, Măstăcani, Movileni, Negrilești, Poiana, Scânteiești, Schela, Slobozia Conachi, Tulucești, Țepu and Valea Mărului.
- Cluster 5: Galați.

Average values for each cluster were calculated (Table 4).

Table 4 Clusters characteristics

#	No. of LAUs	A	B	C	D
Cluster 1	19	2.576	48	2.53	51.44
Cluster 2	3	7.319	32	1.15	722.44
Cluster 3	18	7.854	24	1.04	115.24
Cluster 4	24	4.591	49	1.07	125.69
Cluster 5	1	306.617	9	0.04	20.25

Source: the authors

As it can be noticed, Galați city formed a cluster of its own. As the largest urban area in the county, it has the largest population and being so much different from all other LAUs, it stands as proof for the gap between urban and rural areas, having by far the lowest relative poverty rate, compared to the other LAUs in the county. Thus, we'll focus on comparing the other four clusters, more similar, between themselves.

The first cluster contains 19 LAUs, has low population and a low value of implemented projects. This cluster has the highest agricultural area per population, but also shares, together with the fourth cluster, the highest values of relative poverty rate.

The second cluster has a medium relative poverty rate, large population and highest value of implemented projects per population. It includes only three LAUs.

The third cluster contains 18 LAUs, has the largest population, lowest relative poverty rate and a medium value of implemented projects.

The fourth cluster has a medium to low population, highest relative poverty rate and medium value of implemented projects. This cluster is the largest, containing 24 LAUs.

The third and fourth clusters also share some of the lowest values regarding agricultural area per population.

Focusing on the areas with the highest values of relative poverty rate, clusters one and four, we can notice some differences. Even if cluster one has the largest agricultural area per population, it attracted the lowest value of EAFRD funding, less than half of the next lowest value. Cluster four performed better, attracting almost 2.5 times more funding, even with a much smaller agricultural area per population, almost 2.5 times smaller, in fact.

These two clusters, having the highest relative poverty rate and lowest populations, count for 66% of all the LAUs in the county being a cause for concern.

Cluster two is the obvious success story, attracting more than 5.5 times more funding than the next best situated cluster. As seen, the second cluster contains only three LAUs of the total of 65, making it an exception for the county.

Distribution-wise, a high concentration of clusters one and four LAUs can be noticed in the centre, North and North-East parts of the county, making those areas hotspots for high poverty incidence (Fig.4).

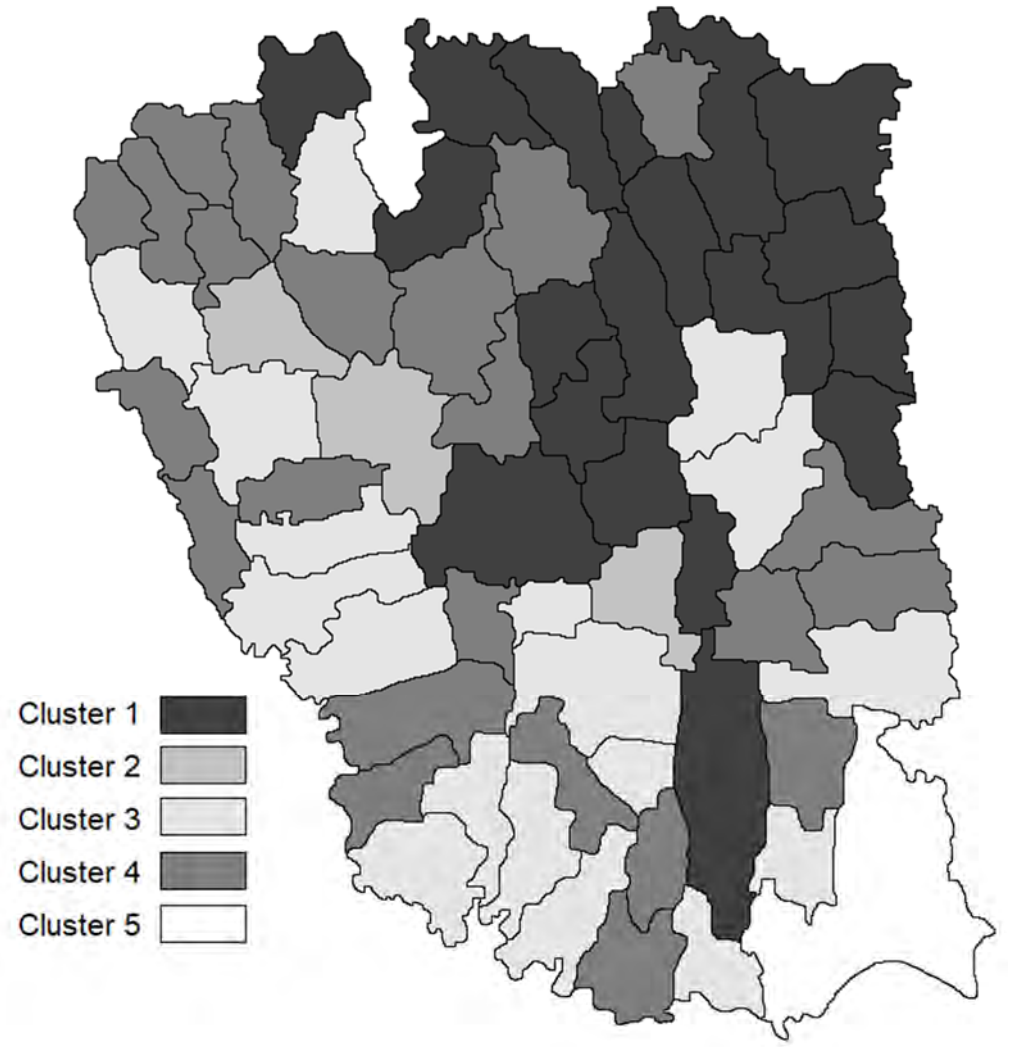

Figure 4 Spatial distribution of clusters within Galați County
Source: the authors

Conclusions

In Romania's case, reaching the proposed objectives was somewhat limited for the 2014-2020 National Rural Development Programme (Paul, 2020). Moreover, previous studies highlighted a tendency for the distribution of funds towards already developed areas, on the expense of less developed ones.

For Galați county, in Romania, a k-means cluster analysis on LAU level, considering four variables (total population, relative poverty rate, agricultural area per population and total value of EAFRD agricultural projects per population), reached an optimum number of five clusters. Cluster analysis proved to be a useful tool for rural development because it allows identifying patterns and grouping within data sets and helps in identifying similar communities or regions, by using different factors. It can be used to inform the design and implementation of targeted rural development programs and policies.

One cluster is composed by only one LAU, the large city of Galați, as a proof for the wide gap between urban and rural areas.

The two largest clusters by number of composing LAUs are also the poorest, representing together 66% of the county's LAUs. One of those clusters, even if having the most important agricultural potential per population, attracted by far the lowest value of EU funding. This cluster also presents the lowest population per LAU.

Generally, LAUs with larger population performed better in terms of population income, having the lowest relative poverty rate. Among them, the LAUs of cluster two performed exceptionally well at attracting EU funding. This

represents the opposite pole compared with cluster one, with the lowest population and lowest attracted EU funds, bringing up the case for the small LAUs administration inefficiency and necessity of territorial reorganization. Like other areas in Romania, Galați County has been affected by emigration, as many people have moved to urban areas or other countries in search of better economic opportunities. This has led to a decline in population and economic activity in some rural areas, further exacerbating the uneven development. Communities with low population performed poorly in attracting EU funds. Territorial reorganization can address these issues by consolidating smaller LAUs into larger ones, creating new LAUs, or merging rural LAUs with neighbouring urban areas. This can help create more efficient and effective governance structures, and make it easier for residents to access services and markets. Additionally, it can also reduce administrative costs and improve the delivery of public services.

LAUs of cluster two represent success stories to be followed, especially by LAUs of clusters one and four. Know-how exchange can be beneficial in this regards and Local Action Groups (LAGs) can play an important role in this approach.

Rural development in Romania, including Galați County, has been uneven. Some rural areas have seen significant economic growth and modernization, while others have been left behind. This is due to a variety of factors, including differences in access to resources, population and EU funding.

For economic convergence at county level, development strategies need to focus on underdeveloped hotspot areas, like the central, northern and north-eastern parts of the county. Dedicated actions need to be designed especially for these areas, considering the specific problems they are facing. Further analysis of the differences compared to the others clusters might give an important insight on this matter. A bottom-up approach would also include relevant LAGs in this process.

Current research focused only on EAFRD funding towards agricultural exploitations. For a more detailed approach, further research is necessary in order to highlight other relevant differences between communities in different clusters, including consideration of other EAFRD submeasures, like economic diversification, processing agricultural products or infrastructure investments.

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✉ **Correspondence**

Alexandru Sin

National Institute for Economic Research "Costin C. Kirițescu", Romanian Academy
Calea 13 Septembrie no.13, 050711 Bucharest, Romania

E-mail: alxsin@gmail.com

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Influence of demonetization on various sectors of the Indian economy

Anita Prasad
Manav Rachna International Institutes of Research and Studies, Faridabad, HR, India
https://orcid.org/0000-0001-6130-193X

Anandajit Goswami
Manav Rachna International Institutes of Research and Studies, Faridabad, HR, India
https://orcid.org/0000-0002-2710-0883

Amulya Gurtu
University of Kansas, Overland Park, KS, USA
https://orcid.org/0000-0003-3149-8668

Abstract

Background: India demonetized the currency in November 2016, scrapping 86.9 percent of the currency in circulation. This policy disrupted most economic activities because India was predominantly a cash economy.

Purpose: The study aims to analyze the impact of demonetization on the informal-formal sector and the Indian stock markets, where investment reflects investors' confidence. Another purpose is to know the usefulness of demonetization in the proliferation of digitalization.

Study design/methodology/approach: The study incorporates primary data to determine the impact on informal and formal workers' income and the acceptance of digitalization in rural-urban areas in Faridabad, Haryana. A survey was conducted, and samples for informal-formal workers and rural-urban households were collected and analyzed using the F test and the ANOVA model using an independent dummy or qualitative variables. The secondary data of the Indian stock market were empirically tested and forecasted using the Autoregressive Conditional Heteroskedasticity (ARCH) model.

Finding/Conclusions: The empirical analysis reveals that after demonetization, informal workers' earnings dropped significantly, and there is a substantial income disparity between informal-formal workers. A wide gap persists in adopting digital transactions due to low awareness of digital instruments in rural areas compared to urban areas. On the contrary, no significant impact is noticed in the Indian stock market as the forecasted value of shares trading depicts positive growth. The study identifies the gaps in policy implementation. It exposes the implementation of macroeconomic policies ensuring the protection of the interest and livelihood of economically vulnerable populations. The spread of awareness towards electronic transactions may help to promote digitalization

Limitations/future research: The study is limited to a few areas. Hence, the scope of future research rests on macro-level data where comparison could be conducted between rural and urban areas across various states in India.

Keywords
informal sector; demonetization; digitalization; rural development; stock market; ARCH model; ANOVA model.

Introduction

India is the fifth-largest and fastest-growing economy in the world (WEF, 2021). However, the Indian economy is a large informal and largely rural economy that suffered from black money, fake currency, and lack of digitalization. To address these challenges, the Government of India (GoI) announced a demonetization policy effective from midnight of November 8, 2016 (RBI, 2017). Demonetization makes a currency unit lose its legal tender status (Taqi, 2018; Sutar, Dhalmahapatra & Chakraborty, 2022). The policy scraped existing INR 500 and INR 1000 bills and introduced new INR 500 and INR 2000 bills (Lahiri, 2016). However, all scrapped bills were allowed to be exchanged at the banks until December 30, 2016, and cash withdrawal was limited to INR 20,000 per week at the bank counter (RBI, 2016). The policy also significantly defined the limit to withdraw INR 2000 per card per day from ATMs (Automatic Teller Machines) up to November 18, 2016. The limit was raised to INR 4,000 on November 19, 2016. However, there were no restrictions on non-cash methods for purchases or transfer of funds to promote e-banking and e-commerce to minimize the informal economy (RBI, 2016). From the national security point of view, the crucial objective of demonetization was to curb terrorism spread through the flow of high denominations of fake Indian currency (Lahiri, 2016; Prakash, 2019). The statistics released by RBI revealed that around 99.3 percent of the demonetized currency was received in the banking system. The remaining 0.7 percent (INR 160,500 Million) could not be traced (Ashwani & Nataraj, 2018). Thus, it divulges that such steps proved to be unfruitful in combating black money, which was another objective of demonetization (Bose, 2019). The announcement of demonetization disrupted the informal economy (Jawed, Dhaigude & Tapar, 2019). In India, the cash shortage affected many in the informal economy because a significant number of transactions, including very high-value transactions such as purchasing a car or a house, were conducted in cash. The sudden cash shortage impacted vulnerable sectors such as farmers, casual workers, micro and small traders, and low-income households (Viswanathan, Jaikumar, Sreekumar & Dutta, 2021). It caused a fall in economic activities (Ghosh, 2017). As per the RBI reports, the impact of demonetization started diluting in January 2017 and dissipated by mid-February, indicating the pace of remonetization (RBI, 2017). Further, the implementation of demonetization led to a short-term marginal downward trend in the Indian stock markets. However, it showed an upward trend gradually (Ashwani & Nataraj, 2018).

The sixth anniversary of demonetization was on November 8, 2022. The debate about its success or failure continues inconclusively. Raghuram Rajan, former governor of the Reserve Bank of India (RBI), stated that the short-term costs of demonetization outweigh its long-term benefits (Ashwani & Nataraj, 2018). Karmakar and Narayanan (2020) also counted that such macroeconomic policy has short-run and long-run impacts. On the other hand, some economists such as Paul Krugman, Manmohan Singh, Amartya Sen, P Chidambaram Kaushik Basu, Jean Dre`ze, Jayati Ghosh, Prabhat Patnaik, Arun Kumar, and Larry Summers did not consider this policy commendable (Jawed *et al*., 2019; Mohindra & Mukherjee, 2018).

Table 1 Chronology of various countries that implemented demonetization

Year	Country	Motive
1967	Singapore	to mitigate high money laundering risk.
1982	Ghana	to control hyperinflation
1985	Myanmar	to control hyperinflation
1987	Myanmar	to control hyperinflation
1988	Australia	to prevent counterfeiting
1990	Brazil	to control hyperinflation
1991	Soviet Union	to fight against unearned income, smuggling, and corruption.
1993	Brazil	to control hyperinflation
1993	Iraq	to finance the fiscal deficit.
1993	Russia	to control hyperinflation
1999	Singapore	to mitigate high money laundering risk.
2009	North Korea	to curb black money.
2012	Denmark	to prevent counterfeiting
2013	Greece	to manage fiscal and banking crises.
2014	Singapore	to mitigate high money laundering risk.
2015	Australia	to prevent counterfeiting
2015	Cyprus	to manage fiscal and banking crises.
2015	Pakistan	to fight corruption and black money.
2015	Zimbabwe	to control hyperinflation
2016	Euro Region	to create a common currency for the EU.
2016	Venezuela	to control hyperinflation

Source: Singh & Prajapati (2020)

Demonetization has been used worldwide as an effective tool to curb black money. It was used in economies where most economic activities were handled in high denomination bills (Lahiri, 2020). After World War II (1939-1945), Britain and other European countries demonetized high-denomination bills to stop unrestricted wealth gain (Lahiri, 2020). The United States and the European Central Bank demonetized large denomination

bills in 1969 and 2017, respectively. Many other countries, such as Ghana, Nigeria, Myanmar, Russia, North Korea, South Africa, and Zimbabwe, had also demonetized their currency (Chattopadhyay, 2019; Kayıkçı, 2022). Table 1 presents historical announcements on demonetization.

Demonetization was implemented in India twice before 2016. Demonetization of 1946 withdrew INR 1,000 and INR 10,000. Similarly, INR 1,000, INR 5000, and INR 10,000 bills were again demonetized in 1978 (Gautam & Jain, 2019; Sivathanu, 2019). The motive of such action was to combat black money and to stop the circulation of fake currencies (Goel, 2018). Hence, demonetization in 2016 was not a novel concept in India.

Various works of literature have already assessed the impact of demonetization. However, there is a research gap in the literature on the effects of demonetization on informal workers, who contribute around 50 percent of the total Indian GDP. There is no study on the influence of demonetization in India on informal sector employees, i.e., this is the first study on this topic. Furthermore, the proliferation of digitalization after an announcement of demonetization is measured using primary data to get a ground-level picture by ascertaining the awareness rate among chosen samples in rural and urban areas of Faridabad. Also, the stock market is considered a barometer of investors' sentiments. The research question is whether this policy has any long-term impact on the stock market. Thus, this paper includes all three aspects to conclude that impact of policy implementation could be moderated if the vulnerable section of society is assured with basic income. Secondly, digitalization could be highly promoted if people are aware of digital payment techniques.

We tested these gaps through the following hypotheses:

$H_{1(null)}$: Demonetization has not affected the informal workers more than formal workers.

$H_{2(null)}$: No infrastructural and economic bottleneck exists between urban and rural areas.

$H_{3(null)}$: Demonetization had no considerable effect on the Indian Stock market.

With this background, the paper is divided into six sections. Section one focuses on the objective of demonetization and discusses its impact on the general price level. Section two throws light on its theoretical concepts of demonetization. Section three will assess the impact of demonetization. Section four focuses on the methodology adopted for empirical analysis. Section five highlights the findings and their association with future policy, and the last section concludes the paper.

1. Demonetization: a necessity or casualty

Demonetization is a liquidity shock to economies thriving on cash transactions (Singh & Ghosh, 2021). It is the act of stripping the money supply from the economy. Its ripple effects lead to low consumption, investment, production, and employment. Nevertheless, it was implemented in 1946, 1978, and 2016 to revitalize the economy (Gautam & Jain, 2019). According to Anoop, Narayan and Reddy (2018), demonetization aims to promote a cashless economy. Financial inclusion via the promotion of alternative means of payment (mobile payment technology) gives a safety net during a cash crisis (Pal, De' & Herath, 2020). Many studies confirmed that a cashless economy boosts private consumption and GDP growth (Mukhopadhyay, 2016). The reports of RBI indicate that post-demonetization, there has been a sharp rise in the number of accounts (272,000 Million to 728,340 Million) under the Pradhan Mantri Jan Dhan Yojana (PMJDY) and a surge in digital transactions (RBI, 2017; Fouillet, Guérin & Servet, 2021; Jawed *et al*., 2019). However, Singh & Prajapati (2020) found that infrastructural bottlenecks (less availability of bank branches, agricultural credit society, and ATMs) were perceived as hindrances to encouraging digital transactions. Hence, there is a long way to promote digitalization catering to all small sections of Indian states.

Furthermore, considering the inflationary impact, the data on food inflation showed a sharp decline of about 240 bps between October 2016 and January 2017, reflecting the combined effect of record pulses production, significant winter arrivals of vegetables, and compression in demand due to demonetization (RBI, 2017). Inflation excluding food and fuel was marked unaffected. Hence, the headline CPI inflation fell by around 100 bps to 3.2 percent in January 2017, the lowest inflation reading since the publication of the all-India CPI inflation series (RBI, 2017) shown in Table 2.

However, with the recovery of demand from the latter part of Q4 of 2016-17, inflation risks to CPI excluding food and fuel and headline inflation are,

therefore, showed remarkable height. Hence, the policy led to a fall in price, but it showed remarkable growth after some time.

Table 2 CPI Inflation

Category	Nov 2015	Dec 2015	Jan 2016	Oct 2016	Nov 2016	Dec 2016	Jan 2017
Fuel & light	5.3	5.4	5.3	2.9	2.8	3.8	3.4
Clothing and footwear	5.8	5.7	5.7	5.2	5.0	5.0	4.7
Housing	5.0	5.1	5.2	5.1	5.0	5.0	5.0
Miscellaneous*	3.8	4.0	3.9	4.7	4.8	4.7	5.1
CPI-excluding Food-fuel	4.7	4.9	4.7	4.9	4.9	4.9	5.1

Source: RBI (2017)

*Includes household goods and services; health; transport and communication; recreation and amusement; education; and personal care and effects.

Conclusively, the macroeconomic policy of demonetization proves to be both a necessity and a casualty. This is because, on one side, it acted as a tool to fight against corruption and terrorism and increased digital payments; on the other side, it negatively affected those who were dependent on cash. Next, we discuss the theoretical aspect of demonetization.

2. Theoretical concept of demonetization: a liquidity shock

From a macroeconomic perspective, liquidity means the availability of funds on short notice. If money fails to meet the demand of people with ease, then it may be termed a liquidity shock. (Dornbusch, Fischer & Startz, 2011). Liquidity shock due to monetary policy or any other reason has its origin in the past as well; some of the most popular crises are the Great Depression of 1930, the financial crises of 2008-09 (Lucas, 2014), the Asian crisis in 1998, the German banking and currency crisis in 1931 and the crisis in the euro area that started in 2010 (Bindseil & Winkler, 2012). Similarly, there was a government shutdown in the USA in 2013. In this case, there was a temporary drop in liquidity through a cut in employee paychecks. Due to this, spending dropped sharply, and consumption was met by short-term liquidity (Gelman, Kariv, Shapiro, Silverman & Tadelis, 2020). Christiano (1994) suggested that the federal reserve (the central bank of the U.S.A.) needs to maintain the money supply. It needs to apply the monetary policy so that it does not obstruct income, employment, and aggregate spending. It should positively create shock in financial markets by increasing the money supply, due to which the nominal interest rate could fall and employment and output rise. On the contrary, when the federal reserve decreases the money supply, the interest rate increases, which may depress the economy in terms of GDP, investment, and employment contraction. This process that affects interest rates, investment, and output is termed the liquidity effect. Lucas (2014) suggested that a sudden reduction in the money supply leads to deflation and a reduction in spending. This happens because a sudden loss of liquidity leads people to reduce spending to rebuild a desired ratio of cash to spending flows.

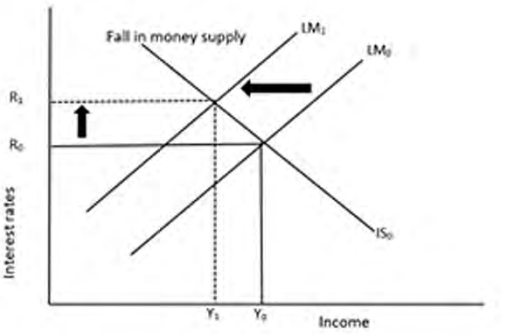

Figure 1 Demonetization and equilibrium of IS/LM curve
Source: Branson (2019)

Seeley (2017) posited that the IS-LM (investment-savings and liquidity preference-money supply) model is a helpful tool to assess the impact of different policy actions and external shocks and helps to know the effect of policies on output and interest rates. Figure 1 illustrates the impact of the decrease in the money supply. As a result of the fall in money supply, the income dropped from Y_0 to Y_1, and an increase in interest rates from R_0 to R_1 may lead to falling in investment and loss of production.

Chodorow-Reich, Gopinath, Mishra & Narayanan. (2020) highlighted the positive relationship between cash in hand and tax evasion. It is hypothesized that keeping cash reduces the effective tax rate contributing to tax evasion. Sabnavis, Sawarkar and Mishra (2016) also highlighted that if the supply of unaccounted money is taken from the money market through monetary policy, it will help to remove unaccounted money because black money holders will not be able to deposit the stack of unaccounted money in the bank and that money will become scrap. Chanda (2016) also counted that demonetization is a valuable tool to combat black money and helps to redistribute wealth. Hoarders will try to launder their money by overpaying their daily wage workers. If hoarders purchase

properties from black money, the resale value will drop. This can, in return, also impact the real estate market and the respective employment in the real estate market. Overall, this can also have a spiraling influence on economic activities and job creation. Effectively, this can impact the construction sector and the associated informal economy related to the construction sector. Waknis (2017) studied the decrease in money supply due to demonetization from the Indian perspective connecting it with the informal sector. They concluded that a reduction in money supply led to less cash availability and, consequently, a fall in output production within the informal sector. This was accelerated by a decrease in the demand for output by consumers due to a fall in cash availability. Accordingly, the informal economy had a significant impact on employment, output, real interest rate, and aggregate price level.

