Article

Taxonomic analysis of the level of private equity/ venture capital market development in Europe

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Abstract: Determining the level of PE/VC market development and the way it operates is extremely difficult. Despite countless reports and analyses concerning the PE/VC market, there is a lack of study on that sector based on a synthetic index. The usage of taxonomic methods in the PE/VC market analysis may be extremely useful in its proper characterizing. An in-depth study allows the identification of weaknesses and strengths as well as opportunities and threats related to a specific stage of PE/VC market development in a given country, that gives the opportunity to determine public activities that could affect the acceleration of this market development in future. The main objective of the study was to conduct a taxonomic analysis of the level of PE/VC market development in Europe, in 2010-2015. It is worth mentioning that the term "level of development" does not refer only to the value of investment or its dynamics, but to a set of objectified features that create one synthetic indicator. The conducted analysis using the Hellwig method allowed to determine the ranking of European countries in terms of the level of PE/VC market development, which reveal some significant differences in the functioning of the this market within Europe. Further detailed analysis of the designated groups of countries made it possible to determine the characteristics of such clusters. The construction of the level of private equity/venture capital market development ranking over the years enabled defining the current status and indicating the direction of possible changes.

Keywords: Hellwig method, taxonomy, venture capital.

JEL Classification: G1, O16, O52

1. Introduction

Nowadays, PE/VC market is seen as the factor stabilizing the financial and capital market, especially during the economic crisis. European Union institutions as well appreciate the role of these investments, especially VC, which is proved by the multiple use of PE/VC entities as the intermediary of capital in the EU financing programs implemented. The analysis of the current state and level of development of this market and its reaction to market turbulences in recent years, in relation to the situation of other European countries, is therefore important for understanding the mechanisms of its existence, in order to identify areas of actions accelerating its development.

Despite considerable interest in the subject of venture capital, there is lack in the literature of the analysis of the level of PE/VC market development based on a synthetic index. Countless reports and analyses concerning the PE/VC market were created, containing a lot of information presented from different perspectives, however, they do not give the possibility to make comparisons on a global basis. The construction of the level of private equity/venture capital market development ranking over the years, such as for example - already existing over 10 years - Innovation Index (European Innovation Scoreboard), would enable defining the current status, indicating the direction of possible changes and verifying the validity of the implemented strategies.

44   The main objective of the study was to conduct a taxonomic analysis of the level of PE/VC market
45   development in Europe, in 2010-2015, when the comparable data were available. The analysis allowed
46   to determine the ranking of European countries from the perspective of PE/VC market. It is worth
47   mentioning that the term "level of development" does not refer only to the value of investment or its
48   dynamics, but to a set of objectified features that create one indicator of the level of PE/VC market
49   development. Thanks to the study and the analysis of other countries experience, weaknesses and
50   strengths, as well as, opportunities and threats arising from a particular stage of PE/VC market
51   development of the can be identified. It gives the opportunity to plan certain activities that could affect
52   the acceleration of the development of this sector, and indirectly the economy of a particular country.
53   In the study there were used data collected and processed by research agencies and public
54   institutions such as Invest Europe (previously EVCA), Eurostat, State Statistics Service of Ukraine (due
55   to the limited data in Eurostat for Ukraine, information were obtained directly from the Department of
56   International Cooperation and Integration European Statistical Office of Ukraine and data published
57   by this Office).

58   **2. Methodology**

59   The PE/VC market is a complex object, thus the level of its development is determined by many
60   characteristics. Such as in the case of technical progress assessment, social and economic development
61   valuation, living conditions or technical infrastructure evaluation, the assessment of the level of
62   PE/VC market development in particular countries generates a significant problem. The level of
63   market similarity in two countries measured by one indicator may be high, however, due to another
64   feature, can be low. Therefore, it is worth using the methods of taxonomic comparative analysis.
65   A taxonomic analysis is a scientific discipline that allows the study of complex objects, which
66   variation is simultaneously influenced by many factors. Professor Zdzislaw Hellwig defined it as
67   "methods and techniques for comparing multi-feature objects"   (Hellwig   1981).   Taxonomic
68   analysis covers research activities such as assessing the similarity of individual units, their sequence
69   and classification (Nowak 1997). These methods are used in economic studies to determine the order
70   of objects difficult to be classified on the basis of only one feature, such as the classification of
71   countries due to the level of economic development of enterprises or due to their financial condition
72   (Bąk 2016). They can be determined only by measuring the values of aggregate variables comprising
73   of individual observations (Bąk 2013).
74   In the literature there are presented many classifications of a multi-parameter methods. They
75   differ by procedure, area of application, level of calculation effort, formalization degree or duration.
76   Such a large diversity of taxonomic methods results from the complexity of the multi-feature
77   classification as well as from the fact there are many ways to create groups of units with similar
78   characteristics. In this regard, the choice of appropriate classification method is not simple. Professor
79   Z. Hellweg (Hellwig 1968) was the first who founded a synthetic development measure method.
80   Hellwig's method synthesizes information from series of diagnostic measures and assigns to the
81   analyzed phenomenon one aggregate feature (Krakowiak-Bal 2005) presented by one numerical
82   value, which facilitates all comparisons between European countries. It is a method that was used to
83   analyze the level of PE/VC market development in European countries.

84   *2.2. Hellwig method scheme*

85   The Hellwig method is a linear ordering method, which is based on projecting on a straight line
86   individual points located in a multidimensional space. The analyzed objects are put in order based
87   on the development index formula, which is a synthetic measure, combining information from a
88   series of variables into one aggregate indicator (Grabiński 1992).
89   To analyse the level of PE/VC market development in European countries using the taxonomic
90   cluster analysis, it is necessary to identify the factors describing the development of this market. It
91   allows to establish the hierarchy of objects by ordering them from the highest to the lowest and thus
92   distinguish groups of objects similar to each other by achieving factors that are considered to be

93   important for determining the level of PE/VC market development (when these objects are described
94   for more than one feature).
95   The construction of the Hellwig's taxonomic measure (Hellwig 1968) begins with determining
96   the set of diagnostic variables marked with the appropriate symbol X (X1, X2,…, Xk) and the fulfilled
97   information matrix of particular objects. The matrix is saved as (1):

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \cdots \\ X_m \end{bmatrix} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1k} \\ x_{21} & x_{22} & \cdots & x_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mk} \end{bmatrix} \tag{1}$$

99   Where:
100   x_{ij}– value of the j diagnostic variable for the i object;
101   $i = (1,2…,m)$; m – number of objects;
102   $j = (1,2…,k)$; k – number of diagnostic variable.
103   Afterwards, there should be determined the nature of the diagnostic variable. If higher values
104   of a given variable allow to qualify the object as better within the general criterion, this is called a
105   stimulant. On the other hand, when the higher values of the property cause a worse assessment of
106   the object, then it is the destimulant (Depta 2005). In taxonomic analysis, it is also important to unify
107   the level of variability of features in order to ensure their comparability. To bring the characteristics
108   to be comparable, it is necessary to standardized them based on the formula (2) below:

$$Z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_{xj}} \tag{2}$$

110   where:
111   x_{ij} – empirical value of j diagnostic variable for i object,
112   $\bar{x}_j$– arithmetic average of diagnostic variable x_j,
113   S_{xj} – standard deviation from diagnostic variable x_j.
114   As a result of standardization, there is obtained a standard synthetic variable, called development
115   model P_{0j} (Hellwig 1968) presented in the formula (3):
116
117                              $P_{0j} = [z_{01}, z_{02},…,z_{0k}],$