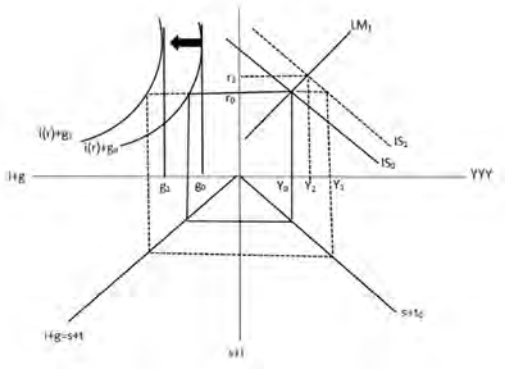

Figure 2 Increase in government spending and impact on income
Source: Branson (2019)

Moreover, such impact may be ameliorated if the government increases its expenditure or purchases in the economy; this is shown in Figure 2. The government purchases may be diverted towards social security transfer, especially for informal sectors, and considerable investments to promote digitalization in rural areas so that the parity between urban and rural could be maintained. In Figure 2, the change in government spending from g_0 to g_1 leads to an increase in income from Y_0 to Y_2 with higher interest rates r_2. Hence, fiscal policy may prove to be a helpful tool to increase income which was diminished due to the monetary policy of demonetization.

Furthermore, Arora, Kaur and Kaur (2019) studied the impact of demonetization on a business cycle. The authors have chosen Hawtrey's business cycle model. Business cycles occur due to changes in effective demand through changes in bank credit. Credit creation increases the money supply, which further changes effective demand and, consequently, the business cycle in the economy. Hence, monetary factors affect economic activities, and it was concluded that demonetization leads to a decline in economic growth. Moreover, a strong relationship was perceived between money stock (M3) and the Index of Industrial Production (IIP), a proxy of economic activities, where changes in money supply significantly fluctuate IIP hence, dwindling growth rates. This further validates Hawtrey's theory that liquidity conditions determine economic activities and economic growth, which is also applicable in India (Arora *et al*., 2019).

According to Roy (2019), the announcement of demonetization negatively impacted the M1 money supply in the ambiance of a stable economic environment. Demonetization decreased cash circulation and increased bank deposits with no credit expansion (Basu, Basu & Nag, 2018). The author analyzed macroeconomic policy using the AD (Aggregate Demand) and AS (Aggregate Supply) models. They assessed how uncertainty due to demonetization led to adverse macroeconomic consequences internally and externally. On the demand side, aggregate consumption and investment start falling due to the lack of cash, particularly in an economy that thrives on cash transactions. On the supply side, monetary shock disrupts the foreign exchange market leading to the depreciation of exchange rates. Consequently, rise in the price of imported goods and the price level.

Table 3 Rate of Interest (2012-2020)

Year	Rate of Interest* (%)
2012	8.00
2013	7.50
2014	8.00
2015	6.75
2016	6.25
2017	6.25
2018	6.00
2019	6.00
2020	4.00

* for the quarter ending September
Source: RBI Annual Repor (2012 – 2020)

Moreover, demonetization also had a partial impact on the Indian economy. Some of the partial effects were related to the liquidity flow and availability within the economy. This was because people could deposit cash but could not withdraw their money, so the deposits in the bank started to increase. Further, it did not affect other aspects of

monetary policy, such as the overall liabilities of the RBI and the market interest rate (Chodorow-Reich *et al*., 2020). The consistencies of interest rates are illustrated in Table 3.

Thus, after discussing the theoretical aspect of demonetization moving forward to the sectoral impact using primary and secondary data.

3. Impact of demonetization

The Indian economy is cash-driven (Chauhan & Kaushik, 2017). The announcement of demonetization caused tremendous hardship to the cash-dependent sectors, supplemented with a drop in growth rates (Basu *et al*., 2018). The impact of demonetization is analyzed on principal sectors like formal-informal, rural-urban, and the stock market in the following sub-sections.

3.1. Informal and formal sector

In India, 85 percent of the total workers are informal (excluding the agricultural workforce); overall, it is over 90 percent of the entire workforce (ILO, 2019). In developing economies, the informal employment share is 85.8 percent in Africa, 68.2 percent in Asia and the Pacific, 68.6 percent in the Arab states, and 25.1 percent in Europe and Central Asia (ILO, 2018).

As per the report of NCEUS (2007), the informal workers are primarily devoid of social security and job protection, and it also comprises the workers engaged in the formal sector without any employment and social security benefits. In addition, informal employment means insecure worker relations, low wages, and short-term worker arrangements wherein the workers are not protected by worker laws and do not benefit from social welfare systems (Bhattacharya, 2019). On the contrary, formal workers are hardly poor and are supplemented with social security benefits. They are salaried and white-collar workers. Table 4 shows the maximum employment of informal which is five times higher than formal employment.

Table 4 Size of Formal and Informal employment in India, 2017-18

Type	Non-farm employment in millions			
	Manufacturing	Non-Manufacturing	Services	Total
Formal	8.6	3.1	31.1	42.8
Informal	47.7	55.9	113.4	217

Source: ILO (2019)

Moreover, the colossal cash dependency of the informal sector in India and the sudden withdrawal of currency have left this sector appalled. This situation shocked the demand and supply (Kameswaran & Muralidhar, 2019). As per Karmakar and Narayanan (2020), the people who do not hold bank accounts failed to deposit their hard-earned money in the bank safely, and thus all money got scraped. Therefore, the study was undertaken in the presence of informal and formal workers in Faridabad, Haryana, to assess the influence on informal and formal workers after demonetization.

3.2. Rural and urban divide

The rural and urban areas are specified by settlement and occupation. Rural people depend on agriculture, and urban people are involved in industries (Tacoli, 1998). The people living in rural areas are highly dependent on cash for their daily transactions, especially farmers and daily wage workers (Shahare, 2017). The present study is about the sectoral impact of demonetization. This section focuses on how macroeconomic policy promotes digitalization and awareness in e-banking facilities in rural and urban areas. According to the 2011 Indian census reports, India has 833 million (70 percent of the population) rural population, and the remaining 377 million live in urban areas (Shahare, 2017). Adopting Information and Communication Technologies (ICTs) and digitalization are major contributors to enhanced productivity and efficiency (Maiti, Castellacci & Melchior, 2020). The government of India launched the "Digital India" program in 2015 to promote technology and access to government services through the internet (Maiti et al., 2020). RBI launched 'Vision-2018' in June 2016 to promote electronic payments and settlements. After demonetization, India experienced a 20 percent rise in prepaid payments in the retail sector (Balaji & Balaji, 2017). Figure 3 shows the changes in digital transactions over time.

Digital transactions in Figure 3 have shown a continuous increase since November 2016 and a remarkable increase since June 2019. Even the RBI data showed that post-demonetization, transactions in India increased by 133 percent, and an additional 1.5 million people started using debit cards (Balaji & Balaji, 2017). However, ATMs, credit cards, and debit cards were not popular in rural areas (Shahare, 2017). Sudden cash shortage coupled with low electronic payments led to decreased purchasing power, particularly in the rural population.

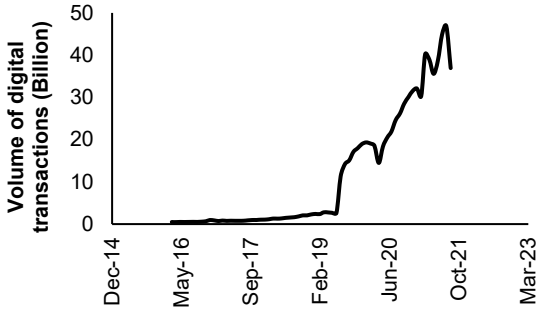

Figure 3 Changes in the number of digital transactions.
Source: NPCI (2021)

On the other side, there has been an increase in digital payments, particularly in urban areas (Kameswaran & Hulikal Muralidhar, 2019). However**,** macro-level data is not sufficient alone to depict a clear perspective. Accordingly, micro-level data from rural and urban areas of Faridabad, Haryana, is analyzed to identify a comparison between rural and urban areas. Further, the empirical results will test how far the demonetization policy contributes to the spread of digitalization in rural and urban areas.

3.3. The Indian stock market

This section sheds light on the impact of demonetization on the Indian stock market through the secondary data of shares traded. The stock market holds many funds and indicates the economy's health (Anoop *et al*., 2018; Jawed *et al*., 2019). Monetary policy changes significantly impacted the stock market (Pal & Garg, 2019). Indian equity markets have shown a declining trend since demonetization (Giri & Singh, 2017). The two benchmark equity indices, the NIFTY 50, fell 6.3 percent from November 8 until November 22, 2016, and the S&P BSE Sensex fell 5.9 percent during the same period (Giri & Singh, 2017). The market capitalization of BSE and NSE on March 31, 2016, was INR 94 trillion and INR 93 trillion, respectively (Pal & Garg, 2019). The gross purchase and sale of equity on March 31, 2016, were INR 59 billion (USD 0.98 billion) and INR 44 billion (USD 0.73 billion), respectively. However, after demonetization, the impacts on shares trading are analyzed empirically. Figure 4 presents the trends of shares trading.

The number of traded shares increased except in December 2016, when the quantity of share trading declined abruptly, showing a deep gorge in Figure 4. This reflects investors' loss of confidence in the stock market. The cash crunch with the public and restrictions on daily transactions during the demonetization period forced the investors to withdraw their hard-earned money from the market and invest in safer instruments, namely fixed deposits and saving bank accounts. The ARCH model has been used to empirically test the impact of demonetization on the stock market and determine its future trends.

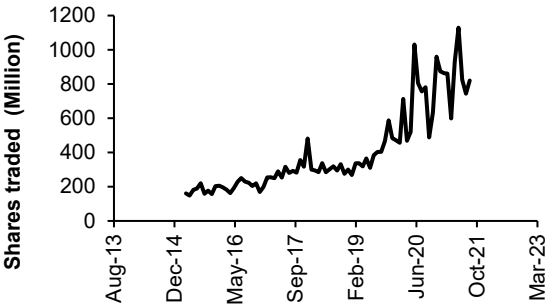

Figure 4 Quantity of shares traded.
Source: NSE (2021)

4. Methodology

The nature of the research is exploratory and descriptive. The studies were conducted in Faridabad, an industrial city in North India, to assess the sectoral impact of demonetization on rural-urban and formal-informal economies. Secondary data were gathered from various sources to ascertain sectorial impact. Primary data were collected from two hundred fifty-two workers from different occupations.

As per the 2011 census, the total area of Faridabad is 741 sq. km, of which 523 sq. km is rural and 218 sq. km is urban. Further, 79.51 percent of the population live in urban areas, and the remaining 20.49 percent are in rural areas. Two rural areas, Tigaon and Tilpat, and two urban areas, Roshan Nagar and Surya Nagar, were selected in the Faridabad district. The sample had 252 respondents, 50 percent from urban and 50 percent from rural areas. The distribution of males and females in rural and urban areas is also 50: 50. The F-test is applied to ascertain any significant income difference between formal and informal sectors before and after demonetization. The Analysis of Variance (ANOVA) model has been used to determine the average awareness rate (dependent variable) in rural and urban areas to showcase the influence of demonetization in promoting digitalization.

For analyzing the impact of demonetization on the Indian stock market, the Chow test was applied to ascertain the structural changes due to

demonetization, followed by the ARCH model to forecast data. The Augmented Dickey-Fuller Test showed non-stationary data. The data relating to the total number of stocks traded from 2015 to 2019 have been taken from National Stock Exchange (NSE). The ARCH model was incorporated to assess the volatility clustering of the series. After ascertaining the presence of the ARCH effect, the estimated ARCH model was created to forecast the mean and variance. Various analyses were performed using Excel, STATA, and EViews software.

5. Findings

This section summarizes the findings on the impact of demonetization on informal-formal workers, rural-urban areas, and the stock market under three subsections as follows:

5.1. Impact of demonetization on informal and formal workers

During the survey, informal and formal workers were asked to provide data and their experiences due to the implementation of demonetization. It was seen that informal workers are impacted more than formal workers, as the loss of income in the case of informal workers is more prominent than formal workers. This is shown in Figure 5 and Figure 6.

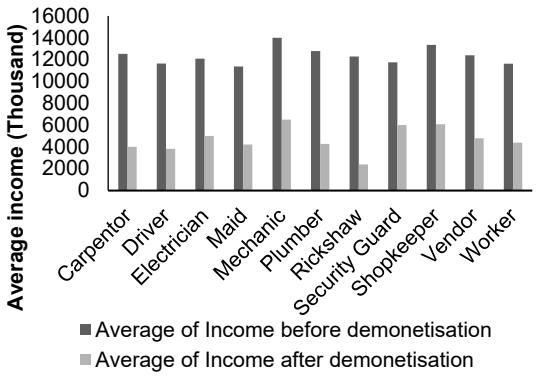

Figure 5 Income before and after demonetization of informal workers
Source: the authors' calculation from survey data

Further, it was found that the savings of informal workers diminished abruptly. Liquidity constraints led them to borrow money from money lenders at a high interest rate. It was also found that most women had no bank accounts to put their hard-earned money safely. Thus, demonetization reduced their cash holding, which was further aggravated due to a decrease in consumption. Figures 5 and 6 show that during demonetization, the formal workers did not suffer much, and their cash was stacked for a few months. No significant financial losses were noticed for formal workers. On the contrary, informal workers were severely impacted due to demonetizations. Their income dropped suddenly due to a cash shortage.

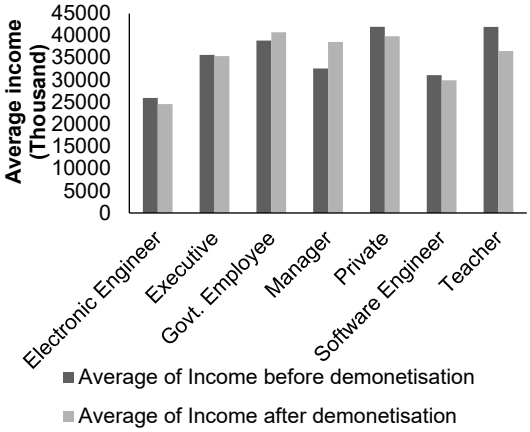

Figure 6 Income before and after demonetization of formal workers
Source: the authors' calculation

For testing the concept, our null and alternate hypotheses are:

$H_{1(null)}$: Demonetization has not affected the informal workers more than formal workers.

$H_{1(alternate)}$: Demonetization has affected informal workers more than formal workers.

Table 5 F-test

Particulars	Income after demonetization (Formal)	Income after demonetization (Informal)
Mean	36219.03	4482.444
Variance	3.41E+08	9607420
df	125	125
F	35.47798	
P (F<=f) one-tail	6.65E-63	
F Critical one-tail	1.343613	

Source: the authors' calculation from survey data

The F-test (Table 5) is used for empirical analysis of the income after demonetization for both informal and formal workers. Post-demonetization, the income of informal workers dropped drastically as compared to formal workers, with no significant impact on their income.

Since the F-value is greater than the critical value at the significance level (95 percent), the null hypothesis is rejected, i.e., the demonetization has significantly affected informal workers more than formal workers.

5.2. Digitalization in rural and urban areas

It is the first time in India that demonetization has ignited digitalization, and the primary and secondary data support it. The good thing is that most people have adopted digital payment in urban areas. Figure 7 shows the adoption of various modes of payment, such as Unified Payment Interface (UPI), Debit card, Paytm, and cash.

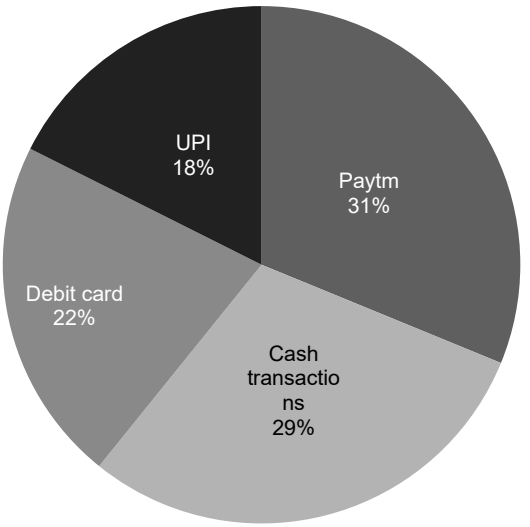

Figure 7 Various modes of payments by urban households.
Source: the authors' calculation

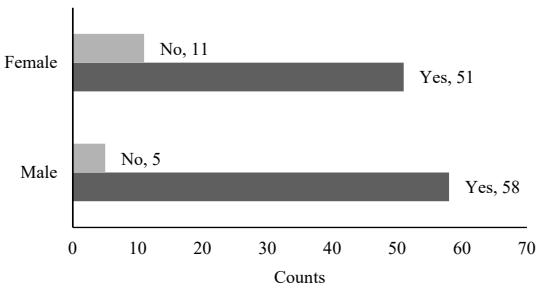

Figure 8 Bank accounts of urban households
Source: the authors' calculation

In urban areas, it is revealed that 29 percent of the population still uses cash transactions in day-to-day business/financial activities and has not adapted to digital payments. The adoption of digital payment, such as Paytm, covers a maximum area of about 31 percent. The urban population is more comfortable with Paytm because it is easy to carry out various small transactions quickly.

Figure 8 shows the adoption of bank accounts between males and females in urban areas. Gender-wise, males have a higher proportion of bank accounts than females. On the other side, women had fewer bank accounts than men. Further, the survey also found that homemakers in urban areas are uncomfortable with digital payment.

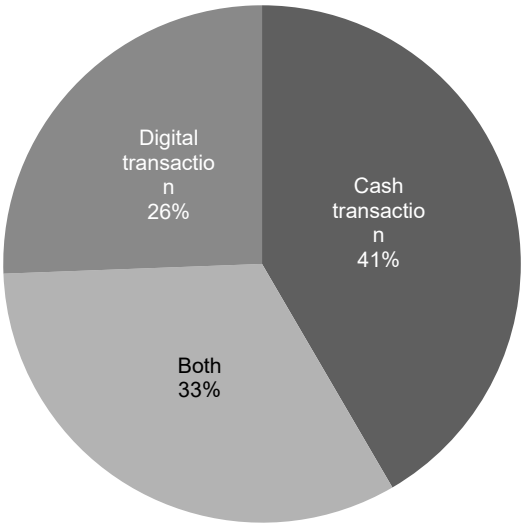

Figure 9 Comfort level in transactions by urban households
Source: the authors' calculation

Figure 9 shows the comfort level among urban households in transactions where it was found that they are still comfortable in cash transactions which is 41 percent, followed by those who use cash and digital payments. They feel comfortable making every small transaction in cash, although they have access to digital payments. Another point of this analysis is that if 41 percent of the urban population are comfortable with cash, and 59 percent are happy to use digital transactions, which is a good sign of digital penetration.

The survey in rural areas revealed that bank branches and automated teller machines (ATMs) are not found nearby. Hence, digitalization in rural areas is less prevalent. Most of the respondents were not aware of mobile banking and far away from the technical know-how of digital payments, and were found to be more comfortable in cash transactions. Figure 10 reveals the mode of payments adopted by rural households, as 83 percent of rural households still use cash in day-to-day transactions despite digital payments, most popularly Paytm, which is easy to use. Rural areas are still lagging in digitalization, as merely 17 percent of the population use digital transactions for their day-to-day activities.

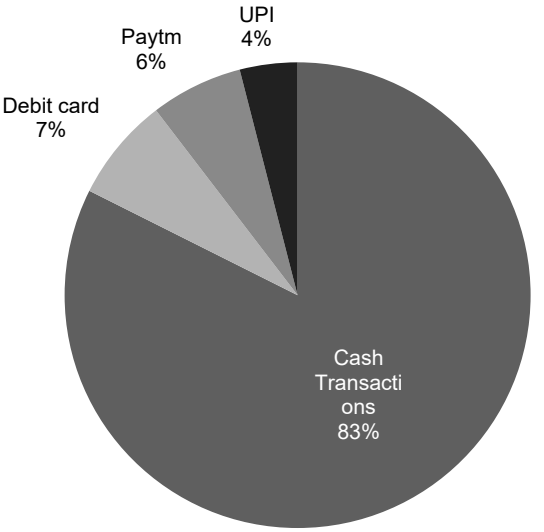

Figure 10 Various modes of payments by rural households
Source: the authors' calculation

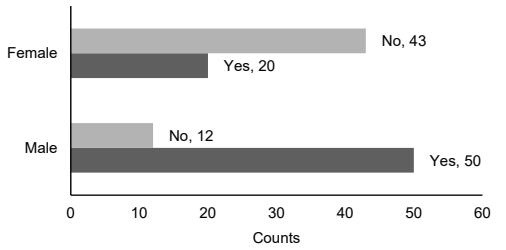

Figure 11 Bank accounts of rural households
Source: the authors' calculation

Figure 11 throws light on males and females having bank accounts. Unfortunately, many females still do not have active accounts in banks. Due to the lack of bank branches nearby, they are reluctant to visit bank branches to open their bank accounts. Further constraints, namely the vicinity of financial institutions or banks, daily wage workers' time overlapsing with banking hours, financial illiteracy, and a lack of awareness, are the significant problems discouraging rural households from adopting electronic payment services.

Figure 12 shows that selected samples are essentially bent towards cash transactions, which is 85 percent larger than urban households, which is 41 percent. They are still restricting themselves from using electronic payments. One of the key findings from the survey in rural areas is that digital transactions are becoming costly because of low income. On the other side, internet service providers charge a high price. In such a situation, they are left with only one option: cash. Moreover, poor rural people's low literacy and digital transaction awareness hinder the growth of a cashless environment.

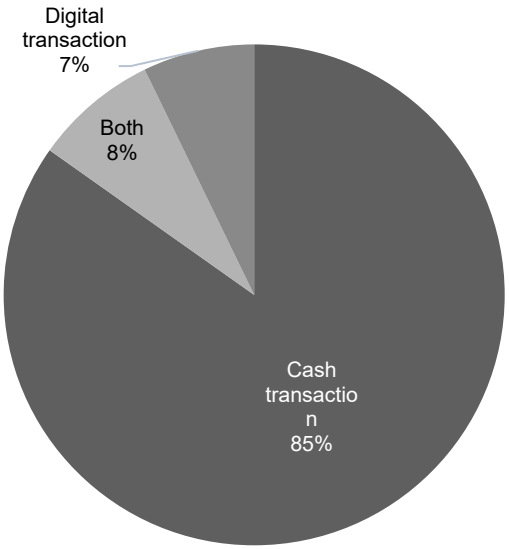

Figure 12 Comfort level in transactions by rural households
Source: the authors' calculation

Further, the hypotheses for this study are:

$H_{2(null)}$: No infrastructural and economic bottleneck exists between urban and rural areas.
$H_{2(alternate)}$: There is an infrastructural and economic bottleneck between urban and rural areas.

ANOVA was conducted on primary data to ascertain the mean value of awareness rate among the sample in urban and rural areas of Faridabad, shown in Table 6. ANOVA is used to know the statistical significance of the relationship between regressand and dummy regressors (Allen, 1997). In this context, three categories have been made based on the awareness level of rural and urban households. The weightage of each variable is 10 percent, 30 percent, and 60 percent (categorized by authors).

Table 6 Classification of Awareness Level

Awareness Levels		
10%	**30%**	**60%**
Knowledge of having a bank account	Knowledge of having a Bank account + Mobile transactions (Internet banking and Mobile banking)	Knowledge of having a Bank account + Mobile transactions (Internet banking and Mobile banking) + Process of digital payments

Source: the authors' calculation

Table 7 Results from Dummy variable Regression Model

Variables	Area of Residence	Dummy variable regression model
Rate of Awareness	44.16 (β_1) -24.4 (β_2)	$Y_i = \beta_1 + \beta_2 D_2 + u$ Where, Y=Awareness rate (percent) β_1= The mean awareness rate of urban β_2= The mean awareness rate of rural D_2= Area of Residence; 0= Urban, 1= Rural
Actual average awareness rate (calculated)	19.76	

Source: the authors' calculation

Table 7 presents a dummy regression model that the actual awareness rate among the rural-urban population is around 20 percent, considering urban as the benchmark category. Hence, the statistical findings of urban and rural households proved the proposed hypothesis of an infrastructural and economic bottleneck between urban and rural areas.

5.3. An impact of demonetization on the Indian stock market

Various authors have given their mixed analyses; some supported the fact that there is a significant impact of demonetization on the stock market, while others do not agree with this statement. A Chow test has been applied to find whether there is a structural change due to the implementation of demonetization, where two sets of time-period have been selected. The first data set starts from January 2015 to October 2016, and the second set begins from November 2016 to December 2019 (Table 8). The chow test is widely used to determine structural instability in time series data (Nielsen & Whitby, 2015).

Table 8 Equations for the Chow test

Period	Equations	Observations
01/2015-10/2016 (pre-demonetization)	$Y_t = \lambda_1 + \lambda_2 X_t + \mu_{1t}$	n_1=22
11/2016-12/2019 (post-demonetization)	$Y_t = \gamma_1 + \gamma_2 X_t + \mu_{2t}$	n_2=38
01/2015-12/2019	$Y_t = \alpha_1 + \alpha_2 X_t + \mu t$	n=60

Source: the authors' calculation

Table 9 Chow test

F-Value		
Calculated	**Critical**	**df**
31.74	3.16	2 and 56

Source: the authors' calculation

Furthermore, to know that there is a structural change due to the implementation of the demonetization Chow test was applied (Table 9), resulting in a critical value of F, which is less than the calculated F value. Hence, by rejecting the null hypothesis that assumes no structural change, it has proven that a decrease in money supply certainly impacted the total number of shares traded. The findings are represented in Tables 10 and 11.

Table 10 Regression analysis

Variables	Constant	Coefficient	F-value	Observations	df	Period
Quantity of shares traded (dependent variable) Money supply (independent variable)	1.255541	2.252032	24.96	60	58	2015 – 2019 (Combined data)
Quantity of shares traded (dependent variable) Money supply (independent variable)	-1.35534	1.843836	5.02	22	20	Jan2015 – Oct2016 (pre-demonetization)
Quantity of shares traded (dependent variable) Money supply (independent variable)	9.673168	1.892455	23.97	38	36	Nov2016 – Dec2019 (post-demonetization)

Source: the authors' calculation

Table 11 Descriptive statistics

Quantity of shares traded (billion)	Mean	Minimum	Maximum
Pre-demonetization (2015 to 2016)	19.31	14.79	25.00
Post-demonetization (2016 to 2019)	33.17	24.94	58.75

Source: the authors' calculation

Compared with the two sets of data, the combined data (2015-2019) found a structural change due to demonetization, which means that the parameter is not constant throughout the entire period. There was a shock observed due to monetary changes.

Further, the descriptive statistics are shown in Table 11, revealing the mean value of shares traded pre and post-demonetization. It is observable that

the mean value of the quantity of traded shares increased from 19.31 billion to 33.17 billion after the declaration of monetary policy. If the minimum and maximum value are to be considered in that case, it also shows a pre and post-intervention rise, revealing no significant impact on the number of shares traded due to the declaration of demonetization.

With the above findings, this section moves forward to empirically analyze the impact of demonetization on the number of shares traded from 60 observations. The Augmented Dickey-Fuller (ADF) test was conducted to ascertain its volatility concerning a past period. The calculated t-value is higher than the critical t-value, and the p-value is higher than 0.005. Hence, the data were found statistically insignificant, which means the data is not stationary (Table 12).

Table 12 Augmented Dickey-Fuller test, Lag Length: 1

Null Hypothesis: The number of shares traded has a Unit root	
t-Statistics	-2.20
Critical t value at 5% level	-3.48
p-value	0.4801

Source: the authors' calculation

Further, an ARCH model will assess the volatility clustering in a given series. Using the ARCH model for variance in time series data to analyze and forecast volatility, this section predicts a model to ascertain the validity of the announcement of demonetization. After conducting a heteroskedasticity test, the ARCH model is shown in Table 13, and the hypotheses for this study are:

$H_{3(null)}$: Demonetization had no considerable effect on the Indian Stock market.
$H_{3(alternate)}$: Demonetization considerably affected the Indian Stock market.

Table 13 ARCH Equations

The mean equation of the ARCH model	$qst= \beta_0=1.07$
The variance equation of the ARCH model	$h_{t+1}=\beta_0+\beta_1 u^2_{t-1}=11.68+0.86\ u^2_{t-1}$

Source: the authors' calculation

where *qst* is the number of shares traded, β_0 mean value of shares traded, and β_1 coefficient of residual. Moreover, Figure 13 represents how conditional variance coincides with those of the original plot of the series

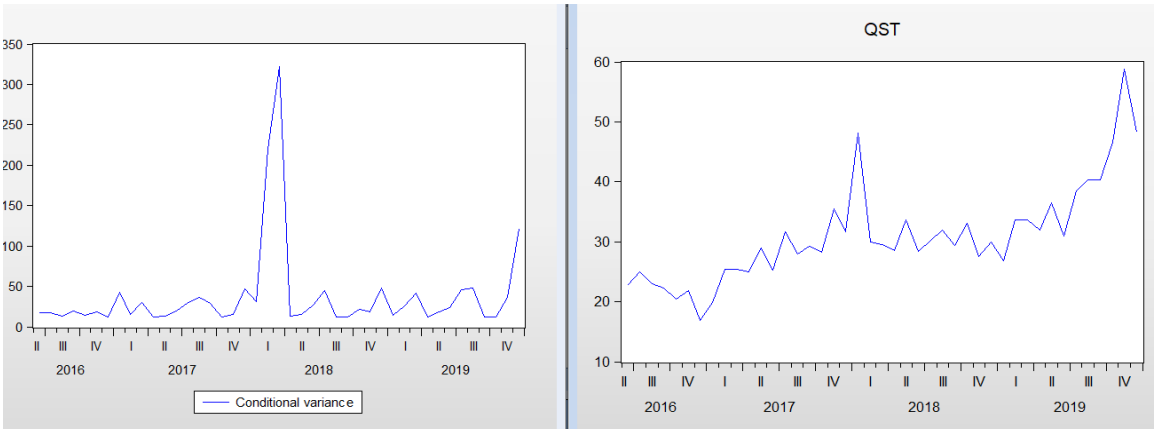

Figure13 Coincidence of actual data with variance
Source: the authors' calculation using E-Views

Figure 14 represents the forecasted value of the number of shares traded. It shows a meager fall in the short run after the announcement of demonetization. Still, there is consistency in shares trading with an increasing trend in the long run, so in the future also, there is no possibility of significant deviation in the trading of shares making volatility stable, as it lies within the standard error band, which implies that there is no significant impact of demonetization on shares trading. Also, Theil Inequality Coefficient, which is represented as (U), lies between 0 and 1 or close to zero (0.149), which means the predictive power of the model is strong (Mackay & Bliemel, 2014). Thus, our null hypothesis that demonetization has no considerable effect on the Indian Stock market is accepted. Further, the descriptive statistics of pre and post-intervention demonetization show that the average quantity of shares traded is 19.31 billion and 33.17 billion, respectively. This indicates no significant fall in shares traded post-demonetization. However, after looking at the series, it decreased significantly up to around 16 billion during demonetization.

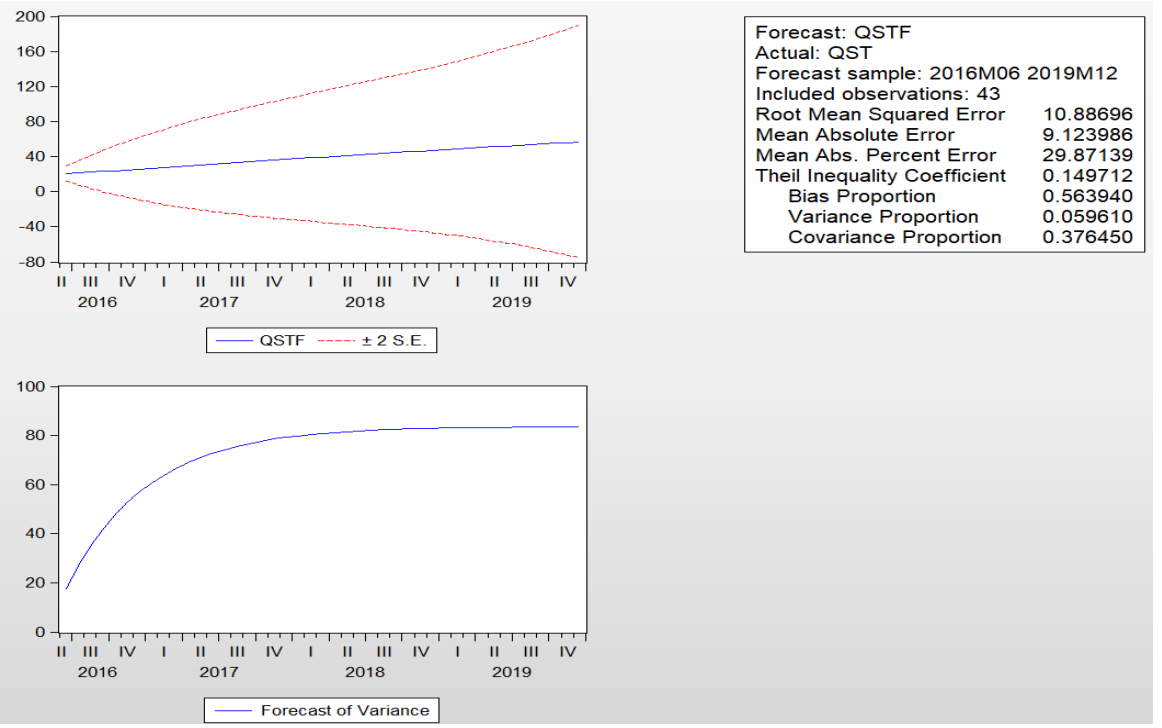

Figure14 Forecast of variance

Source: the authors' calculation using E-Views

6. Conclusion

The announcement of demonetization caused pain to the general population, as 86.9 percent of the total currency in circulation was wiped out from the economy (Rajagopalan, 2020). This macroeconomic policy had a diverse impact on different sectors, but informal workers suffered unintentionally and became more vulnerable. The study illustrates that informal workers lost income, savings, and consumption. On the contrary, formal workers who have economic backup and are financially literate were not impacted or suffered as much. Simultaneously, the model used for the study appears to be robust and efficient. The empirical model's robustness has been tested with actual field data and is efficient due to unbiased, significant estimators. The model was tested statistically, showing a substantial impact of demonetization on informal workers. Thus, implementing macroeconomic policies may ensure the protection of the interests and livelihood of an economically vulnerable population.

This survey proves that urban households are educated and capable of doing digital transactions; they do not face any difficulties in adopting technology or doing digital transactions. However, people in rural areas have low education, so they are uncomfortable with digital transactions and suffer greatly from income and purchasing power loss. Hence, despite substantial technological advancements in digital payments, the motive of moving away from cash is fading because it is easier to pay in cash. Moreover, the study observes a vast disparity in the budding of digitalization between rural and urban areas. There is no doubt that digital transactions are growing, but the slow pace needs to be accelerated rapidly. It is commendable that various government policies have already been rolled out to promote digitalization, like Jan Dhan Yojana (JDY) and Jan Dhan Aadhar Mobile (JAM). Still, there is a lack of awareness and financial literacy that needs to be considered by all stakeholders.

Additionally, the empirical study reveals that the stock market is not affected. The fall of share trading was observed three to four months after demonetization. However, later, it showed an increasing trend, which is a good sign of progress. Even forecasted value also showed a growing trend of shares trading.

Hence, this step has two aspects. First, it is deliberately exercised for the betterment of the economy. Second, it has a negative impact that reduces income leading to a fall in the rate of

consumption, investment, and savings which may further aggravate the economic condition of informal workers. Given the above, the following are recommended from a policy perspective:

- Empowerment of informal workers to get maximum benefits from social security schemes launched by the government.
- Equal wages for male and female workers are also a crucial aspect of economic development for the informal sector.
- Women must be economically empowered. This is because, during the case study, most women had no bank accounts and were highly impacted economically due to demonetization.
- Affordable digital platforms to promote digitalization, especially in rural areas.
- Comprehensive policies for cybercrime and provision of strict punishment.
- Guarantee of quick compensation in case of siphoning off money.
- Expansion of banking services, especially in rural areas, and extension of working hours of banks so that daily wage workers could get time to open or manage accounts.
- Dissemination of information among the illiterate population so they can perform digital transactions in their daily lives.
- Promotion of digital payment techniques.
- Preventing monopolization of digital payment services to rationalize taxes and surcharges.
- FDI on digital transactions and technology is welcome in India, especially in rural areas.
- Frequent conduction of awareness campaigns related to digital transactions in institutions like schools, colleges, and factories.

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✉ **Correspondence**

Amulya Gurtu

The University of Kansas
12600 Quivira Road, Overland Park, KS 66213, USA

E-mail: amulya.gurtu@ku.edu

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Role of intangible assets in global value chains: evidence from the Slovak Republic

Júlia Ďurčová
Technical university of Košice, Faculty of economics, Košice, Slovakia,
https://orcid.org/0000-0002-9312-914X
Marek Pekarčík
Technical university of Košice, Faculty of economics, Košice, Slovakia
https://orcid.org/0000-0002-1384-4304

Abstract
Background: Slovak firms are very strongly integrated into globally organized production. However, their position in global value chains (GVCs) concentrates on downstream activities with lower value added generation.
Purpose: Intangible assets should be an important driver of the creation and productivity growth of domestic value added and thus of international competitiveness. Key activities supporting the creation and productivity of value added within GVCs can be done through an innovation environment, investments in intangible ICT assets and improving the quality of human capital.
Approach: This paper aims to analyse, according to econometric model based on panel data analysis, the role of intangibles in Slovak GVC participation. Moreover, the linkages between investment in selected intangibles and different forms of integration into GVCs – forward and backward, are examined.
Findings: Our results show that the accumulation of intangibles is positively associated with Slovak participation and position within GVCs. The same result is confirmed separately for forward and backward participation. When intangibles are divided into three groups, only computerized information and economic competencies are significantly associated with Slovak GVC participation and position. They increase the quality of human capital, organization and management of production and create a favourable competitive environment.
Limitations: Further research could be extended to a more detailed examination of the impact of intangibles on specific sectors. The availability of data on the creation of value added and thus involvement in the GVCs is a major limitation at the macroeconomic level. Therefore, it is necessary to verify these findings with an analysis at the firms' level data.

Keywords: intangible assets, global value chains, intangible ICT assets, innovative property, economic competencies

Introduction

Nowadays, it is not a matter of whether to participate in the global economy, but how to do so gainfully (Fernandez-Stark & Gereffi, 2018). Recent empirical research verifies the close relationship between innovation, value creation and economic growth. Intangible investment is expected to shift productivity growth, global competition as well as upgrading in global value chains (GVCs). The relationship between intangibles and productivity is well documented in many empirical studies, but not the relation between intangible assets and GVCs participation and value added appropriation. Jona-Lasinio & Meliciani (2018) bring the first step to mapping the role of intangibles for globally organized production. They concluded that investment in intangibles fosters participation in GVCs and

higher value added creation along the chain. Therefore, the countries must produce sophisticated products to compete in high value added activities within GVCs. So, if the country wants to increase participation in GVCs in more valuable activities, it is important to support the accumulation of intangibles, which leads to the development of innovative infrastructure and quality human capital. The intangibles should be an important driver of countries integration in the globally organized production. Exporting companies are generally more productive than companies that produce exclusively for their domestic market. The competitive pressure on foreign markets is often fiercer, which leads exporting companies to increase productivity (Jona-Lasinio & Meliciani, 2019). Participation in GVCs and productivity are mutually connected. For example, international trade and GVCs participation support the specialization of countries and firms in the most productive activities and offshoring less productive. Moreover, it facilitates the import and export of technology as well as the interaction of firms from different countries which can lead to knowledge spillover. The increased international competition supports productive firms through growing economies of scale (Jona-Lasinio & Meliciani, 2018). Therefore, this paper aims to analyze the role of intangibles for GVC participation in the case of the Slovak Republic - the small and highly open economy of Central Europe. We will investigate (i) the impact of intangibles on GVCs participation; (ii) the impact of individual forms of intangibles on GVC participation and (iii) the impact of intangibles on different forms of participation (forward and backward). Our study will rely on existing studies and provide a perspective from the point of view of a small and very open economy.

The paper is organized as follows: the introduction, the review of empirical literature (Section 1), GVC participation and intangibles: measurement and data (Section 2), the research methodology (Section 3), presentation and discussion of the results (Section 4) and concluding remarks (Section 5).

1. Theoretical background

The recent changes in the world and world trade have strong consequences for the established functioning of the economy. For the CEE region, GVCs have become a determining factor of economic systems, and their integration together with foreign direct investment has contributed to productivity growth and convergence to the EU (Pellényi, 2020). According to Ge, Fu, Xie, Liu, & Mo (2018), GVCs productivity effect is obvious in capital-intensive, technology-intensive enterprises. However, there has been a slowdown in the development of new technologies in the leading companies of CEE countries, and thus the value added appropriation in these countries is slowing down. Pavlínek and Ženka, (2011, 2016). We can observe a change in the paradigm of globally organized production and the international fragmentation of production. The determinant of this change is ongoing industrial revolution conceptualized as Industry 4.0. Butollo, Gereffi and Krzywdinski (2022) summarize theoretical and empirical contributions on how the determinants of Industry 4.0 (AI, IoT) affect globally organized production within GVC. Delera, Pietrobelli, Calza and Lavopa (2022) confirmed the positive association between companies' participation in GVC and the ability to adopt Industry 4.0 technologies and determinants. Firms are adapting to Industry 4.0 by developing value chains based on technological resources and capabilities (Castelo-Branco, Oliveira, Simoes-Coelho & Portugal, 2022). Industry 4.0 gradually changes the comparative advantages of individual companies and countries through the adoption of new technologies and innovations. These are stimulated and supported by the intangibles. The development of new technologies faces the problem of sufficient intellectual and innovative capital. Therefore, it is necessary to pay attention to those factors that positively affect GVCs' upgrading, and the creation of domestic value added (DVA). For Slovakia, a very open and export-oriented economy, it is the eminent interest to correctly identify determinants supporting the development of an intellectual and innovative environment and the quality of human capital.

The form of the country's participation in GVCs is crucial. The main interest of a country or firms is to participate in globally organized production activities and tasks characterized by a high level of value added. Value added is increasingly concentrated on pre-production and post-production activities. Countries engaged in these types of activities achieve a higher position in the GVCs as well as a competitive advantage in the knowledge economy. These countries are also characterized by higher intangibles. According to Durand and Milberg (2018) and Rikap (2022), these countries created so-called Intellectual monopolies.

Intangible assets can be split into three basic groups: innovative property, computerized information, and economic competencies (Corrado, Haskel & Jona_Lasinio, 2017). Economic competencies represent a specific type of intangible assets, not reported in traditional statistics or national accounts due to the complexity of quantification. This type of intangibles has an impact on business performance as it increases production efficiency and allows a country to participate in the production of technologically and highly sophisticated products with a high degree of value added.

The empirical literature encounters the problem of availability and reporting of high-quality and accurate data on intangible assets as well as conceptual definitions and uniform methodology (Mojca, Ahmed, Josh, Alberto, Giulio & Tjaša, 2023). However, there exist several studies dealing with this problem. For example, Kano, Tsang and Yeung (2020) map the rapidly growing domain of GVC, De Marchi and Alford (2022) examine the role of state policymaking in a context of GVC and Paoloni, Coluccia, Fontana and Solimene (2020) bring structured literature review based on knowledge management, intellectual capital and entrepreneurship and examine the role of knowledge and information as a strategic component for company. Corrado, Haskel, Jona-Lasionio and Iommi (2013, 2016) bring the methodology for measurement of intangibles. Pekarčík & Ďurčová (2020) examine the role of intangible assets within GVCs. Chen, Los and Timmer (2018) research the role of intangibles in GVCs. Pekarčík, Ďurčová and Glova (2022) examine the role of ICT assets on participation in GVCs. Marcolin, Miroudot and Squicciarini (2016) and Marcolin and Squicciarini (2017) analyse the interaction between global value chains and investments in intangible assets based on knowledge capital. They showed that industry-level investment in organizational capital is significantly positively correlated with the country's backward participation in GVCs and concluded that investment in knowledge capital and integration into GVCs can be mutually emphasized. Buckley, Strange, Timmer and de Vries (2022) confirm the importance of intangible asset accumulation within GVC as a driver of economic development and show that returns captured by intangible assets are greater than from tangible assets. The research on the impact of intangible asset accumulation on economic development is not limited only to global level. On the regional level, Gumbau-Albert and Maudos (2022) confirm that the intangible assets explain regional GVA growth. Jona-Lasinio et al. (2019) find that, in advanced countries, intangibles have a positive effect on participation in GVCs and they complement tangibles. Moreover, within intangibles it is non-R&D (mainly training) as the main driver of participation. Intangibles influence both forward and backward participation (training and organizational capital forward participation; marketing, advertising, and design backward participation). The study of Vrh (2018) also examines the differences between EU countries (new' (CEE-10) and 'old' (EU-15) countries). The results showed that the group of CEE-10 countries missed the investments in intangibles and can increase GVC participation primarily through foreign direct investment, spillover effect and imported intangibles. Adarov and Stehreh (2020) conclude that intangibles have significantly positive effects on productivity growth, increase participation and position in GVCs, and the level of domestic value-added creation. Jaax and Miroudot (2021) state that the fragmentation of production and, consequently, the catch-up in the value chain, depends on the development of domestic innovation capabilities. This can be influenced by specific government policies that can affect how innovation is shared across countries and the potential for knowledge spillover. Nonnis, Bounfour and Kim (2023) examine the role of knowledge spillover between European countries using principal component analysis to aggregate intangibles. Ito, Ikeuchi, Criscuolo, Timmis, and Bergeaud (2023) confirm, based on OECD ICIO Tables, that the firms in key hubs within GVCs benefit from knowledge spillover. Tsakanikas, Caloghirou and Dimas (2022) support the premise of knowledge spillover through intangibles and find that imported intangibles and patents contribute to manufacturing sectoral specialization in GVCs and domestic intangibles are correlated with innovation. Therefore, our research focuses on the impact of intangible accumulation at Slovak industrial level on participation and position in GVCs. In the next section we provide a deeper definition and measurement of variables.

2. Data analysis

Our analysis is based on value added flows data retrieved from OECD – TIVA database (OECD, 2019). Indicators of Backward (BL) and Forward (FL) participation indexes are measured according to the specification of Koopman, Powers, Wang,

and Wei (2010), Hummels, Ishii and Yi (2001) and Johnson (2017). Overall GVCs participation is given by the sum of BL and FL. GVCs position is measured according to Banerjee and Zeman (2020) or Jona-Lasinio, Manzocchi and Meliciani (2019), as the ratio of FL to BL – the relative downstream or upstream country's position. This variable helps us understand the country's ability to appropriate the share of value added created within the GVCs.

The data of intangibles are retrieved from EUKLEMS and INTAN-Invest databases for the period 1995 to 2017 (data for a longer period are not currently available) (see Tab.1). The INTAN-Invest and EUKLEMS databases are consistent with National Accounting Principles and expand data on the intangibles associated with economic competencies.

Table 1 Forms and sources of variables

Name of variable	Definition
DVAFEX_TOT_H_ln	Domestic value added embodied in foreign exports / Total hours worked (natural logarithm)
FVADEX_TOT_H_ln	Foreign value added embodied in domestic exports / Total hours worked (natural logarithm)
Δ Tang_ln	Total tangible assets - Tangibles
Δ TotIntg_ln	Total intangible assets - Intangibles
Δ SoftDB_ln	Intangible ICT assets
Δ InovProp_ln	Innovative property
Δ EconComp_ln	Economic Competencies
CIT	Corporate income tax rate

Source: the authors, own, according to Corrado et al. 2016; Stehrer, Bykova, Jäger, Reiter & Schwarzhappel, 2019

We divide intangibles into three basic groups, according to Corrado et al. (2016). The first group - Computerized Information, consists of computer software and databases. The second - Innovative Property - includes the innovative activity built on a scientific base of knowledge as well as innovation and new product, process R&D. The third - Economic Competencies - includes spending on strategic planning, worker training, redesigning or reconfiguring existing products in existing markets, investment to retain or gain market share and investment in brand names (Corrado et al. 2016).

Figure 1 depicts Slovak participation in globally organized production which was increasing over the observed period, but mainly between 1995 and 2005. It is known as the main transformation period of the Slovak economy, by process of privatization as well as foreign direct investment growth (e.g., green field investment of PSA, Kia, etc.). The average value of Slovak participation in GVCs was rising and now is more than 61%. The data for backward and forward participation reveals that the participation in the global production network is concentrated mainly in downstream production, meaning that Slovak production is involved in activities with low value-added generation. However, the development of the domestic value added in Slovak export (Fig. 1 DVA – right axis) is growing.

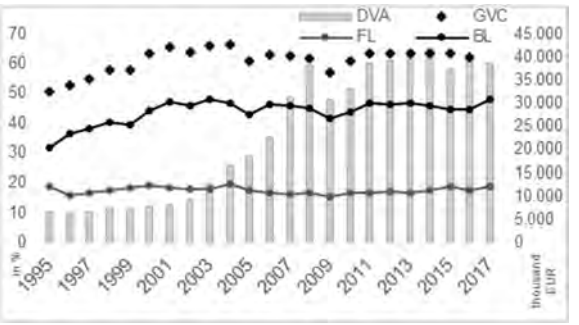

Figure 1 The development of GVCs participation and domestic value added
Source: the authors, data from OECD (2019)

Figure 2 illustrates the accumulation of intangibles in Slovakia. Intangibles were growing; moreover, the share of total intangibles to total tangibles was increasing, so the intangibles in the Slovak Republic increased. Before the accession to the EU the share of intangibles to tangibles was approximately 16%, while after accession (i.e., after 2004), this share was more than 30%.

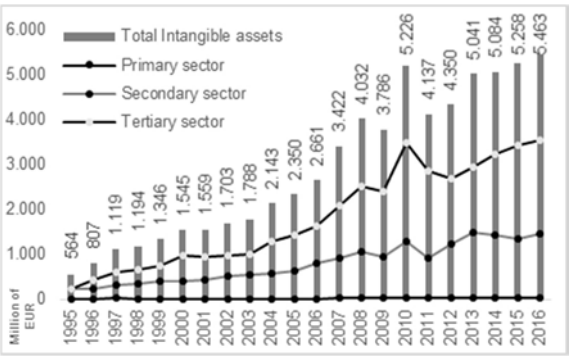

Figure 2 The development of Intangible assets in Slovak Republic
Source: the authors, data from OECD (2019)

In 2017, this share represented approximately 35%. As expected, intangibles are mainly concentrated in tertiary sectors. Furthermore, there is a significant difference between intangibles and tangibles. For example, in manufacturing,

intangibles increased almost six times while tangibles just three times.

3. Econometric approach

In an econometric analysis by implementing the Hausmann panel robustness test (Hausman, 1978), we confirm the panel regression with random effect. This empirical strategy is consistent with the structure of the data and with the econometric strategy of Jona-Lasinio et al. (2019) and Vrh (2018). We confirm that the total panel is robust. We use lagged data for capital inputs due to the intangibles methodology and the potential endogeneity problem. Based on the theoretical background and literature review, we formulate the following hypotheses:

HP1. Intangible assets have a positive impact on the SR participation in the GVCs.

HP2. Intangible assets have a positive impact on the SR position in the GVCs.

HP3. Economic competencies have the highest positive impact on the SR participation in the GVCs.

Our benchmark equation is as follows:

$$lnY_{i,t}^{GVC} = \alpha \Delta lnK_{i,t}^{Tang} + \sum_{q \in Q} \beta_q \Delta \ln K_{i,t}^{TotIntg} + \gamma X_{i,t} + u_{i,t} + \varepsilon_{i,t} \quad (1)$$

where i = industry; t=time; q= specific types of intangibles (SoftDB, InovProp, EconComp); $Y_{i,t}^{GVC}$ represents different indicators of GVCs participation (total, backward and forward participation and GVCs position); $K_{i,t}^{Tang}$ is tangible assets; $K_{i,t}^{TotIntg}$ represents intangible assets (see Tab.1); X are control variable (corporate income tax rate); $u_{i,t}$ is the industry and time random effects; $\varepsilon_{i,t}$ is the random error term. We use lagged (one-year) panel data for the period 1995 – 2017 (575 observations - 25 sectors and 23 years). We use sector data according to the classification of ISIC Rev 4. The industrial sector is divided according to individual categories. Other sectors are in aggregate form. GVCs variables are based on gross export and were standardized by the number of total hours worked from the EU-KLEMS database due to various disparities. Capital input data are indexed (2010=100). We want to investigate the impact of changes in the accumulation of intangibles on the GVCs participation and position. As a control variable, we use the corporate income tax rate. It may have an impact on multinational corporations and their decision to locate a foreign affiliate. The higher the tax rate, the lower the probability of placing a foreign affiliate in a country. Increasing tax rate will thus cause a reduction in the creation of domestic value added share of gross export.

Intangibles supports participation, and more importantly, supports the appropriation of value added within the GVCs (position). Therefore, we direct our research to identify specific types of intangibles that improve the creation of Slovak DVA e.g., GVC participation and position. We assume that the intangibles will have a positive impact on the appropriation of value added within GVCs. Since Slovak republic uses its comparative advantage in the form of a relatively cheap and well-qualified labour force and is close to final demand markets, its predominant form of participation in GVCs is backward linkages. This means that Slovak production is dependent on the import of intermediate products, i.e., foreign value added. According to Pellényi (2020), CEE countries can fall into the limitation trap of the volume of domestic value added in export. Slovak specialization in manufacturing activities in the GVCs may cause the economy to fall into this trap. Upgrading and modernization of products, processes and skills in the GVCs and manufacturing industry through the accumulation of intangibles can contribute to increasing the creation of DVA and thus a greater value-added appropriation within GVCs. In the case of process upgrading, we observe that Slovak companies accumulate intangibles primarily associated with economic competencies (organizational capital, training etc.). Therefore, we assume that their accumulation can help increase participation. In the case of product upgrading, the country needs to have a robust innovation environment. Intangibles associated with innovation assets (R&D, design etc.) can help to support this environment. However, it is important that investments in innovation are linked to specific companies.

We assume that the coefficients of tangibles and intangibles will be positive, confirming the positive impact on GVCs participation. We expect that tangibles have a stronger positive impact on Slovak participation in the GVCs in different forms of participation.

Regarding the impact of individual forms of intangibles, we assume that in the case of forward and backward participation intangibles have a relatively strong positive impact. Computerized information (SoftDb) and economic competencies

(EconComp) will be important drivers for GVCs participation. Moreover, we assume that intangibles have a stronger positive impact on Slovak position in the GVCs, thus Slovak ability to appropriate the value added within GVCs. We expect the coefficient for economic competencies (EconComp) to be higher than other types of intangibles, as they represent the largest part of intangibles. The economic competencies support the improvement of human capital. Their high accumulation in countries with a predominant BL participation is due to the exigency of multinational corporations to train their manufacturing employees. Innovative property (InovProp) is expected to have a strong impact on domestic value added, the country's participation and position in GVCs, productivity as well as economic growth. Investment in computerized information (SoftDb) is particularly important for exporting countries, trading in international markets with goods and services embodying high levels of foreign value added. This is the case of an export-oriented economy e.g., the Slovak Republic. We present the econometric results of the regression analysis in the next section.

4. Research results

The first regression results for the total tangibles (Tang) and total intangibles (TotIntg) are presented in Table 2; in the following Table 3 we show the regression results for forward and backward participation; in Table 4 we exhibit individual effects of Computerized Information (SoftDb), Innovative Property (InovProp) and Economic Competencies (EconComp).

The coefficient for TotIntg is significant and positive, supporting our first hypothesis, that intangibles have a positive effect on the participation of the Slovak Republic in GVCs. Our findings are consistent with Jona-Lasinio et al. (2019), Durand and Milberg (2018), emphasizing the positive effect of intangibles on participation in GVCs. As expected, all intangibles contribute positively to both forward and backward participation.

We expect that tangibles will be more associated with participation in GVCs. These have a greater impact on total (0.510), FL (0.484) and BL (0.496) participation than intangibles (Tab.2 and 3). However, the difference between the impact of tangibles and intangibles on the involvement of Slovakia in GVCs are very small. We confirm that tangibles are predominantly associated with BL participation, thereby confirming the described condition, relative comparative advantage and impact of high BL participation. Intangibles are more associated with the position, which means that their accumulation supports Slovakia´s appropriation of value added. The value of coefficient is 0.236, indicating that the 10% increase in their accumulation is, assuming ceteris paribus, associated with 2.3% improvement in Slovak ability to appropriate value added within the GVCs.

Table 2 The effect of tangibles and intangibles on Slovak participation and position in the GVCs

GVCs	GVC Part.	GVC Part.	GVC Position	GVC Position
Tang_ln$_{t-1}$	0.510***		0.220***	
	(0.048)		(0.029)	
TotIntg_ln$_{t-1}$		0.507***		0.236***
		(0.053)		(0.031)
CIT_ln	-1.996***	-1.964***	-0.132**	-0.097*
	(0.091)	(0.095)	(0.051)	(0.057)
Balanced	YES	YES	YES	YES
Random	YES	YES	YES	YES
No. of obs.	550	550	550	550
R2	0.710	0.698	0.198	0.196
F_stat.	***	***	***	***
Hausmann	0.9997	0.06712	0.9811	0.7955

Source: the authors,
Note: Standard errors in parentheses
*p<0.1; **p<0.05; ***p<0.01

Moreover, our results show that tangibles are significant for forward and backward participation (Tab. 3). Tangibles are primarily associated with BL participation. The strong positive impact of tangibles on BL participation is also confirmed by Marcolin, Le Mouel and Squicciarini (2017). The Slovak Republic was oriented towards tangibles; therefore, it is normal that we observe a greater impact of tangibles with BL participation. The results imply that intangibles could positively influence BL, FL and Total GVCs participation.

As we expected, we observe a negative coefficient for the control variable, which indicates that increasing the corporate income tax rate (CIT) has a negative impact on the country's involvement in globally organized production – rising obstacles to cross-border trade.

Intangibles tend to take significant part in global value chains in European countries (e.g., Adarov & Stehrer, 2019; 2020). Our findings show that intangibles are positively related to the Slovak GVCs participation. However, not all intangibles are equally relevant. While the effect of Economic Competencies on participation is large and positive, it is small and positive for Computerized

Information (software and databases) and insignificant in the case of Innovative Property. In Table 4, we analyse the impact of different types of intangibles on total participation in GVCs. The results (Tab. 4) show that the economic competencies have the greatest positive impact (0.584) on the integration of Slovakia in the GVCs. Intangible ICT assets (0.045) have the second most important impact. The coefficient of innovative assets is not statistically significant. According to our results, Economic Competencies support the Slovak involvement in GVCs the most.

Table 3 The effect of tangibles and intangibles on Slovak FL and BL participation in the GVCs

GVCs	FL	FL	BL	BL
Tang_ln$_{t-1}$	0.484***		0.496***	
	(0.046)		(0.055)	
TotIntg_ln$_{t-1}$		0.466***		0.493***
		(0.051)		(0.060)
CIT_ln	-1.943***	-1.930***	-2.042***	-2.011***
	(0.081)	(0.094)	(0.104)	(0.111)
Balanced	YES	YES	YES	YES
Rando	YES	YES	YES	YES
No. obs.	550	550	550	550
R2	0.717	0.703	0.659	0.648
F_stat.	***	***	***	***
Hausmann	0.09975	0.0570	0.9984	0.1775

Source: the authors,
Note: Standard errors in parentheses *p<0.1; **p<0.05; ***p<0.01

Economic Competencies are associated with improving the quality of human capital, organization of production and management. A large part of economic competencies, even in Slovakia, was associated with activities with a lower rate of value added – assembly and production. Therefore, Economic Competencies support Slovak participation in the GVCs very positively.

Intangible ICT assets are associated with the increase in Slovak GVC participation. This type of intangibles is inevitable in organizing global production networks. Ensuring up-to-date fast communication within supply chains and customers is an important area of business organization today. The use of intangible ICT assets, such as software and databases, improve productivity and we confirm that they also improve Slovak involvement in GVCs.

Investment in Innovative Property can become an instrument to increase drawing benefits from GVCs. In the case of Slovak innovation assets, the coefficient is not statistically significant. Further investment in Innovative Property can increase the returns from backward GVCs participation. It can take the form of generating new knowledge or expertise and enhancing the absorptive capacity of firms and their ability to exploit inputs from globally organized production. According to Montresor and Vezzani (2016) the specific types of Innovative Property, such as Design and R&D, could increase an innovative environment. However, it is striking that this type of intangibles has declined (- 17%) in total intangible assets in Slovakia based on INTAN – Invest data.

Table 4 The effect of specific types of intangibles on Slovak participation in the GVCs

	GVCs Participation		
Tang_ln $_{t-1}$	0.329***	0.336***	0.196***
	(0.038)	(0.038)	(0.040)
SoftDB_ln $_{t-1}$	0.045**		
	(0.023)		
InovProp_ln $_{t-1}$		0.032	
		(0.022)	
EconComp_ln $_{t-1}$			0.584***
			(0.073)
CIT_ln	-2.121***	-2.191***	-1.669***
	(0.091)	(0.086)	(0.103)
Balanced	YES	YES	YES
Random	YES	YES	YES
No. of obs.	550	550	550
R2	0.700	0.699	0.730
F_stat.	***	***	***
Hausmann	0.6136	0.9858	0.4015

Source: the authors,
Note: Standard errors in parentheses *p<0.1; **p<0.05; ***p<0.01

Each country has a specific way of participating in the GVCs and so, it is not entirely possible to abstract the overall aggregate results for individual countries. Therefore, it is important to analyse the impact of specific types of intangibles on the individual country´s participation and position. The appropriate setting of national public policies to support the creation of a knowledge-based economy on the principle of the accumulation of intangibles is essential. Our results show that in the case of Slovakia, investment in intangibles, primarily in economic competencies i.e. the quality of human capital, is the most important factor for business productivity growth and GVC participation. Currently, more than ever, if firms want to achieve a higher level of participation and increase their position in the GVC, they need to allocate resources not only into innovative property but also to economic competencies such as organizational capital or training. The increasing quality of human capital becomes a key element that managers must focus on in order to maintain their international competitiveness within the

framework of global organized production.

Marrocu, Paci and Pontis (2011) highlight the importance of policies designed to stimulate the accumulation of intangibles at the firm's level. The positive effect of intangible assets, especially intellectual capital on business performance also confirmed Radonic, Milosavljevic and Knezevic (2021) and this positive effect on market value firms was also confirmed by Dancakova, Sopko, Glova and Andrejovská (2022) and Glova, Andrejovska and Vegsoova (2020). Factors with a strong impact on unlocking the potential of intangibles accumulation are presented by Thum-Thysen, Voigt, Bilbao-Osorio, Maier and Ognyanova (2017, 2019). It is important to support and create a pro-competitive regulation framework that aimed at the reduction of barriers to adopt new technologies and thereby contributing to the development of the necessary innovation ecosystem. Thus, an important conclusion for policymakers is to stimulate the accumulation of intangibles which have the potential to improve the productivity of firms as well as domestic value added and improve the appropriation of value added within the GVC.

Conclusions

The participation of the Slovak Republic in the GVCs increased, mainly due to the backward participation. This brings a lot of positive effects for Slovak economy, however, the gains could be even higher. The question is how to increase the benefits and gains from participation in GVCs. The recent problem is that more than half of Slovak firms´ exports are composed of foreign value added - imported intermediates. It indicates that the Slovak position concentrates on downstream activities of GVCs with lower domestic value added creation. A key element, necessary for countries and firms to compete in high value added activities, is the capability to produce sophisticated products within the sophisticated process, which is closely linked to the endowment of intangibles. Therefore, we investigate to what extent the intangibles accumulation is associated with the GVCs participation and position (value added appropriation) in the Slovak Republic.

To our knowledge, the contribution of our research is, to be the first to examine the interaction between intangibles and the participation and position of the Slovak Republic in the GVCs. Our results show that the accumulation of intangibles is positively associated with the participation of Slovak firms in GVCs, and the most important result is that intangibles improve Slovak value-added appropriation i.e., position. The same result is confirmed separately for forward and backward participation.

Economic competencies and Intangible ICT assets (Computerised information) are positively associated with GVCs participation. We find that economic competencies positively support involvement of Slovak firms in GVCs. It increases the quality of human capital, and organization and management of production and thus creates a favourable competitive environment for firms. Intangible ICT assets have a significant impact on improving the country's participation in the GVCs. Investment in Innovative property can become an instrument to increase drawing benefits from GVCs involvement. However, it is striking that this type of intangibles has declined in total Slovak intangibles.

We confirmed that intangibles support Slovak firm's involvement and value-added appropriation within GVCs. Therefore, it is necessary to create through policy implementation, an attractive and competitive environment that will support the accumulation of innovative intangibles. Further research could be extended to a more detailed examination of the impact of intangibles on specific sectors according to the ISIC rev. 4 classification. It is important to analyse the role of the accumulation of more detailed specific types of intangibles at the sectoral level because we observe large differences in their impact on the creation and productivity of value added. The availability of data on the creation of value added and thus involvement in the GVCs is a major limitation at the macroeconomic level. Therefore, it is necessary to verify these findings with an analysis at the firm's level data.

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✉ **Correspondence**

Júlia Ďurčová

Technical university of Košice, Faculty of economics, Kosice, Němcovej 32, 04001 Košice, Slovakia

E-mail: julia.durcova@tuke.sk

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The influence of the number of patents on the economic growth of the country – evidence from Serbia and Hungary

Ivana Domazet
Institute of Economic Sciences, Belgrade, Serbia
https://orcid.org/0000-0002-3493-4616
Darko Marjanović
Institute of Economic Sciences, Belgrade, Serbia
https://orcid.org/0000-0001-7336-1964
Deniz Ahmetagić
University of Novi Sad, Faculty of Economics in Subotica, Subotica, Serbia
https://orcid.org/0009-0002-0671-8163
Vladimir Simović
Institute of Economic Sciences, Belgrade, Serbia
https://orcid.org/0000-0002-6441-833X

Abstract
Background: One of the indicators of a country's innovation is the total number of registered patents. This paper analyzes the number of registered patents and the impact they can have on the country's economic growth and innovation. .
Purpose: The paper aims to determine whether there is a positive impact of market verification of the results of research and development activities, measured by the number of patents per million inhabitants, on economic growth and the growth of innovation in the country.
Study design/methodology/approach: Quantitative research design was applied in the analysis since the task was to investigate the influence of the number of patents on the economic growth of the country. The empirical research covered two countries - Serbia and Hungary. It used secondary data from the international databases of the World Bank and World Intellectual Property Organization, covering the period from 2008 to 2018.
Finding/conclusions: The results of the empirical research showed that the increase in the number of patents per million inhabitants contributes only to the innovation index's growth in Hungary. On the other hand, in the case of Serbia, there is no statistically significant relationship between the number of patents per million inhabitants and the country's innovation index, or the number of patents per million inhabitants and GDP per capita.
Limitations/future research: The limitations are: the small number of analyzed countries and the number of indicators analyzed. Therefore, in the framework of future research, it would be desirable to expand the analysis to more countries and establish the impact of patents on more indicators of innovation.

Keywords
Patents, innovation, GDP per capita, economic growth

Introduction

Scientific and technological progress has created new waves of innovation, especially in information and communication technologies. Thus, innovation processes have become less focused on individual companies and more dependent on the interaction between global networks of actors in the public and private sectors. The technological-innovation system implies networks, that is, a system of networks, of connected actors whose functions relate to a certain technological field and which include the creation, expansion and use of technology. The list of actors of a certain technological innovation system can be determined according to the databases of economic associations on companies classified according to different industrial branches, by analyzing the number of patents, which can indicate the scope and direction of technological activities in different organizations, by bibliometric analysis, which will enable the compilation of a list of the most active organizations in the field of technology development according to published works, or based on interviews and conversations with experts in the field of technology and industrial development.

Economic growth is attributed to the increase in national output resulting from technological innovation. For many years, innovation has been accepted as a basic factor of economic growth (Lee et al., 2010). As competition between countries increases and global growth slows, the need to prioritize innovation and research and development has never been stronger. The link between innovation and economic growth is undeniable but also complex. Public and private sector investments create jobs, develop industry, encourage innovation and make the country's economy more competitive in many different areas. Innovation plays a central role in ensuring economic and social prosperity, boosts productivity and leads to market growth. There are a number of different ways of measuring innovation, such as research and development spending, the number of patents in one year, the number of researchers per thousand full-time employees, as well as the widespread effect of technology spillovers between firms, industries and countries. The increased use of patents to protect inventions by companies and research organizations is closely related to the development of innovation processes and economies.

1. Literature review

Innovations are regarded as the engine of growth and long-term economic development of a country (Hai et al., 2022). According to Alheet & Hamdan (2022), "innovation is often seen as a driving force for a country's sustainable and long-term economic growth". Although innovations are considered an undeniable engine of growth, they can also have harmful consequences for society and the environment (Biggi & Giuliani, 2021). According to Lomachynska & Podgorna (2018), the success of a country's economy is determined by its innovative development. Research and development is a key contributor to organizations' pursuit of innovation (Scoresby et al., 2022). Research and development and innovation activities, which lead to technological progress, are considered important factors that contribute to stable and continuous economic growth" (Abibo et al., 2022, p. 4). The effect of institutions on innovation is particularly pronounced for high-tech innovations, which suggests that innovations could be a key channel through which institutions stimulate economic growth (Donges et al., 2022; Domazet et al., 2021; Kicová, 2019).

Innovation is imperative for the economic viability and sustainability of organizations (Nanyangwe et al., 2021). Governments and organizations that invest more in R&D create innovations that lead to an increase in the competitiveness of their products and services, GDP growth and a higher level of population well-being (Androniceanu et al., 2020). Technology transfer and productivity consecutively fully mediate the relationship between innovation and competitiveness (Rambe & Khaola, 2022). Also, competition exerts a feedback effect on market structure via the process of innovation (Sandrini, 2022). One of the most effective methods for raising the competitiveness of the economy and stable and continuous economic growth are research and development activities (Kim, 2011). The fact is that numerous innovations have improved quality and lowered prices for many input factors, which contribute to the competitiveness of the industry (Lebel et al., 2021). However, financial crises generally have a negative influence on companies' willingness to innovate (Disoska, et al., 2020). Increasing competitiveness brings economic changes as a result of the application of more modern technologies and new methods of production, with

the development of completely new skills (Domazet et al., 2018). The innovation systems approach stresses the diversity of types, forms, and sources of knowledge that are required for successful innovation processes (Daimer et al., 2021). Sustainability-driven innovation takes many forms: from developing new or improved products or services to creating new processes and business models (Strielkowski et al., 2022). The link between innovation and economic growth must have an adequate institutional framework, as well as expert human capital, and all for the purpose of commercializing a new product. This is precisely the way to promote economic growth through innovative activities (Law et al., 2020). Developing economies, which recognize the importance of innovation, are implementing activities to improve their innovation capabilities (Sharma et al., 2018).

According to Yesilay et al. (2015, p. 1), "there is a significant relationship between R&D activities and R&D experiences and patents". Research on innovation has grown in recent decades, and most papers on this topic use patents as variables to measure innovation (Chang et al., 2018; Frietsch et al., 2014; Falk & Train, 2017; Sampat & Williams, 2019). R&D investment is the most significant factor affecting patenting (Li et al., 2020). Patents have a significant positive impact on trade in services, science and technology (Marjanović et al., 2019). The total number of patents filed in a country is often used as an indicator for innovation (O'Neale & Hendy, 2012). More patents lead to more innovation and vice versa, a patent can be an economic policy instrument to encourage investment in R&D (Tanane, 2020). The main reason why states allow patent protection is to encourage innovation. However, the magnitude of R&D incentives and patent protection depends on how effective patents are as a mechanism for profit appropriation (Czarnitzki & Toole, 2011). Measuring patent similarity, as one of the basic elements for patent analysis, can reveal and assess whether an invention meets the criteria of novelty and innovation (An et al., 2021). However, it is very difficult to estimate the value of a patent before its commercialization in the market (Hsieh, 2013). Stronger protection of patent rights is thought to encourage innovation by ensuring a return on investment in R&D (Maskus et al, 2019).

2. Methodology and results

Innovations are an important channel through which economic institutions contribute to a better effect of economic growth and increased production in the long term. Intellectual property rights, such as patents, aim to address the problem of underinvestment in research and development, allowing inventors a return on invested capital. The main goal of the paper was to verify the existence of a positive impact of market verification of the results of R&D activities, measured by the number of patents per million inhabitants, on:

- growth of the country's innovation index;
- country's economic growth, measured by GDP per capita.

The paper uses a quantitative research design, which was chosen because it investigates the relationships between variables that are measured on an interval or ratio scale. The features of the quantitative research design was to accurately measure the investigated phenomena and discover the connections between them. A comparative approach was chosen in order to examine the researched phenomena and their relationships in as much detail as possible within the framework of a quantitative research design. The analysis included two countries (Serbia and Hungary), while the time period was 2008 - 2018. The following international databases were chosen as sources of secondary data:

1. World Intellectual Property Organization
2. World Bank.

By its very nature, the collected secondary data had the character of time series, so appropriate econometric models for time series were used for the analysis.

Table 1. Data on the number of patents, innovation index and GDP per capita for Serbia and Hungary

Country	**Serbia**				
Variables / year	Total number of patents	Total number of inhabitants	Number of patents *	GII**	GDP ***
2008	-	7,350,222	-	-	4,380
2009	353	7,320,807	48.21	2.57	4,280
2010	391	7,291,436	53.62	2.68	4,330
2011	243	7,234,099	33.59	36.31	4,450
2012	234	7,199,077	32.50	40.00	4,400
2013	332	7,164,132	46.34	37.87	4,590
2014	289	7,130,576	40.53	35.89	4,540
2015	248	7,095,383	34.95	36.47	4,640
2016	279	7,058,322	39.53	33.75	4,820
2017	296	7,020,858	42.16	35.34	4,950
2018	308	6,982,084	44.11	35.46	5,190
Country	**Hungary**				
2008	-	10,038,188	-	2.88	10,500
2009	1,853	10,022,650	184.88	3.34	9,810
2010	1,634	10,000,023	163.40	3.54	9,900
2011	1,714	9,971,727	171.88	48.12	10,110
2012	1,655	9,920,362	166.83	46.50	10,010
2013	1,560	9,893,082	157.68	46.93	10,230
2014	1,434	9,866,468	145.34	44.61	10,690
2015	1,496	9,843,028	151.98	43.00	11,130
2016	1,538	9,814,023	156.71	44.71	11,410
2017	1,263	9,787,966	129.03	41.74	11,930
2018	1,340	9,768,785	137.17	44.94	12,560

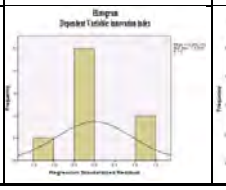
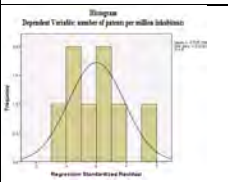
Notes: * calculated number of patents per million inhabitants; **GII = global innovation index; *** the data is presented as GDP per capita

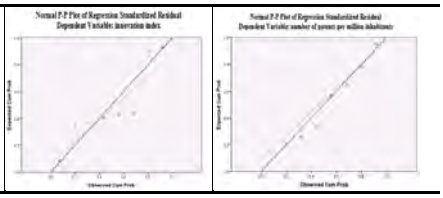
Source: The World Intellectual Property Organization (2019); World Bank (2019)

As shown in Table 1, data for the year 2008 on the total number of applied patents for the analyzed countries was unavailable. Consequently, the number of patents per capita for a given year could not be calculated. In addition, data on the innovation index of Serbia and Hungary for 2008, 2009 and 2010 were presented using a different methodology compared to the years that followed. Bearing in mind the above, and for the sake of the accuracy of the results of the statistical analysis, only the period from 2011 to 2018 was included in the analysis itself. Statistical testing of relationships between variables was performed using simple linear regression for each pair of independent and dependent variables individually.

In the first case, in the example of Serbia, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (the dependent variable = innovation index; the independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 2.

Table 2. Verification of fulfillment of assumptions - Case I (Serbia)

Variable / assumption	**Number of patents per million inhabitants (n = 8)**	**Innovation index (n = 8)**
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 1.325	d = 1.606
Histogram		

P-P normality diagram	

Source: the authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3.** In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 2). The assumptions are not met.

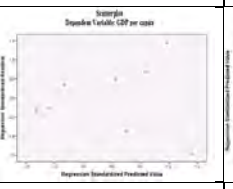
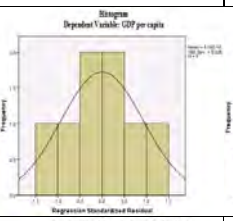
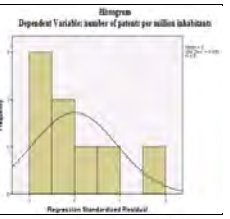
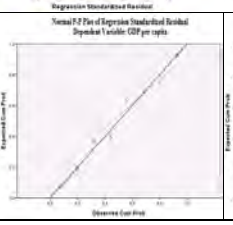
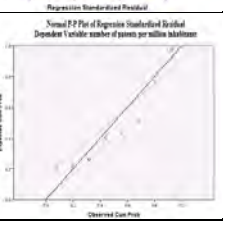
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=1,325). The assumption is not met.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that observations are independent when it comes to the country's innovation index (d=1.606). The assumption is fulfilled.

Ass. 5. and **Ass. 6**. Based on the performed analysis and obtained results shown in table 2 (histograms and P-P diagrams of normality), it was determined that there is no absence of heteroskedasticity and normal distribution of residual errors. Assumptions are not made.

In the second case, in the example of Serbia, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = GDP per capita; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 3.

Table 3. Verification of fulfillment of assumptions - Case II (Serbia)

Variable / assumption	Number of patents per million inhabitants (n = 8)	BDP per capita (n = 8)
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 0.625	d = 1.922
Histogram		
P-P normality diagram		

Source: the authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3**. In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 3). Assumptions are not met.

Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 3, it was determined that there is no independence of observations when it comes to the number of patents per million inhabitants (d=0,625). The assumption is not met.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 3, it was determined that observations are independent when it comes to the country's innovation index (d=1.922). The assumption is fulfilled.

Ass. 5. and **Ass. 6**. The results shown in table 5 (histograms and P-P diagrams of normality) were intended to show the absence of heteroskedasticity

and the normal distribution of residual errors in the dependent and independent variables. The assumptions are partially fulfilled.

Given that the obtained results showed that these assumptions were not met or only partially met, the next task was to transform the data based on the logarithm (table 4).

Table 4. Results of linear regression

Model Summary[b]

Variables
The number of patents per million inhabitants and the country's innovation index

R	R Square	Adjusted R Square	SE of the Estimate
0.373[a]	0.139	-0.004	0.02202

a. Predictors: (Constant), patent_transf
b. Dependent Variable: index_and_transf

Variables
The number of patents per million inhabitants and GDP per capita

R	R Square	Adjusted R Square	SE of the Estimate
0.631[a]	0.398	0.298	0.02058

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_transf

ANOVA[b]

Variables
The number of patents per million inhabitants and the country's innovation index

	Sum of Squares	df	Mean Square	F	p
Regression	0.000	1	0.000	0.971	0.363[a]
Residual	0.003	6	0.000		
Total	0.003	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: index_and_transf

Variables
The number of patents per million inhabitants and GDP per capita

	Sum of Squares	df	Mean Square	F	p
Regression	0.002	1	0.002	3.973	0.093[a]
Residual	0.003	6	0.000		
Total	0.004	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_transf

Coefficients[a]

Variables
The number of patents per million inhabitants and the country's innovation index

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	1.790	0.233		7.689	0.000
patent_transf	-0.144	0.146	-0.373	-0.985	0.363

a. Dependent Variable: index_and_transf

Variables
The number of patents per million inhabitants and GDP per capita

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	3.238	0.217	0.631	14.888	0.000
patent_transf	0.272	0.137		1.993	0.093

a. Dependent Variable: BDP_and_transf

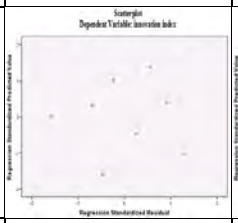
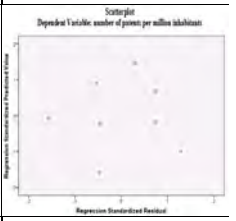
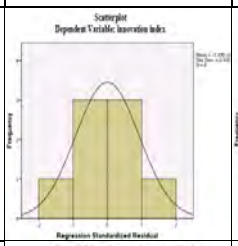
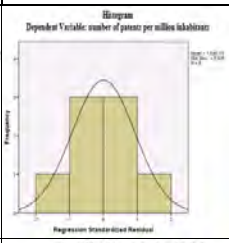
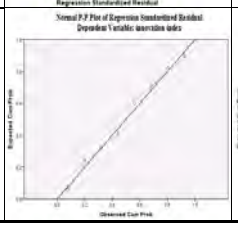
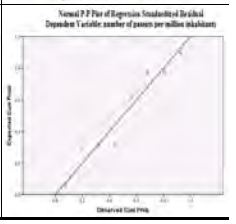
Source: the authors' research

In the simple linear regression model for the variables number of patents per million inhabitants and the country's innovation index, a correlation coefficient of R = 0.373 was determined, which can be considered a medium according to Cohen's criteria. Based on the obtained results R^2 = 0.137 (coefficient of determination) and Adj.R^2 = -0.004 (corrected coefficient of determination), the conclusion is that a total of 13.7% of changes in the dependent country's innovation index can be explained by changes in the independent variable number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 0.971, p = 0.363, it can be concluded that the regression model at the p < 0.050 level was not statistically significant. According to Domazet et al. (2022, 196-197), "that result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for changes in the country's innovation index". The obtained results showed that the value of the ordinary regression coefficient is B = 1.790 (SE B = 0.233), while the value of the standardized regression coefficient is β = -0.373 (Domazet et al., 2022). Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and country's innovation index in the case of Serbia.

In the simple linear regression model for the variables number of patents per million inhabitants and GDP per capita, a correlation coefficient of R = 0.631 was determined, which can be considered as large (significant) according to Cohen's criteria. Based on the obtained results, R^2 = 0.398 (coefficient of determination) and Adj.R^2 = 0.298 (corrected coefficient of determination), it is concluded that a total of 39.8% and 29.8% of changes in the dependent variable GDP per capita can be explained by changes in the independent variable, the number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 3.973, p = 0.093, it can be concluded that the regression model at the p < 0.050 level was not statistically significant. According to Domazet et al. (2022, 199) "that result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants does not provide a statistically significant explanation for changes in the GDP per capita". The obtained results showed that the value of the ordinary regression coefficient is B = 3.238 (SE B = 0.217), while the value of the standardized regression coefficient is β = 0.631 (Domazet et al., 2022). Given that the coefficients of correlation and determination had a small value, with the absence of statistical significance of the regression model, it can be concluded that there is no statistically significant relationship between the number of patents per million inhabitants and the GDP per capita in the case of Serbia.

In the first case, using the example of Hungary, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = innovation index; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 5.

Table 5. Verification of fulfillment of assumptions - Case I (Hungary)

Variable / assumption	Number of patents per million inhabitants (n = 8)	Innovation index (n = 8)
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 1.585	d = 1.306
Histogram		
P-P normality diagram		

Source: the authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3.** In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 5). The assumptions are not met.

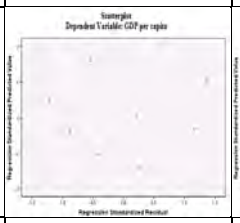
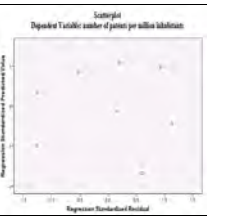
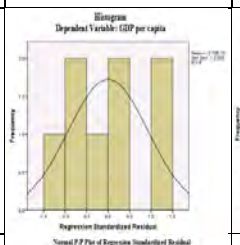
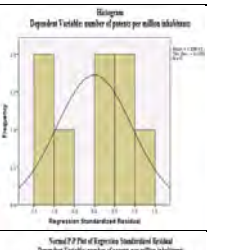
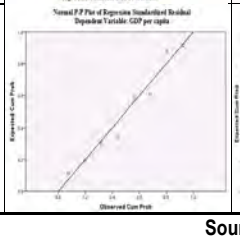
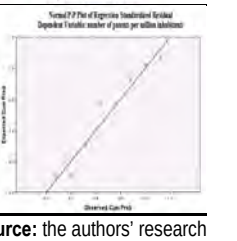
Ass. 4a. Based on the conducted Durbin Watson statistic and the obtained results shown in table 5, it was determined that there is the independence of observations when it comes to the number of patents per million inhabitants (d=1,585). The assumption is fulfilled.

Ass. 4b. Based on the conducted Durbin Watson statistic and the obtained results shown in table 2, it was determined that observations is no independent when it comes to the country's innovation index (d=1.306). The assumption is not met.

Ass. 5. and **Ass. 6**. Based on the performed analysis and obtained results shown in table 2 (histograms and P-P diagrams of normality), it was determined that there is no absence of heteroskedasticity and normal distribution of residual errors. Assumptions are not made. The assumption is fulfilled.

In another case, using the example of Hungary, the task was to determine whether all six assumptions (Ass.1 - Ass.6) were fulfilled for both observed variables (dependent variable = GDP per capita; independent variable = number of patents per million inhabitants). The results of the simple linear regression are presented in Table 6.

Table 6. Verification of fulfillment of assumptions - Case II (Hungary)

Variable / assumption	Number of patents per million inhabitants (n = 8)	BDP per capita (n = 8)
The nature of the variable	Metric	Metric
Distribution diagram		
Value of indicators of Durbin-Watson statistics	d = 1.700	d = 2.291
Histogram		
P-P normality diagram		

Source: the authors' research

Ass. 1. The task was to determine whether the variables have a continuous nature. The analysis showed that both observed variables have a metric measurement and are therefore treated as metric

variables measured on a ratio scale. The assumption is fulfilled.

Ass. 2. and **Ass. 3.** In the conducted analysis, it was not established that there is a linear relationship between the dependent and independent variables. Also, the absence of atypical points was not determined (distribution diagram, table 6). The assumptions are not met.

Ass. 4. Based on the conducted Durbin Watson statistic and the obtained results shown in table 6, it was determined that observations are independent when it comes to the number of patents per million inhabitants (d=1.700) and BDP per capita (2.291). The assumption is fulfilled.

Ass. 5. and **Ass. 6**. The results shown in table 6 (histograms and P-P diagrams of normality) were intended to show the absence of heteroskedasticity and the normal distribution of residual errors in the dependent and independent variables. The assumptions are partially fulfilled.

Given that the obtained results showed that these assumptions were not met or only partially met, the next task was to transform the data based on the logarithm (table 7).

Table 7. Results of linear regression

Model Summary[b]

Variables

The number of patents per million inhabitants and the country's innovation index

R	R Square	Adjusted R Square	SE of the Estimate
0.810[a]	0.656	0.599	0.01280

a. Predictors: (Constant), patent_transf
b. Dependent Variable: index_and_transf

Variables

The number of patents per million inhabitants and GDP per capita

R	R Square	Adjusted R Square	SE of the Estimate
0.831[a]	0.690	0.639	0.02155

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_transf

ANOVA[b]

Variables

The number of patents per million inhabitants and the country's innovation index

	Sum of Squares	df	Mean Square	F	p
Regression	0.002	1	0.002	11.454	0.015[a]
Residual	0.001	6	0.000		
Total	0.003	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: index_and_transf

Variables

The number of patents per million inhabitants and GDP per capita

	Sum of Squares	df	Mean Square	F	p
Regression	0.006	1	0.006	13.377	0.011[a]
Residual	0.003	6	0.000		
Total	0.009	7			

a. Predictors: (Constant), patent_transf
b. Dependent Variable: BDP_and_transf

Coefficients[a]

Variables

The number of patents per million inhabitants and the country's innovation index

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	0.802	0.252		3.190	0.019
patent_transf	0.390	0.115	0.810	3.384	0.015

a. Dependent Variable: index_and_transf

Variables

The number of patents per million inhabitants and GDP per capita

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	5.588	0.423		13.202	0.000
patent_transf	-0.710	0.194	-0.831	-3.657	0.011

a. Dependent Variable: BDP_and_transf

Source: the authors' research

In the simple linear regression model for the variables number of patents per million inhabitants and the country's innovation index, a correlation coefficient of R = 0.810 was determined, which can be considered as large (significant) according to Cohen's criteria. Based on the obtained results R^2 = 0.656, (coefficient of determination) and Adj.R^2 = 0.599 (corrected coefficient of determination), it is concluded that a total of 65.6% and 59.9% of changes in the dependent variable, the country's innovation index, can be explained by changes in the independent variable, the number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the ANOVA test F (1,6) = 11.454, p = 0.015, it can be concluded that the regression model at the p < 0.050 level was statistically significant. According to Domazet et al. (2022, 199), "that result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants provide a statistically significant explanation for changes in the country's innovation index". The obtained results showed that the value of the ordinary regression coefficient is B was statistically significant at the p < 0.050 level and amounted to B = 0.802 (SE B = 0.252) (Domazet et al., 2022). Based on it, a regression equation can be derived in the form:

Innovation index = 0.802 + 0.390 x (number of patents per million inhabitants) (1)

This means that with each unit increase in the number of patents per million inhabitants, the innovation index of Hungary changes according to the formula 0.802 + 0.390 x (the number of patents per million inhabitants). In addition "the standardized beta regression coefficient in this case was β = 0.810, and can be qualified as large" (Domazet et al., 2022, p. 196).

In the simple linear regression model for the variables number of patents per million inhabitants and GDP per capita, a correlation coefficient of R = 0.831 was determined, which can be considered as large according to Cohen's criteria. Based on the obtained results R^2 = 0.690, (coefficient of determination) and Adj.R^2 = 0.639 (corrected coefficient of determination), it is concluded that a total of 69% and 63.9% of changes in the dependent variable, the GDP per capita, can be explained by changes in the independent variable, the number of patents per million inhabitants (Domazet et al., 2022). Based on the results of the

ANOVA test F (1,6) = 13.377, p = 0.011), it can be concluded that the regression model at the p < 0.050 level was statistically significant. According to Domazet et al. (2022, 199) "that result provides additional information about the relationship between the independent and dependent variables included in the regression model and shows that the change in the number of patents per million inhabitants provide a statistically significant explanation for changes in the GDP per capita". The obtained results showed that the value of the ordinary regression coefficient is B was statistically significant at the p < 0.050 level and amounted to B = 5.588 (SE B = 0.423) (Domazet et al., 2022). Based on it, a regression equation can be derived in the form:

BDP per capita = 5.588 – 0.710 x (number of patents per million inhabitants) (2)

This means that with each unit increase in the number of patents per million inhabitants, the innovation index of Hungary changes according to the formula 5.588 – 0.710 x (the number of patents per million inhabitants). In addition, "the standardized beta regression coefficient in this case was β = -0.831, and can be qualified as large" (Domazet et al., 2022, 196).

According to Domazet et al. (2022, p. 201), "the obtained negative value of the standardized regression coefficient β in this particular case means that with each unit" increase in the number of patents per million inhabitants, the GDP per capita decreases by a value of -0.810. Given that, according to the data, the number of patents per million inhabitants in Hungary decreased during the observed period, this means that with each unit of decrease in the number of patents per million inhabitants in Hungary, GDP per capita in the value of 0.810 occurred.

Conclusion

Empirical research confirms the existence of a relationship between the number of patents per million inhabitants and the country's innovation index only in the case of Hungary. In the other analyzed cases, no connections were found between the number of patents per million inhabitants on the one hand and the country's innovation index and GDP per capita growth on the other hand. The lack of influence of the number of patents per capita on the country's innovation index and BSP growth can be viewed from several angles.

First, an additional explanation of the obtained research results can be given by the European Innovation Scoreboard according to the efficiency of national innovation systems and the results of innovation activities. The survey is published every year by the European Commission, classifying countries into leaders in innovation, strong innovators, moderate innovators and modest innovators. In this ranking, Hungary is included in the group of countries that can be characterized as moderate innovators, while Serbia belongs to the group of weak innovators.

Second, it is necessary to verify the existence or establish the connections that innovations have with Hofstede's dimensions of national culture, because culture is considered one of the key factors in the innovation management process. The negative results obtained through the conducted research are partially explained by the high values of power distance that characterize the national cultures of Serbia and Hungary, as well as the negative relationship between this dimension of national culture and innovation.

Third, given the connection between national and organizational culture, and the fact that national culture provides a framework, i.e. a contextual milieu in which innovative activities can develop in different organizations, when interpreting the results, the organizational cultures of individual companies should also be taken into account. In terms of innovation activities, organizational culture can be defined as one of the key systems of the company, which is based on the values on which the principles and norms of company management rest. Therefore, any analysis that deals with innovation at the organizational level, i.e. at the company level, should take into account how the company plans its innovation activities, what kind of innovation infrastructure it has, what is the impact of innovation activities on the business of the company and how the company applies innovations. However, such an analysis would require the collection of primary data from companies from Serbia and Hungary, which may be a task in some future research.

Fourth, the impact of the operations of multinational companies and the inflow of foreign investments on innovation can be positive both for the innovation of the country where these companies start their operations, and for its economy as a whole. Bearing this in mind, it is legitimate to ask the question to what extent foreign investments improved the development of the innovation systems of Serbia and Hungary, enabled the smooth development of patents, and

how much this affected innovation and GDP growth.

If the national innovation systems of Serbia and Hungary are compared, it can be concluded that there are problems in the cooperation between the academic community and the business sector, that the demand for innovation in their economies is small, and the systems themselves are underfunded and ineffective. With that in mind, the result obtained is not surprising. Even if these countries had a higher average number of patents per capita, invested far more in the field of research and development, and employed a far greater number of researchers, it would not give a significant result. This happens due to unresolved issues of cooperation between science and business, the successful application of patents in the business sector, both industry and services, and the issue of low demand for innovation.

The information obtained through the conducted empirical research primarily carries a warning for decision makers regarding the efficiency of national innovation systems, absorption possibilities and the demand for innovations at the level of national economies. In this sense, the primary task for decision-makers concerns raising awareness of the importance of innovations and increasing demand for them at the level of the national economy. However, even if the studied countries have a much higher number of patents per million inhabitants than the current figures, this will not affect the increase in innovation of the economy and the growth of well-being if (a) patents do not find a place for their application, (b) business entities do not have the capacity for their application, and (c) until everyone understands that the application of those patents enables them to achieve better business results.

The conducted research also has several limitations. The first limitation of this research is related to the number of countries included in the research, considering that the analysis was done only for Serbia and Hungary. A recommendation for future researches is to include three or more countries that belong to one region in the analysis. Another limitation of this research was related to the number of indicators that were analyzed. In this research, the influence of the number of patents on the growth of innovation and economic growth was tested, while some other indicators (e.g. production growth) should be included in some future research. The third limitation of this research is the time period covered by the analysis, which in this case was from 2008 to 2018. The recommendation to researchers is to use a longer time series (20 or more years) in some subsequent research.

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✉ **Correspondence**

Ivana Domazet

Institute of Economic Sciences
Zmaj Jovina 12, 11000, Belgrade, Serbia

E-mail: ivana.domazet@ien.bg.ac.rs

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Adaptation of the entrepreneurship competences questionnaire - when entrepreneurship is more than just business

Radka Čopková
Technical University of Košice, Faculty of Economics, Košice, Slovakia
https://orcid.org/0000-0001-6395-0300
Marek Gróf
Technical University of Košice, Faculty of Economics, Košice, Slovakia
https://orcid.org/0000-0001-8542-8521
Jana Zausinová
Technical University of Košice, Faculty of Economics, Košice, Slovakia
https://orcid.org/0000-0002-6784-2531
Marianna Siničáková
Technical University of Košice, Faculty of Economics, Košice, Slovakia
https://orcid.org/0000-0001-7551-4231

Abstract
Background Since 2006, entrepreneurship competence has been considered one of the eight key competences for lifelong learning, which are important for personal development, social inclusion, active citizenship, and employment. In 2015, the EntreComp framework was created. The framework structures partial entrepreneurship competences to support their development in European citizens regardless of the field of education, professional or occupational orientation, as a critical part of increasing competitiveness and innovation potential of a country.
Purpose: The present paper aimed to develop a questionnaire based on the EntreComp framework, which would serve as a self-assessment tool for one's entrepreneurship competences, which could be used to adopt curricular or extra-curricular and non-formal, education to better serve this goal.
Study design/methodology/approach: The validity and reliability of the questionnaire was examined on a sample of university students in different fields of study – technical and natural sciences, humanities, economics, and medicine. The purpose of the sample diversity is the emphasis on the independence of entrepreneurship competence on professional orientation.
Findings/conclusions: The result of the study is a 60-item questionnaire consisting of three factors and fifteen subfactors helping to identify educational needs in the field of entrepreneurship, based on the subjective perception of the individual. In comparison with already existing tools, this questionnaire was developed on the strong basis of EntreComp framework and supports the idea of the broader context of entrepreneurship competence than just the business level, while covering cognitive, personal, and behavioural level of the entrepreneurial potential.
Limitations/future research: In the future, its application in other age or social groups is suggested.

Keywords
entrepreneurship; entrepreneurship competence; lifelong learning; questionnaire

Introduction

Sufficient entrepreneurship competence in population encourages the foundation of small and medium enterprises, which in turn are major contributors to economic output of a country (Janowski, Gonchar & Yakovyshyn, 2023). According to the European Commission (European Commission, 2020), small and medium enterprises created 54.5% of the whole EU gross domestic product and 61% of all European labour positions in 2018. Therefore, enhancement of entrepreneurship competence should be the centre of attention of central and local governments, higher education institutions and other stakeholders to avoid entrepreneurship educational failures as highlighted e.g. by Funken, Gielnik & Foo (2020) and to consider experiential education instead (Bell & Bell, 2020). Ahn and Winters (2022) examined causal effects of formal education on entrepreneurship proving that education increases probability of entrepreneurship.

Proven by the existence of many definitions, there are several ways in which the phenomenon of entrepreneurship is understood. Probably the most basic way people perceive entrepreneurship is its strongly economic (business) meaning - starting a business, moving in the market, creating products, and providing services, recognizing opportunities, creating new value. Komarkova, Gagliardi, Conrads and Collado (2015) state that over time, this phenomenon began to transcend the boundaries of strictly economic perception and entrepreneurship is now recognized on a much broader scale of produced values - social, cultural, or environmental (Komarkova et al., 2015; McCallum, Weicht, McMullan, & Price, 2018). The range of values that are created through entrepreneurship greatly expands the possibilities of applying other knowledge, skills, and attitudes. After being reduced to business-oriented terminology, according to the OECD (Komarkova et al., 2015) entrepreneurship is defined as "a phenomenon associated with entrepreneurial (human) activity, which is then characterized by value generation, creation or expansion, and identification and exploitation of opportunities."

Based on this meaning shift, there was a tendency to perceive entrepreneurship as a competence. As reported by Komarkova et al. (2015), primarily a distinction between entrepreneurial competence and competency was explained. Entrepreneurial competency is associated with behaviour, motivation, and personality traits. Entrepreneurial competence is tied to measurable results of performance. In the end, the European Parliament and Council (2006) defined competence as a combination of skills, knowledge, and attitudes. This clarifies that entrepreneurship competence reflects a performance/outcomes approach, with behaviour, motivation, and personality traits (competency) as its defining elements. Nevertheless, Komarkova et al. (2015) use the term entrepreneurial competence in both meanings - competence and competency.

The European Parliament and Council (2006) identified entrepreneurship as one of the eight key competences for lifelong learning - literacy; languages; science, technology, engineering and mathematics (STEM); digital; personal, social and learning; civic; entrepreneurship; cultural awareness and expression. All mentioned competences are considered necessary for personal development, social inclusion, active citizenship, and employment (Bacigalupo, Kampylis, Punie, & Van den Brande, 2016). Zhang and Huang (2021) identified issues in entrepreneurship resilience implied by current global economic crisis and post-COVID19 consequences.

1. EntreComp

The EntreComp concept was created (McCallum et al., 2018) in 2015. The aim was to systematize the support system for the development of the entrepreneurial competences of the European population. This framework not only defines exactly what we mean by entrepreneurship as a competence for lifelong learning, but also offers EU citizens universal possibilities for applying procedures for its development in the context of formal education, non-formal education, and training in schools as well as job. It describes and explains which partial knowledge, skills, and attitudes need to be developed to learn to spot opportunities in surroundings, seek resources, and act to create values of different origin (Komarkova et al., 2015; McCallum et al., 2018).

The EntreComp framework consists of three main areas. Each of them is characterized by five competences (Bacigalupo et al., 2016), covering personal, cognitive, and behavioural levels of entrepreneurship competence:

Ideas and Opportunities: Spotting opportunities (using imagination and abilities to identify opportunities for creating value); Creativity (developing creative and purposeful ideas); Vision

(working towards the vision of the future); Valuing ideas (making the most of ideas and opportunities); Ethical and sustainable thinking (assessing the consequences and impact of ideas, opportunities and actions)

Resources: Self-awareness and self-efficacy (believing in oneself and keeping up development); Motivation and perseverance (staying focused and not giving up); Mobilizing resources (gathering and managing the resources one needs); Financial and economic literacy (developing financial and economic know-how); Mobilizing others (inspiring, enthusing and getting others on the board)

Into Action: Taking the initiative (going for it); Planning and management (prioritizing, organizing, and following-up); Coping with uncertainty, ambiguity, and risk (making decisions dealing with uncertainty, ambiguity, and risk); Working with others (teaming up, collaborating and networking); Learning through experience (learning by doing).

Each of these fifteen competences is saturated with two or six additional subcompetences, which makes a total of 60 subcompetences. They are referred to as threads. Each of the 60 threads is defined by eight learning objectives (discover / explore / experiment / dare / improve / reinforce / expand / transform) at four levels of difficulty (foundation / intermediate / advanced / expert). There are 0 to 2 objectives at every level of difficulty. The meaning of this so-called progression model is to point out the effort to reduce external support for the learner and gain autonomy. The whole EntreComp framework thus defines the 442 educational goals needed for the development of entrepreneurial competence (Bacigalupo et al., 2016; McCallum et al., 2018).

These competences do not work in isolation but are interconnected and equally important, with no single key competence. It is not required or expected to have all the competences equally and fully developed, as each entrepreneurship activity and each individual is unique (McCallum et al., 2018).

Since one of the purposes of EntreComp is its implementation into the education and training process, the question of how entrepreneurship competence can be captured has arisen (Bacigalupo et al., 2016). Komarkova et al. (2015) present several tools, as an attempt to capture entrepreneurship competence as a whole. The presented methodologies were focused more on the practical demonstration of knowledge, skills, and attitudes in the form of presentations, projects, discussions, exams. The authors point out the questionable validity. In addition to this practical test, the Enterprise Skills Pass also includes a self-assessment tool aimed at assessing one's progress. Also, one of the components of the Global Entrepreneurship Monitor (GEM) is self-assessment in the area of perception of one's business predispositions (Pilková, Holienka, Rehák, Kovačičová, Komorník, Mitková, et al., 2017). The research was also carried out on Slovak university students who perceived their abilities, skills, and experience for business as sufficient, but the tool focused on entrepreneurship in the economic meaning, in terms of business activity that results in profit, not in terms of entrepreneurship competence. Another approach was brought by the study of Muñiz, Suárez-Álvarez, Pedrosa, Fonseca-Pedrero, and GarcíaCueto (2014), who developed the Battery for the Assessment of the Enterprising Personality (BEPE) for the young population. The tool focuses on specific personality traits, defining so-called entrepreneurial personality by traits such as self-efficacy, risk-taking, innovativeness, achievement motivation, autonomy, internal locus of control, optimism, and stress tolerance. The psychometric properties of BEPE-A (Adaptive) were already examined by Ortuño-Sierra, Gargallo Ibort, Ciarreta López, & Dalmau Torres (2021), who also claim that new instruments are still needed.

Therefore, the present study aims to construct and examine the reliability and validity of a questionnaire exploring the perception of one's entrepreneurship competence. In contrast to previous studies that dealt with skill or ability demonstrations, business context, and entrepreneurial personality, our research focuses on cognitive, personal, and behavioural levels of entrepreneurial potential that are not covered by other available questionnaires.

2. Present study

If entrepreneurship competence is a factor that predisposes an individual to create various values, a tool capturing individual's beliefs about their knowledge, skills, and attitudes seems to be beneficial.

Our starting point for creating such a tool was the EntreComp framework, which defines entrepreneurship as competence and at the same time defines 442 learning objectives at eight levels of difficulty (example of the objective: "I can explain what makes an opportunity to create

value.") (McCallum et al., 2018). As shown, many of these educational goals take the form of "I" statements. The statement form is the reason why we found them suitable for a self-assessment questionnaire. However, as the number of items was too high, a reduction was necessary. At first, the key how to extract the items that would be most suitable for the questionnaire had to be defined. In the context of the progression model, participants are supposed to dispose of certain starting level of entrepreneurial competence while attending educational activities supporting its development. This is the reason to start at the basic skill level – Foundation – and its first sub-levels – discover or explore. The Foundation level is characterized by dependence on external support (Bacigalupo et al., 2016). At the sub-level of discovery, it is the ability to discover potential, mainly through the supervision of teachers, mentors, coaches, etc. (McCallum et al., 2018). Strauti, Dumitrache, and Taucean (2018) state that the minimum level of entrepreneurship competences of university students studying engineering should be at least at intermediate level (building independence), ideally advanced (taking responsibility). However, this questionnaire aims to be a universal tool suitable also for less "entrepreneurial" fields. Items were formulated at the most basic level (foundation), because entrepreneurship competence is connected to the creation of values outside of the economic context as well. In order to prevent inciting too self-confident responses which result from trying to maintain a positive self-image (Jones & Berglas, 1978) avoiding "I" statements during item formulation came into the question. Based on the negative feedback of the small test sample the original "I" statement wording of the educational objectives was left. Likert scale of five points (1 = strongly disagree; 5 = strongly agree) was added to each goal. The resulting questionnaire disposed of 60 items, covering all 3 areas of entrepreneurship competences, but also 15 subcompetences and their 60 threads. Evaluation and results interpretation of the questionnaire is thus possible at different levels as needed and emphasized in the original framework (Bacigalupo et al., 2016; McCallum et al., 2018).

We emphasize that the questionnaire is self-assessed - it shows how respondents see themselves, not what their objective abilities are like.

2.1. Study I – Reliability analysis

2.1.1. Methods

2.1.1.1 Participants

The research sample consisted of 653 Slovak university students (Mage = 22.08; SD = 2.19), 37.20 % men (N = 243; Mage = 21.95; SD = 1.99) and 62.80 % women (N = 410; Mage = 22.15; SD = 2.30). Respondents attended all levels of study – bachelor's (60.50 %), master's/engineering (27.87 %), doctoral (0.76 %) and combined (10.87 %) in five different study fields – economic (39.51 %), technical (29.86 %), social sciences/humanities (15.62 %), medical (11.18 %) and sciences (3.83 %).

2.1.1.2 Measures

EntreComp questionnaire - consists of 60 statements that saturate 3 factors of entrepreneurship competence:

- **Ideas and Opportunities (IO)** - Spotting opportunities (IOF1); Creativity (IOF2); Vision (IOF3); Valuing ideas (IOF4); Ethical and sustainable thinking (IOF5)
- **Resources (R)** - Self – awareness and self-efficacy (RF1); Motivation and perseverance (RF2); Mobilising resources (RF3); Financial and economic literacy (RF4); Mobilising others (RF5)
- **Into Action (IA)** - Taking the initiative (IAF1); Planning and management (IAF2); Coping with uncertainty, ambiguity, and risk (IAF3); Working with others (IAF4); Learning through experience (IAF5)

The number of items in the subfactors varied from two to six. Respondents rate statements on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree).

2.1.1.3 Procedure

The questionnaire was distributed to respondents in the period February – April 2021. The current situation associated with the COVID-19 pandemic allowed collection only in an electronic way. (Google Docs Form web application). Respondents were informed that the completion of the questionnaire was voluntary and anonymous, and the data would be processed only in this research.

A total of 12 partial collections took place. One part took place during online lectures on the Cisco Webex and Microsoft Teams platforms. The online

environment allowed respondents to leave the session anonymously at any time and not to submit the completed form. By participating and completing a questionnaire, they agreed to participate in the research study. The return rate of the questionnaires was 75.1%. In the second part of the collection, the convenience and purposive sampling methods were used via groups of students on social networks and e-mails. The exact return rate could not be identified, as it is difficult to find out in the online environment out of formal sessions.

To ensure that all respondents are Slovak native speakers, all other nationalities were excluded. There was no missing data in the dataset because all items were marked as required. Multivariate outliers were captured with Mahalanobis distance. The normality of the data distribution was tested using the skewness, kurtosis, and Shapiro-Wilk's test. The internal consistency of the questionnaire was tested using McDonald's omega (ω) and Cronbach's alpha (α). Test-retest reliability was tested on only three subsamples (N = 182) from the original 12 after two weeks due to sample availability, using the intraclass correlation coefficient. The return rate of the questionnaires was 64.5 %. Intercorrelations between factors and subfactors of the questionnaire were tested using Spearman correlation coefficient (ρ). In the confirmatory factor analysis (CFA), diagonally weighted least squares (DWLS) estimation method with robust correction was used, which deals better with data that do not meet the criterion of normal distribution (Mîndrila, 2010). The following model fit indicators were evaluated: chi-square ($\chi 2$), relative chi-square ($\chi 2$ / df) Tucker-Lewis index (TLI), comparative fit index (CFI), and the root mean square error of approximation (RMSEA).

The data were subjected to statistical analysis in IBM SPSS Statistics 21, Jamovi 1.2.9, and Jasp 0.14.1.

The pilot version of the questionnaire was created in English, according to the default document. Reliability and validity examination took place in Slovakia; therefore it was necessary to translate the questionnaire. The translation from the English language into the Slovak language was performed by two independent experts in the field of translating. The back-translation into English was done by a third expert. The final wording of the items was discussed to adjust the linguistic nuances. The essence of the meaning of the item was retained, but at the same time, the wording of the item is natural for the Slovak-speaking respondents.

2.1.2. Results

Analyses were performed in several steps. Firstly, normality testing, outliers testing, and descriptive analysis were performed. Subsequently, the internal consistency, test-retest reliability, intercorrelations, and factor structure of the questionnaire were tested.

Based on testing multivariate outliers using the Mahalanobis distance, 19 cases that did not meet the specified criterion (MD = 37.7; $p < 0.001$) were excluded from the sample. The value of skewness and kurtosis did not exceed the criterion > ±1. But Shapiro-Wilk's test showed that the data are not normally distributed ($p < 0.05$), which influenced the subsequent analyses.

Descriptive analysis of the 3 factors and 15 subfactors of the questionnaire is presented in Table 1. The average scale values show that the respondents answered around the mean value, leaning to the second half of the scale.

Table 1 Descriptive and reliability analysis

	descriptives N = 653				internal consistency N = 653			test-retest N = 108		
	M	**SD**	**Min**	**Max**	**Items (n)**	**α**	**ω**	**ICC**	**LB**	**UB**
IO	3.83	0.50	2.00	5.00	**18**	**0.86**	**0.86**	**0.88**	**0.82**	**0.92**
IOF1	3.60	0.64	1.50	5.00	4	0.60	0.61	0.70	0.56	0.79
IOF2	3.72	0.65	1.60	5.00	5	0.74	0.74	0.80	0.72	0.86
IOF3	4.27	0.67	1.67	5.00	3	0.67	0.68	0.77	0.66	0.84
IOF4	3.58	0.82	1.50	5.00	2	0.39	0.40	0.62	0.45	0.74
IOF5	4.12	0.56	2.25	5.00	4	0.57	0.62	0.77	0.66	0.84
R	3.96	0.50	2.42	5.00	**21**	**0.87**	**0.87**	**0.88**	**0.83**	**0.92**
RF1	4.14	0.60	2.00	5.00	4	0.71	0.71	0.82	0.74	0.88
RF2	3.85	0.69	1.60	5.00	5	0.80	0.80	0.86	0.79	0.90
RF3	4.23	0.58	2.25	5.00	4	0.49	0.50	0.79	0.70	0.86
RF4	3.98	0.74	1.00	5.00	4	0.73	0.76	0.81	0.72	0.87
RF5	3.63	0.78	1.50	5.00	4	0.75	0.74	0.80	0.72	0.86
IA	3.85	0.55	1.57	5.00	**21**	**0.90**	**0.90**	**0.85**	**0.79**	**0.90**
IAF1	3.90	0.71	1.33	5.00	3	0.63	0.64	0.87	0.81	0.91

IAF2	3.64	0.70	1.17	5.00	6	0.81	0.82	0.84	0.76	0.83
IAF3	3.57	0.77	1.00	5.00	3	0.66	0.69	0.59	0.41	0.72
IAF4	4.19	0.61	1.83	5.00	6	0.79	0.79	0.73	0.61	0.82
IAF5	3.84	0.73	1.33	5.00	3	0.73	0.73	0.65	0.50	0.76

Note: *M = mean; SD = standard deviation; MIN = minimum; MAX = maximum; n = number; α = Cronbach´s alpha; ω = McDonald´s omega; ICC = intraclass correlation coefficient; LB = lower bound; UB = upper bound*

Source: the authors

Internal consistency analysis was performed by using two coefficients – McDonald's omega and Cronbach's alpha (Table 1). Criteria for assessment were as follows > 0.90 excellent; 0.89 > 0.80 good; 0.79 > 0.70 acceptable; 0.69 > 0.60 poor; 0.59 > 0.50 insufficient (Field, 2013). However, with a small number of items, Cronbach's alpha values around 0.50 are also acceptable (Field, 2013).

The *Ideas & Opportunities* and *Resources* factors reached very good reliability values, and the *Into Action* factor was excellent. A detailed analysis of subfactors showed that the values of the coefficients range from insufficient to very good. The subfactor of *valuing ideas* was especially problematic because the values of both Cronbach's alpha and McDonald's omega were at an insufficient level. The same problem was detected in the *mobilizing resources* subfactor in the *Resources* factor. The subfactors *spotting opportunities, vision, ethical & sustainable thinking, taking the initiative, and coping with uncertainty, ambiguity & risk* also showed a lower internal consistency. Again, these are scales with a small number of items. Given that overall, the main factors of the questionnaire dispose of a very good to excellent internal consistency, the subscales remained. However, the interpretation of results at the subscale level needs to be approached with caution.

Intraclass correlation coefficient, two-way mixed effects model, and type absolute agreement were used to test test-retest reliability. Criteria for assessment were as follows: < 0.5 poor; < 0.7 moderate; < 0.9 good; > 0.9 excellent (Koo & Li, 2016). The results are shown in Table 1. According to the established criteria for intraclass correlation coefficient values with a confidence interval of 95 %, the analysis reached satisfactory results. At the factor level, the results were consistent over time. There was a lower consistency in the sub-factor *valuing ideas* and *coping with uncertainty, ambiguity & risk*, which consist of a small number of items. Overall, the results of the test-retest reliability were very satisfactory, and the questionnaire seems to be consistent over time.

Next, intercorrelations between the factors were examined. The analysis confirmed significantly strong positive relationships between all three factors: $\rho_{IO-R} = 0.739$ ($p < 0.001$; 95 % CI [0.697; 0.769]); $\rho_{IO-IA} = 0.729$ ($p < 0.001$; 95 % CI [0.690; 0.763]); $\rho_{R-IA} = 0.802$ ($p < 0.001$; 95 % CI [0.773; 0.828]).

The same procedure was used at the level of subfactors (F1 – F5 for each factor). Relationships between all variables were positive and statistically significant at the level $p < 0.001$ (Table 2). The subfactors saturating the factor *Ideas & Opportunities* had weaker to moderate relationships. For the subfactors of the *Resources* factor relationships were slightly weaker. Although the relationships between subfactors of *Into Action* factor were not very strong, it is statistically significant.

Table 2 Intercorrelations of EntreComp questionnaire subfactors

	F1			**F2**			**F3**			**F4**			**F5**		
	IO	**R**	**IA**	**IO**	**R**	**IA**	**IO**	**R**	**IA**	**IO**	**R**	**IA**	**IO**	**R**	**IA**
F1	-	-	-												
F2	.62	.61	.56	-	-	-									
F3	.44	.43	.33	.52	.37	.63	-	-	-						
F4	.46	.31	.40	.53	.34	.50	.46	.34	.43	-	-	-			
F5	.40	.52	.49	.44	.63	.57	.46	.31	.54	.36	.31	.50	-	-	-

Source: the authors

In the confirmatory factor analysis (CFA), diagonal weighted least squares (DWLS) estimation method with robust correction was used, which deals better with data that do not meet the criterion of normal distribution (Mîndrila, 2010).

Two hypothetical models were tested; each of them reflects the structure of the EntreComp theoretical framework (Komarkova et al., 2015). In the first model (Model A), the three main factors of the questionnaire (Ideas & Opportunities, Resources, Into Action) were set as latent variables and the 15 subfactors were set as observed variables (IOF1 - IOF5; RF1 - RF5; IAF1 - IAF5). In the second model (Model B), the latent variables were the same, but the observed variables were set at the item level of the given factor. In both models, the chi-square value was statistically significant ($p < 0.05$), which is not a satisfactory result for this type of analysis, but given the size of the research sample, this result is understandable (Babyak & Green, 2010). All other indicators of the model fit reached satisfactory values (Table 3). When comparing the models, Model A achieved slightly better results. However, for both models, the factor structure of the questionnaire was verified.

Table 3 Confirmatory factor analysis of EntreComp questionnaire – Model fit

model	N	χ^2	df	p	χ^2/df	CFI	TLI	RMSEA	RMSEA 90 % CI	
									LB	UB
Model A	653	138.61	87	<0.001	1.59	0.99	0.99	0.03	0.02	0.04
Model B	653	4115.87	1707	<0.001	2.41	0.97	0.96	0.05	0.05	0.05

Note: *N = number of respondents; χ2 = chi square; df = degrees of freedom; ** p <0.01 (Sig.- 2-tailed); χ2 / df = ratio of chi-square value to degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation, CI = confidence interval; LB = lower bound; UB = upper bound*

Source: the authors

3.1. Study II – Validity

The second part of the study was focused on the relationships of the EntreComp questionnaire and its factors and subfactors with other variables. The convergent and divergent validity of the EntreComp questionnaire was examined in this way.

3.1.1. Methods

3.1.1.1 Participants

The research sample consisted of 169 Slovak university students (M_{age} = 21.97; SD = 2.22), 30.20 % men (N = 51; M_{age} = 22.20; SD = 2.01) and 69.80 % women (N = 118; M_{age} = 21.20; SD = 1.51). Respondents attended all levels of study – bachelor's (75.14 %), master's / engineering (18.34 %), doctoral (0.60 %) and combined (5.92 %) in five different directions – economic (65.10 %), technical (14.79 %), social sciences/humanities (11.24 %), medical (4.14 %) and sciences (4.73 %).

3.1.1.2 Measures

Except of *EntreComp* questionnaire, the following measures were used as validation methods:

- *Grit* (Duckworth & Quinn, 2009; Kropáčová, S., Slezáčková, & Jarden, 2018);
- *General self-efficacy scale* (Košč, Heftyová, Schwarzer, & Jerusalem, 1993);
- *Brief Self-control Scale* (Tangney, Baumeister, & Boone, 2004);
- *Motivation* (Sheldon, & Elliot, 1999);
- *DOSPERT - Domain-Specific Risk-Taking* (Blais & Weber, 2006);
- *TEIQue - Trait Emotional Intelligence Questionnaire* (Kaliská, Nábělková, & Salbot, 2015; Petrides, & Furnham, 2009);
- *NEO FFI – Five-factor personality inventory* (McCrae & Costa, 2004; Ruisel, & Halama, 2007);
- *Short Dark Triad Scale* (Čopková & Šafár, 2021; Jones & Paulhus, 2014).

3.1.1.3 Measures

The procedure was run in the same way as in Study I. The return rate of the questionnaires was 64.5 %.

There were no missing data in the dataset because all items were marked as required in the online form. The normality of the data distribution was tested using the skewness, kurtosis, and Shapiro-Wilk's test. The internal consistency of the questionnaire was tested using McDonald's omega (ω). Convergent and divergent validity was tested using the Spearman correlation coefficient (ρ). The data were subjected to statistical analysis in IBM SPSS Statistics 21, Jamovi 1.2.9.

2.1.2. Results

The value of skewness and kurtosis did not exceed the criterion > ±1, but Shapiro-Wilk's test showed that the data are not normally distributed ($p < 0.05$). Thus, a nonparametric Spearman correlation coefficient was used to verify convergent and divergent validity. Convergent validity was confirmed in the factor *Ideas & Opportunities*, which correlated positively and significantly with extraversion, openness, conscientiousness, narcissism, grit, perseverance of effort, self-efficacy, self-control, autonomous motivation, emotionality, and sociability. Divergent validity proved to be a negatively significant correlation with neuroticism, and psychopathy.

In the *Resources* factor, convergent validity was confirmed by a positive significant relationship with extraversion, conscientiousness, narcissism, perseverance of effort, self-efficacy, self-control, autonomous motivation, emotionality, and sociability. Divergent validity was confirmed by a negative significant relationship with neuroticism.

In the *Into Action* factor, convergent validity was confirmed by a positive significant relationship with extraversion, openness, conscientiousness, grit, consistency of interest, perseverance of effort, self-efficacy, self-control, autonomous motivation, sociability, and emotionality. Divergent validity was confirmed by a negative significant relationship with neuroticism and psychopathy. Specific values of correlation coefficients are presented in the table (Table 4).

Table 4 Convergent and divergent validity of EntreComp questionnaire factors

		IO	R	IA
NEO FFI	*neuroticism*	**-.34*** **	**-.33*** **	**-.27*** **
	extraversion	**.44*** **	**.50*** **	**.40*** **
	openness	**.22****	.14	**.24****
	agreeableness	.13	.03	0.08
	conscientiousness	**.48***	**.61*** **	**.52*** **
Short Dark Triad	*Machiavellianism*	-.00	.04	-.06
	narcissism	**.18***	**.32*** **	.14
	psychopathy	**-.15***	-.05	**-.18***
Short Grit Scale	*total*	**.16***	.19*	**.17***
	consistency of interest	-.14	-.12	**.15***
	perseverance of effort	**.45*** **	**.46*** **	**.46*** **
General self-efficacy scale		**.62*** **	**.65*** **	**.61*** **
Brief Self-control Scale		**.40*** **	**.48*** **	**.39*** **
Motivation	*autonomous*	**.37*** **	**.43*** **	**.42*** **
	non-autonomous	-.06	-.07	-.06
DOSPERT	*ethical*	-.04	-.04	.04
	social	-.04	.02	.04
	financial	-.01	-.01	-.08
TEIQue	*emotionality*	**.32*** **	**.34*** **	**.34*** **
	sociability	**.41*** **	**.46*** **	**.41*** **

Note: *$p < 0.01$ (Sig.- 2-tailed); **$p < 0.01$ (Sig.- 2-tailed); ***$p < 0.01$ (Sig.- 2-tailed)
Source: the authors

Based on the table above, all three main factors of the EntreComp questionnaire have a significant negative relationship with neuroticism and positive significant relationships with extraversion, conscientiousness, perseverance of effort, self-efficacy, self-control, autonomous motivation, sociability, and emotionality. On the contrary, all factors showed very weak and insignificant relationships with agreeableness, Machiavellianism, non-autonomous motivation, and risk-taking (financial, ethical, social).

Discussion

The main goal of the present study was to create a questionnaire that would capture the perception of one's entrepreneurship competence. As entrepreneurial competence was identified by the European Commission as one of the eight key competences for lifelong learning (European Parliament and Council, 2006), the starting point for the questionnaire development was the European EntreComp framework (Komarkova et al., 2015). The result is a questionnaire consisting of 60 items, which saturate 15 subfactors and those saturate the three main factors. This makes it possible to evaluate the questionnaire at two levels and also partially by individual competences.

The EntreComp framework was created to educate the European population in both formal and informal ways. Naturally, there is a noticeable trend to use the framework in academic settings.

This was the reason why a sample of university students was chosen. Ortuño-Sierra et al. (2021) also point out the importance of a school in entrepreneurial abilities development. Students are in the process of preparation for a particular profession, so their knowledge, skills, and attitudes are supposed to be at the so-called starting line, which varies. Compared to younger students, e.g. in primary and secondary school, university students reach a level of formal thinking, so it should not be a problem for them to understand the abstract statements about value creation.

The secondary goal was to examine the reliability and validity of the new questionnaire. Two separate studies were conducted. In both, the sample consisted of university students. Since entrepreneurship competence is not only about creating financial values, but also about social, cultural, or environmental values (Komarkova et al., 2015; McCallum et al., 2018), social sciences, humanities, natural science, medical and technical study fields were included.

The results indicated that the respondents perceived their competences positively. It looks like they believe in themselves. This result is consistent with the findings of Pilková et al. (2017), who also researched the perception of Slovak university students' entrepreneurship competences. The results could be explained by the basic item formulation on the foundation (discover) level, which is characterized by dependence on external support (Bacigalupo et al., 2016; McCallum et al., 2018). Strauti et al. (2018) state that the minimum level of entrepreneurship competences of university students studying engineering should be at least intermediate (building independence), ideally advanced (taking responsibility). However, not only engineering study fields were included in the sample, so base level was retained.

Testing of internal consistency and time stability yielded satisfactory results. However, the internal consistency coefficients of some subfactors were low. These subfactors were made up of a small number of items, which may be the reason for the low values of the coefficients (Field, 2013). Therefore, these values were accepted as sufficient. The same approach was chosen when interpreting the test-retest results. The relationships between the subfactors of the individual factors were significant and positive, which created a good precondition for verification of the factor structure of the questionnaire. Confirmatory factor analysis, but with robust estimators, because the data were not normally distributed (Mîndrila, 2010), was conducted. Two models were tested. Chi-square was statistically significant in both cases, which is not a satisfactory result for this type of analysis, but given the size of the research sample, this result is understandable (Babyak & Green, 2010). Other indicators reached the required values (Arbuckle, 2011). This result is not entirely surprising, because the items in the questionnaire were derived from the defined educational goals in the EntreComp framework (Komarkova et al., 2015).

The next step was to verify the convergent and divergent validity of the questionnaire. The relationship between Big Five personality traits and entrepreneurship intentions, behaviours, success, activities, experiences, attitudes has been addressed by many researchers in recent years (Antoncic, Bratkovic Kregar, Singh, & DeNoble, 2015; Hachana, Berraies, & Ftiti, 2018; Kerr, Kerr, & Xu, 2018; Leutner, Ahmetoglu, Akhtar, & Chamorro-Premuzic, 2014; Mortan, Ripoll, Carvalho, & Bernal, 2014). Although they did not directly relate to entrepreneurship competence, some connections were found. The results of the current study indicate that entrepreneurship competence has a negative relationship with neuroticism and positive relationships with extraversion, conscientiousness, and openness to experience. Similar results are interpreted by Kerr et al. (2018), who prepared a literature review of the personality traits of entrepreneurs. According to this information, entrepreneurship is characterized by emotional stability (the opposite of neuroticism), openness, and extraversion. Openness, together with extraversion, is also defined by Antoncic et al. (2015) as a key personality characteristic of entrepreneurs. On the contrary, conscientiousness and neuroticism emerged from their research as less relevant personality traits. Zhao, Seibert, and Lumpkin (2010) also identified openness as the key personality trait for entrepreneurship, but along with conscientiousness. All studies, including this one, have concluded that agreeableness is not related to entrepreneurship.

Machiavellianism showed no relationship with entrepreneurial competences, which is surprising result because it is characterized by a tendency to manipulate, to achieve one's own goal regardless of the others (Al Aïn, Carré, Fantini-Hauwel, Baudouin, & Besche-Richard, 2013). On the other hand, if Machiavellianism is perceived as the opposite of agreeableness, this result is understandable. However, narcissism as a feature

of a sense of self-importance and superiority over others (Maynard, Brondolo, Connelly, & Sauer, 2015) had positive relationships with entrepreneurial competences. There were also positive relationships with psychopathy, which is characterized by high impulsivity, excitement seeking, low empathy, low degree of anxiety (Paulhus & Williams, 2002), but the relationships were negative. Kramer, Cesinger, Schwarzinger, and Gelléri (2011) achieved the same results in the case of Machiavellianism and narcissism, but in their research, psychopathy also correlated positively with elements of entrepreneurship intention.

Grit, similarly to perseverance and passion in achieving long-term goals (Duckworth & Quinn, 2009), was positively associated with almost all entrepreneurship competences. Perseverance was considered by Arco-Tirado, Bojica, Fernández-Martín, and Hoyle (2019) to be an important prerequisite for starting a business career with students as well. Their assumption was also confirmed, but they note that this relationship is influenced by other subjective as well as objective features. These results are supported, for example, by the study of Butz, Hanson, Schultz, and Warzynski (2018).

Self-efficacy and self-control had positive relationships with all factors of the questionnaire. With self-efficacy, this is not a surprising result, as it is directly part of the Resources factor. The importance of self-efficacy in the field of entrepreneurship is also pointed out, for example, by Zisser, Johnson, Freeman, and Staudenmaier (2019), Newman, Obschonka, Schwarz, Cohen, and Nielsen (2019), and Gielnik, Bledow, and Stark (2020). Gielnik et al. (2020) also interpret it in connection with self-motivation, which also supports results of this study. According to those, autonomous motivation based on internalized principles (Sheldon & Elliot, 1999) had positive relationships with entrepreneurship competences.

Several studies also linked risk-taking to entrepreneurship, especially entrepreneurship intention, (Macko & Tyszka, 2009; Zhao et al., 2010; Zisser et al., 2019), which points to their interconnectedness. However, the relationships with entrepreneurship competences did not show at all. On the contrary, emotionality and sociability as factors of emotional intelligence have shown positive relationships with all entrepreneurship competences. This result is also supported by previous studies, where emotional intelligence has been positively correlated with entrepreneurship intentions (Zampetakis, Kafetsios, Bouranta, Dewett, & Moustakis, 2009), leadership, motivation, resilience (Humphrey, 2013), entrepreneurial success, and behaviours (Ahmetoglu, Leutner, & Chamorro-Premuzic, 2011).

The presented study also has its limitations. Due to the situation caused by the COVID-19 pandemic, data were collected online via Google Docs Form. In the current situation, this allowed us to gather a large amount of information in a relatively short period of time, at the cost of reduced control over the environment and conditions of the data collection process. Often, students left the lecture before completing the questionnaire. While this can be limiting, only data from those respondents who were really motivated to fill in the questionnaire were obtained. This is perhaps the reason why respondents scored relatively high in subfactors of the questionnaire. It is likely that the respondents who were not willing to fill in the questionnaire do not have sufficient features such as self-control, self-efficacy, conscientiousness, which, according to our findings and the findings of other authors are key traits in entrepreneurship. The formulation of statements in the questionnaire could also be problematic - the form of "I" statements. This may encourage respondents to answer in the agreeing half of the scale (strongly agree). The questionnaire was created in the English version because the EntreComp documents are also in English. Therefore, variation may have arisen during its translation, although experts in the field of translation took part in it. Formulation of the statements in the questionnaire at the most basic level is limitation, but also a stimulus for future research. Strauti et al. (2018) consider the intermediate to advanced level to be suitable level for university students when it comes to engineering area. However, students in other fields also dispose of a certain level of entrepreneurship competences higher than our expected foundation level.

Conclusion

The benefit of the present study is the development of a reliable and valid tool for capturing perceived entrepreneurship competence convenient for self-assessment of students or graduates regardless of their specialization. Thanks to it, the structure of partial competences might be captured. Respectively, it is possible to reveal the perceived strengths and weaknesses of the participants and

compile learning activities accordingly. Because it is not a performance test, but a self-assessment questionnaire, rare information about the self-image of an individual in the field of their entrepreneurship competences is obtained. While other existing tools focus on the skill and ability demonstrations, business context, and entrepreneurial personality, the questionnaire developed on the basis of the EntreComp framework offers the coverage of entrepreneurial competence on cognitive, personal, and behavioural levels in different settings. Another advantage is that questionnaire items are based on the already existing theoretical concept and the resulting educational goals.

The application of the questionnaire is seen in the same way as the authors of the EntreComp framework suggest – in the field of formal and informal education. It could be a primary step in identifying the educational needs of specific groups, thus helping to create specific learning programs and activities to increase the competitiveness and innovation potential of the country. The comparison of perceived own entrepreneurship competence and objective entrepreneurial performance would be interesting as well. In the future, creation and adaptation of other language variations of the EntreComp questionnaire for using in different cultures is recommended. In this way, data from different countries of the European Union might be collected and compared, and entrepreneurship intervention programs adapted accordingly. Different age or social groups as a sample are suggested.

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✉ **Correspondence**
Marianna Siničáková

Technical University of Košice, Faculty of Economics
Němcovej 32, 042 00 Košice, Slovakia

E-mail: marianna.sinicakova@tuke.sk

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Blockchain implementation in smart cities – discussion on performance indicators

Stojan Ivanišević
JKP Informatika, Novi Sad, Serbia
https://orcid.org/0000-0003-4926-8131
Aleksandar Ivić
JKP Informatika, Novi Sad, Serbia
https://orcid.org/0000-0001-7557-1543
Zoran Ćirić
University of Novi Sad, Faculty of Economics in Subotica, Subotica, Serbia
https://orcid.org/0000-0002-8893-5788

Abstract
Background: Blockchain project implementation in smart cities represents a novel challenge in information technologies. Lack of functional framework and guidelines impact these implementations and add additional uncertainty. Authors in their research on this subject seek to discover a functional framework to improve the implementation process. The research is divided into 3 parts: identification of best application areas, critical success factors, and implementation performance indicators.
Purpose: The goal of this paper is to present findings on the performance indicators and offer additional insight into their nature as well as point to lesser-known performance indicators of blockchain projects.
Study design/methodology/approach: Authors used the Delphi technique and according to the methodology, a panel of 33 experts was presented with a list of performance indicators and asked to add additional performance indicators as well as to assess their importance. The research foundation was based on the literature review which resulted in 9 performance indicators for the blockchain project implementation in smart cities.
Findings/conclusions: The experts proposed 8 additional performance indicators; however, only 1 of them had required consensus to be accepted by the panel. This paper will disclose both groups of performance indicators and preserve them for further scientific discussion since the performance indicators that were proposed by the individual experts but did not reach panel consensus will not be contained in the further research results. After all rounds of the Delphi method were finished the experts concluded the list of the 5 most important performance indicators for the implementation of blockchain projects in the smart city.
Limitations/future research: Due to limited resources and lack of experts, the size of the panel is limited to only 33 experts. In addition, smart cities are usually managed by the public sector, so access to all data is limited. The findings presented in the paper can be further used to improve the efficiency of blockchain projects.

Keywords
Blockchain, smart city, performance indicators, e-government, digitalization, open data, Delphi method.

Introduction

The main topic of this article is performance indicators of blockchain project implementation in smart cities. Expertise on this topic is in high demand; however, there are very few available texts and studies on this topic in both scientific literature and other sources. The claims in the scientific literature are mostly based on literature reviews and individual case studies. To the author's

best knowledge, although available papers are peer-reviewed and produced through the valid application of the scientific method, few of them are based on the systematic study of multiple cases to use induction to gain additional insights. Most of the scientific studies on this topic deal with a single-use case, which can prove to be a limiting factor to case conclusions. The hype caused by the rise of cryptocurrencies propelled blockchain to become an overnight buzzword and a technology that gains users faster than the internet at the beginning of the 21st century. The hype was caused by the sharp cryptocurrency price rise and the acceptance of Ethereum cryptocurrency, its underlying technology, and the ecosystem from the major industry players (Enterprise Ethereum Alliance). Suddenly during the blockchain explosion in the year 2017th to exploit this trend, everything became "blockchain", not through the real well-designed application of blockchain technologies, but through the simple marketing trick of creating "blockchain this and that" or even simple adding blockchain to the name without real application of the blockchain technologies. Some of these projects were scams or simply unsuccessful. The downside of this trend created the wrong image of blockchain in both financial, political, and individual views. Blockchain wrongly become a synonym for cryptocurrencies (primarily bitcoin) and similar financial applications of distributed consensus peer-to-peer networks. This strengthened the claims in the general and scientific community that blockchain (bitcoin in particular) is "a new technology that can be used by criminals for money laundering" (Möser, 2013). The novelty of the technology and uncertainty created a veil that for almost 10 years prevented government and large business stakeholders from adequately precipitating the true potential of these technologies and their possible positive impact on information systems and challenges these technologies can solve. From the creation of Bitcoin in 2008 (Nakamoto, 2008) until the creation of EEA (Enterprise Ethereum Alliance) in 2017, blockchain technologies were mostly used and perceived through their financial aspects. After the creation of EEA, blockchain finally became the focus of the scientific community; however, this area of study was much undeveloped - only a few scientific studies on blockchain use in information systems existed before the year 2017. The authors also want to point out that the public incorrectly interpreted blockchain as a technology that can only be applied in the fintech sector (cryptocurrencies and banks) without realizing the other possible applications in the real and government sector. In the author's opinion, the high demand resulted in numerous scientific studies that emerged after 2017, however, articles substantiated by real-life data and use cases are still rare. The scientific community wanted to research a "novel topic" but real data was hard to find. Distributed nature of blockchain systems also makes experimental research simulating real-life use difficult because it is hard to simulate hardware and electricity extensively distributed peer-to-peer networks in laboratory conditions. Lack of tools, expertise, and knowledge limited the available possibility for research. Also, not many projects were implemented; therefore real data and knowledge were scarce. Time passed and implemented pioneer use cases of blockchain technology showed the added value and real benefits of their application in government and smart city environments (Xie, 2019), (Bhushan, 2020), (Khanna, 2021). These pioneer implementations offered a good starting point for further study. The goal of this paper is to show all steps and gained information from the author's study of blockchain technologies implementation in smart cities. Our research on the topic of blockchain implementation in smart cities is still ongoing and it is divided into 3 separate parts: identification of best application areas, critical success factors, and implementation performance indicators. This paper will only deal with a discussion on performance indicators of blockchain implementation projects in smart cities. This research uses the Delphi method.

Research topic and context - Application of blockchain technologies in the smart city

When the advantages of blockchain technologies are compared to the significant issues and flaws of smart city information systems, it is possible to conclude that blockchain systems are the best option for smart city information systems (Idelberger, 2016). This, however, may not be accurate and relevant in all cases, much less universally.

When traditional information systems are exposed to the public and used by tens of thousands of people in a city, they demand a higher level of security and service availability (Maglio, 2009), (Sun, 2016). Blockchain technologies, on the other hand, provide an entirely new mix of technologies to address security and reliability challenges, as

well as service availability and fault tolerance (Cai, 2016), (Garay, 2015).

Lombardi (Lombardi, 2012) made a list of smart city components:

1. Smart economy – viewed as the industry or as an aspect of urban life;
2. Smart citizens – knowledge and human capital;
3. Smart governance – e-Government and open data;
4. Smart mobility – logistics and infrastructures;
5. Smart environment – sustainability;
6. Smart living – liveability, quality of life, and security.

A literature review paper (Ćirić, Blockchain Technology Application Areas in the Smart City Information Systems, 2019) maps potential blockchain uses within components of the smart city from (Lombardi, 2012) list. Blockchain-based systems provide strong security combined with total anonymity (Zyskind, 2015), (Xu, 2016); their distributed nature also increases availability; and finally, their nature is interoperable, improving privacy, security, availability, and heterogeneous architectures. "Blockchain as an emerging technology has many good features, such as trust-free, transparency, pseudonymity, democracy, automation, decentralization, and security. These features of blockchain are helpful to improve smart city services and promote the development of smart cities" (Xie, 2019).

Because of these advantages of blockchain technology, there are more possible uses and, as a result, real-world implementations, scholarly discussions, and studies in the areas of the smart economy (Beck et al., 2016), smart transportation (Podovac, 2021), smart tourism (Tomić, 2020), and supply chain management, as well as e-Government (Böhme, 2015), (Khanna, 2021). The main contribution of blockchain to the smart environment is perceived as an impact on the sustainability of software applications within smart cities, supply chain optimization, and new business models in energy systems (Swan, 2015), (Tapscott, 2016), (Zhao, 2016).

There are clear signs that blockchain technology enhances existing systems based on automatic data processing while assuring enhanced security, transparency, and simpler participation of many actors (individuals or companies alike) (Ćirić, Identification of critical success factors for the implementation of the blockchain projects in the smart cities, 2019). Although the term "Information Systems in Smart Cities" is a broad term, this study focuses on software solutions in smart cities that are related to e-government and blockchain technology's areas of application: transactions, payment and exchange infrastructure, smart contracts, identification, confidential data, data storage, voting, and fundraising (Ćirić, Implementation of Blockchain Technology in the Smart City, 2020).

As revealed in the literature review (Ćirić, Implementation of Blockchain Technology in the Smart City, 2020), papers addressing the application areas of blockchain to promote the sustainability of smart cities exist, but they do not contain a comprehensive framework for the implementation of blockchain technologies in the smart city. The existing published research, on the other hand, examines these applications through the fragmented lens of smaller application areas rather than smart city components (Wang, 2016), (Bhushan et al., 2020). This may be the reason why the authors were unable to locate any functioning framework for the implementation of information systems projects (IS) based on these technologies.

According to the authors of this paper, it is vital to identify the areas where this technology may be used in smart cities and to continue to investigate new applications to define success factors and outcome indicators for the implementation of IS projects based on blockchain technology. Applications of blockchain technology in smart cities should be classified into real-life use cases found within the existing smart cities and those found within the scientific literature to undertake more research on this issue. Further research into effectively implemented blockchain information systems is needed to discover smart city components and specific subsystems where blockchain technologies outperformed conventional information systems in terms of performance and availability.

A synthesis is sought through a brief discussion of the most common challenges and limitations of conventional information systems within a smart city and a brief review of the strong features of blockchain technology.

Studies of blockchain technology exist in each given smart city challenge, along with publications on distributed applications (for instance, multi-level authorization (Cordeschi, 2015), and energy-efficient resource planning in distributed applications (Yli-Huumo, 2016), (Efanov, 2018). A thorough evaluation and acceptance of practical solutions will hasten the resolution of blockchain technology's current issues and limits (Burgess, 2015), (Yang, 2018)

To attain a greater level of sustainability in smart cities, subsystems whose business could be improved utilizing blockchain technology must be identified. Evaluating the challenges and past results of blockchain technology usage will identify the smart cities sub-systems that gain the most from the deployment of this sort of project with the highest project performance.

The information gathered through this scientific method would then be used to identify important success factors and indicators for this type of project execution. **(**Đurkin**,** 2018**)**.

A functional framework for the implementation of information systems projects based on blockchain technologies in smart cities can be built based on the identification of the field of effective application of information systems in smart cities, crucial success factors, and outcome indicators (performance indicators). The research and its results presented in this paper are part of the research on performance indicators as a subcomponent of broader research on the creation of a framework for the implementation of the smart city.

Discussion on the performance indicators

As stated in the introduction the research on performance indicators is a part of research on the implementation of blockchain technologies in smart cities.

During the research preparation, the authors conducted a literature review to detect potential performance indicators and use them as starting point for an Expert panel discussion on performance indicators (Keil, 2013). The following list of performance indicators was created based on the author's research in the scientific literature:

1. public interest in the project,
2. governance and leadership support,
3. budget use,
4. time management (time use),
5. project delivery according to the delivery plan,
6. level of system complexity,
7. number of working nodes in the blockchain,
8. degree in technology innovation,
9. end-user satisfaction.

After the questionnaire was checked, in terms of spotting some irregularities, such as the filling out of the questionnaire, the classification of new factors for successful implementation of blockchain technologies was performed, as well as the unification of terminology for the proposed factors, after which the consolidated list of factors was sent to the panelists. Therefore, in the next phase, participants were sent a list of consolidated factors, collected in the first phase of the questionnaire, and grouped into categories and copies of their first-phase responses, where they were asked to confirm that the answers were interpreted correctly and placed in the appropriate categories.

Following Schmidt's (Schmidt, 1997) procedure of ranking type Delphi research, which involves, first, proposing and validating the proposed factors, then narrowing the list to the most important factors and, ultimately, ranking the list of the most important factors, questionnaires were distributed online, through the Google Forms platform. According to this procedure, panelists were asked to rank the proposed application fields, critical performance factors, and performance indicators of blockchain technology implementation based on the five-point Likert scale (Likert, 1932). Before filling out the questionnaire with the participants, all language terminological disagreements that could be subjectively found in questionnaires were clarified. So before filling out the questionnaire, each participant understood very clearly and unequivocally every position they were to evaluate.

The expert panel discussed these proposed performance indicators and several experts proposed additional performance indicators that in their opinion should be taken into the consideration. The following list of additional performance indicators proposed by the experts participating in the research:

1. user base growth over time,
2. environmental sustainability,
3. risk density,
4. policy revision based on the implementation of new data,
5. ease of access,
6. data integrity,
7. resiliency,
8. the number of transactions executed.

Out of all newly proposed performance indicators on the performance indicator “User base growth over/in time” was accepted as a performance indicator and it was analyzed and used in further research.

The authors of this paper would also like to state a different viewpoint on this subject. This can be done by asking the research question such as "Do blockchain projects have different project performance indicators in comparison to non-blockchain IT projects?" or "What are performance indicators specific to blockchain projects?" If the presented lists are assessed from this point of view, only indicator no. 7 from the first list and indicator no. 8 from the second list can be exclusively tied to blockchain technology use. All the other performance indicators can be applied to assess any other IT project. The strength and validity of these performance indicators can vary depending on the IT project type; however, they can all be used to assess any IT project's performance.

Delphi method

The Delphi study does not depend on a representative statistical sample, but rather on a group decision-making mechanism, which requires qualified experts who understand the problem that is being investigated (Paré, 2013). The researchers designed two questionnaires: the initial one and a second questionnaire, asking respondents to revise their original answers and/or answer other questions based on the feedback from the group in the first study. The researchers repeat this process until respondents reach a satisfactory degree of consensus. During the whole process, respondents are anonymous to each other (though not to the researcher) (Okoli, 2004).

For research purposes, experts are divided into panels. A total number of 33 experts participated in the research.

The experts were divided into two groups:

1. Academics (scientists) dealing with blockchain technologies
2. Experts – practitioners dealing with blockchain technologies

All the experts had years of experience in the field of ICT and immediate knowledge of blockchain solution implementation projects in smart cities or other ICT projects in smart cities that may be relevant.

Experts

The sample included 33 experts in project management, IT, system development, smart cities, blockchain, or any other relevant areas. Most respondents had work experience, in the relevant areas, from 11 to 20 years (39.39%), slightly fewer respondents had 21-30 years of experience (33.33%), and 24.24% of respondents had up to 10 years of work experience, while the least respondents (3.03%) had experience for more than 31 years (Figure 1).

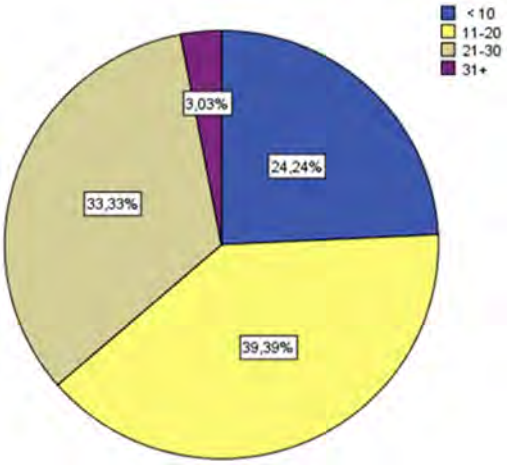

Figure 1 Expert's work experience in relevant areas: project management, IT, system development, smart cities, blockchain, or any other (in years).
Source: the authors.

Most respondents participated in blockchain projects up to 5 times (72.73%), 15.15% of respondents participated in 6-10, while 12.12% of respondents participated in more than 11 blockchain projects (Figure 2).

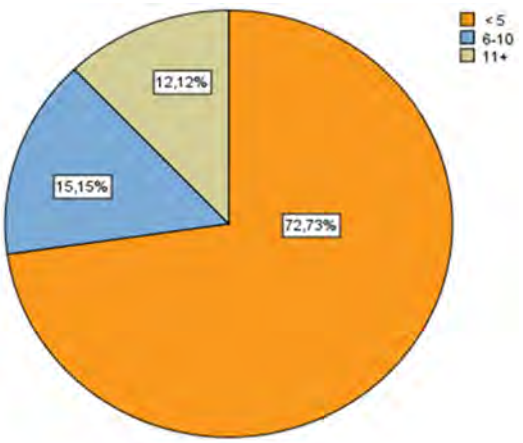

Figure 2 Number of blockchain projects participated by expert
Source: the authors

Based on the survey results, most respondents participated in smart city projects, which included new IT solutions up to five times (84.85%). Significantly fewer respondents (9.09%) participated in 6-10, while the least respondents (6.06%) participated in more than 11 projects

(Figure 3). Also, according to the survey results, one respondent has so far not participated in the design and implementation projects of information systems based on blockchain in smart cities, one respondent on two and one respondent participated in 10, while the other respondents had one participation in the projects.

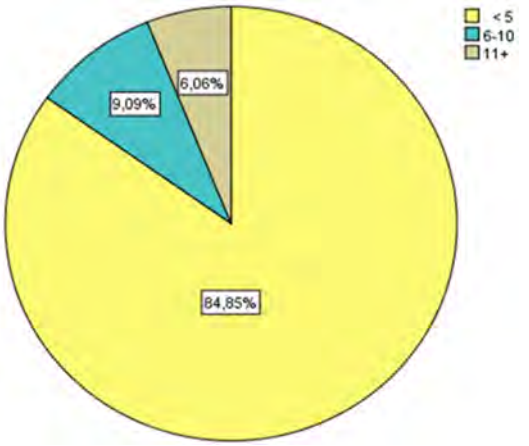

Figure 3 Number of blockchain projects in a smart city which included new IT solutions that expert participated in
Source: the authors

Findings

After all rounds of the Delphi method were finished the experts concluded the list of the performance indicators for the implementation of blockchain projects in the smart city.

As the most important specific activities and performance indicators of blockchain technologies, panelists evaluated the following:

1. end-user satisfaction,
2. user base growth over time,
3. use of the budget,
4. time management.

Discussion

According to the author's best knowledge, there is no similar attempt to use the Delphi method to assess these research areas. This study and the discussion on performance indicators as an attempt to provide scientific knowledge that can aid the implementation of blockchain projects in general and in the smart cities as an area of application that directly benefits all of us. As shown in the "Discussion on the performance indicators" chapter experts that participated in the panel proposed 8 additional performance indicators on top of the 9 performance indicators list created by the authors. However, during the process of reaching consensus according to the Delphi methodology, only one of 8 additional performance indicators had consensus to reach 2nd round of research and have its importance measured. These lists as well as research results are open for further discussion and the authors hope that they contributed to the knowledge on his subject. Since 7 of the performance indicators proposed by the individual experts did not reach a consensus needed to be discussed in the experts' panel, they won't be a subject of further study. It is also important to point out that the only performance indicator that was proposed and accepted by the panel – "User base growth over time" got ranked as 2nd most important performance indicator for blockchain project implementation in smart cities. The user base or the number of participants in the network can be used to estimate the value of the network according to Metcalfe's Law but the authors were unable to find any mention of "user base growth over time" as a blockchain project implementation performance indicator in the scientific literature. According to the authors' best knowledge, there is no other ranking of these performance indicators in the scientific literature. Further study should lead to additional data and interconnections between all 3 parts of the research: areas of application, critical success factors, and performance indicators. The authors desire to create a comprehensive scientific study that can offer help to everyone trying to implement blockchain solutions in the smart city.

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✉ **Correspondence**

Stojan Ivanišević

JKP Informatika
Bulevar kralja Petra I 13, 21000, Novi Sad, Serbia

E-mail: ivanisevic.stojan@nsinfo.co.rs

Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where is current research on blockchain technology? - *A systematic review. PLOS ONE, 11*(10), e0163477. https://doi.org/10.1371/journal.pone.0163477

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The paper must be written in the template which can be found on the Submission of Papers page of the Strategic Management journal web site (https://www.smjournal.rs/index.php/home/about/submissions) and to be sent, together with the Copyright and Use Agreement.

Headings must be short, clearly defined and numbered, except for Introduction and Conclusions. Apply at most three levels of headings.

All tables, graphs and diagrams are expected to back your research findings. They should be clearly referred to and numbered consecutively in Arabic numerals. They should be placed in the text at the appropriate paragraph (just after its reference).

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Mathematical expressions should be numbered on the right side, while all variables and parameters must be defined.

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Ljubojević, T.K. (1998). Ljubojević, T.K. (2000a). Ljubojević, T.K. (2000b). Ljubojević, T.K., & Dimitrijević, N.N. (1994).

The DOI number or URL of a full text version should be added if it exists.
Here is a list of the most common reference types:

A. PERIODICALS

Authors must be listed by their last names, followed by initials. Publication year must be written in parentheses, followed by a full stop. Title of the article must be in sentences case: only the first word and proper nouns in the title are capitalized. The periodical title must be in title case, followed by the volume number, which is also italicized:

Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. *Title of Periodical, volume number* (issue number), pages.

➲ Journal article, one author, paginated by issue

Journals paginated by issue begin with page 1 in every issue, so that the issue number is indicated in parentheses after the
volume. The parentheses and issue numbers are not italicized, e.g.

Seliverstova, Y. (2021). Workforce diversity management: A systematic literature review. *Strategic Management*, *26*(2), 3–11.
https://doi.org/10.5937/StraMan2102003S

➲ Journal article, one author, paginated by volume

Journals paginated by volume begin with page 1 in issue 1, and continue page numbering in issue 2 where issue 1 ended, e.g.

Perić, O. (2006). Bridging the gap: Complex adaptive knowledge management. *Strategic Management, 14*, 654–668.

➲ **Journal article, two authors, paginated by issue**

Dakić, S., & Mijić, K. (2020). Regression analysis of the impact of internal factors on return on assets: A case of meat processing enterprises in Serbia. *Strategic Management*, *25*(1), 29–34. https://doi.org/10.5937/StraMan2001029D

➲ **Journal article, two authors, paginated by volume**

Ljubojević, K., & Dimitrijević, M. (2007). Choosing your CRM strategy. *Strategic Management, 15*, 333-349.

➲ **Journal article, three to six authors, paginated by issue**

Marić, S., Uzelac, O., & Strugar-Jelača, M. (2019). Ownership structure as a measure of corporate performance. *Strategic Management*, *24*(4), 28–37. https://doi.org/10.5937/StraMan1904028M

➲ **Journal article, three to six authors, paginated by volume**

Boškov, T., Ljubojević, K., & Tanasijević, V. (2005). A new approach to CRM. *Strategic Management, 13*, 300-310.

➲ **Journal article, more than six authors, paginated by issue**

Ljubojević, K., Dimitrijević, M., Mirković, D., Tanasijević, V., Perić, O., Jovanov, N., et al. (2005). Putting the user at the center of software testing activity. *Management Information Systems, 3*(1), 99-106.

➲ **Journal article, more than six authors, paginated by volume**

Strakić, F., Mirković, D., Boškov, T., Ljubojević, K., Tanasijević, V., Dimitrijević, M., et al. (2003). Metadata in data
warehouse. *Strategic Management, 11*, 122-132.

➲ **Magazine article**

Strakić, F. (2005, October 15). Remembering users with cookies. *IT Review*, *130*, 20-21.

➲ **Newsletter article with author**

Dimitrijević, M. (2009, September). MySql server, writing library files. *Computing News, 57,* 10-12.

➲ **Newsletter article without author**

VBScript with active server pages. (2009, September). *Computing News,57,* 21-22.

B. BOOKS, BROCHURES, BOOK CHAPTERS, ENCYCLOPEDIA ENTRIES, AND BOOK REVIEWS

Basic format for books

Author, A. A. (Year of publication). *Title of work: Capital letter also for subtitle*. Location: Publisher.

Note: "Location" always refers to the town/city, but you should also include the state/country if the town/city could be mistaken for one in another country.

➲ **Book, one author**

Ljubojević, K. (2005). *Prototyping the interface design*. Subotica: Faculty of Economics in Subotica.

➲ **Book, one author, new edition**

Dimitrijević, M. (2007). *Customer relationship management* (6th ed.). Subotica: Faculty of Economics in Subotica.

➲ **Book, two authors**

Ljubojević, K., Dimitrijević, M. (2007). *The enterprise knowledge portal and its architecture*. Subotica: Faculty of Economics in Subotica.

➲ **Book, three to six authors**

Ljubojević, K., Dimitrijević, M., Mirković, D., Tanasijević, V., & Perić, O. (2006). *Importance of software testing*. Subotica:
Faculty of Economics in Subotica.

➲ **Book, more than six authors**

Mirković, D., Tanasijević, V., Perić, O., Jovanov, N., Boškov, T., Strakić, F., et al. (2007). *Supply chain management*.
Subotica: Faculty of Economics in Subotica.

➲ **Book, no author or editor**

Web user interface (10th ed.). (2003). Subotica: Faculty of Economics.

➲ **Group, corporate, or government author**

Statistical office of the Republic of Serbia. (1978). *Statistical abstract of the Republic of Serbia.*
Belgrade: Ministry of community and social services.

➲ **Edited book**

Dimitrijević, M., & Tanasijević, V. (Eds.). (2004). *Data warehouse architecture*. Subotica: Faculty of Economics.

➲ **Chapter in an edited book**

Boškov, T., & Strakić. F. (2008). Bridging the gap: Complex adaptive knowledge management. In T. Boškov, & V.
Tanasijević (Eds.), *The enterprise knowledge portal and its architecture* (pp. 55-89). Subotica: Faculty of Economics in Subotica.

➲ **Encyclopedia entry**

Mirković, D. (2006). History and the world of mathematicians. In *The new mathematics encyclopedia* (Vol. 56, pp. 23-45).
Subotica: Faculty of Economics.

C. UNPUBLISHED WORKS

➲ **Paper presented at a meeting or a conference**

Ljubojević, K., Tanasijević, V., Dimitrijević, M. (2003). *Designing a web form without tables*. Paper presented at the annual meeting of the Serbian computer alliance, Beograd.

➲ **Paper or manuscript**

Boškov, T., Strakić, F., Ljubojević, K., Dimitrijević, M., & Perić, O. (2007. May). *First steps in visual basic for applications*.
Unpublished paper, Faculty of Economics Subotica, Subotica.

➲ **Doctoral dissertation**

Strakić, F. (2000). *Managing network services: Managing DNS servers*. Unpublished doctoral dissertation, Faculty of
Economics Subotica, Subotica.

➲ **Master's thesis**

Dimitrijević, M. (2003). *Structural modeling: Class and object diagrams*. Unpublished master's thesis, Faculty of Economics
Subotica, Subotica.

D. ELECTRONIC MEDIA

The same guidelines apply for online articles as for printed articles. All the information that the online host makes available must be listed, including an issue number in parentheses:

Author, A. A., & Author, B. B. (Publication date). Title of article. *Title of Online Periodical, volume number* (issue number if
available). Retrieved from http://www.anyaddress.com/full/url/

➲ **Article in an internet-only journal**

Tanasijević, V. (2003, March). Putting the user at the center of software testing activity. *Strategic Management*, *8* (4).
Retrieved October 7, 2004, from http://www.ef.uns.ac.rs/sm2003

➲ **Document from an organization**

Faculty of Economics. (2008, March 5). *A new approach to CRM*. Retrieved July 25, 2008, from http://www.ef.uns.ac.rs/papers/acrm.html

➲ **Article from an online periodical with DOI assigned**

Jovanov, N., & Boškov, T. A PHP project test-driven end to end. *Management Information Systems*, 2 (2), 45-54.
https://doi.org/10.5937/StraMan213302003S

➲ **Article from an online periodical without DOI assigned**

Online journal articles without a DOI require a URL.

Author, A. A., & Author, B. B. (Publication date). Title of article. *Title of Journal, volume number*. Retrieved from http://www.anyaddress.com/full/url/

Jovanov, N., & Boškov, T. A PHP project test-driven end to end. *Management Information Systems*, 2 (2), 45-54. Retrieved from http://www.ef.uns.ac.rs/mis/TestDriven.html.

REFERENCE QUOTATIONS IN THE TEXT

➲ **Quotations**

If a work is directly quoted from, then the author, year of publication and the page reference (preceded by "p.") must be included. The quotation is introduced with an introductory phrase including the author's last name followed by publication date in parentheses.

According to Mirković (2001, p. 201), "The use of data warehouses may be limited, especially if they contain confidential data".

Mirković (2001, p. 201), found that "the use of data warehouses may be limited". What unexpected impact does this have on the range of availability?

If the author is not named in the introductory phrase, the author's last name, publication year, and the page number in
parentheses must be placed at the end of the quotation, e.g.

He stated, "The use of data warehouses may be limited," but he did not fully explain the possible impact (Mirković, 2001, p. 201).

➲ **Summary or paraphrase**

According to Mirković (1991, p. 201), limitations on the use of databases can be external and software-based, or temporary and even discretion-based.

Limitations on the use of databases can be external and software-based, or temporary and even discretion-based
(Mirković, 1991, p. 201).

➲ **One author**

Boškov (2005) compared the access range…

In an early study of access range (Boškov, 2005), it was found...

➲ When there are **two authors**, both names are always cited:

Another study (Mirković & Boškov, 2006) concluded that…

➲ If there are **three to five authors**, all authors must be cited the first time. For subsequent references, the first author's
name will be cited, followed by "et al.".

(Jovanov, Boškov, Perić, Boškov, & Strakić, 2004).

In subsequent citations, only the first author's name is used, followed by "et al." in the introductory phrase or in parentheses: According to Jovanov et al. (2004), further occurences of the phenomenon tend to receive a much wider media coverage.

Further occurences of the phenomenon tend to receive a much wider media coverage (Jovanov et al., 2004). In "et al.", "et" is not followed by a full stop.

➲ **Six or more authors**

The first author's last name followed by "et al." is used in the introductory phrase or in parentheses:

Yossarian et al. (2004) argued that…

… not relevant (Yossarian et al., 2001).

➲ **Unknown author**

If the work does not have an author, the source is cited by its title in the introductory phrase, or the first 1-2 words are placed in the parentheses. Book and report titles must be italicized or underlined, while titles of articles and chapters are placed in quotation marks:

A similar survey was conducted on a number of organizations employing database managers (Limiting database
access, 2005).

If work (such as a newspaper editorial) has no author, the first few words of the title are cited, followed by the year: (The Objectives of Access Delegation, 2007)

Note: In the rare cases when the word "Anonymous" is used for the author, it is treated as the author's name (Anonymous,
2008). The name Anonymous must then be used as the author in the reference list.

➲ **Organization as an Author**

If the author is an organization or a government agency, the organization must be mentioned in the introductory phrase or in the parenthetical citation the first time the source is cited:

> According to the Statistical Office of the Republic of Serbia (1978), …

Also, the full name of corporate authors must be listed in the first reference, with an abbreviation in brackets. The abbreviated name will then be used for subsequent references:

> The overview is limited to towns with 10,000 inhabitants and up (Statistical Office of the Republic of Serbia [SORS],
> 1978).
>
> The list does not include schools that were listed as closed down in the previous statistical overview (SORS, 1978).

➲ When citing **more than one reference from the same author**: (Bezjak, 1999, 2002)
➲ When several **used works by the same author were published in the same year**, they must be cited adding a, b, c, and so on, to the publication date:

> (Griffith, 2002a, 2002b, 2004)

➲ **Two or more works in the same parentheses**

When two or more works are cited parenthetically, they must be cited in the same order as they appear in the reference list, separated by a semicolon.

> (Bezjak, 1999; Griffith, 2004)

➲ **Two or more works by the same author in the same year**

If two or more sources used in the submission were published by the same author in the same year, the entries in the reference list must be ordered using lower-case letters (a, b, c…) with the year. Lower-case letters will also be used with the year in the in-text citation as well:

> Survey results published in Theissen (2004a) show that…

➲ To **credit an author for discovering a work**, when you have not read the original:

> Bergson's research (as cited in Mirković & Boškov, 2006)…

Here, Mirković & Boškov (2006) will appear in the reference list, while Bergson will not.

➲ When **citing more than one author**, the authors must be listed alphabetically:

> (Britten, 2001; Sturlasson, 2002; Wasserwandt, 1997)

➲ When there is **no publication date**: (Hessenberg, n.d.)

➲ **Page numbers must always be given for quotations**:

(Mirković & Boškov, 2006, p.12)

Mirković & Boškov (2006, p. 12) propose the approach by which "the initial viewpoint…

➲ **Referring to a specific part of a work**:

(Theissen, 2004a, chap. 3) (Keaton, 1997, pp. 85-94)

➲ **Personal communications, including interviews, letters, memos, e-mails, and telephone conversations**, are cited as below. (These are *not* included in the reference list.)

(K. Ljubojević, personal communication, May 5, 2008).

FOOTNOTES AND ENDNOTES

A few footnotes may be necessary when elaborating on an issue raised in the text, adding something that is in indirect connection, or providing supplementary technical information. Footnotes and endnotes are numbered with superscript Arabic numerals at the end of the sentence, like this.[1] Endnotes begin on a separate page, after the end of the text. However, *Strategic Management* Programming Board **does not recommend the use of footnotes or endnotes.**

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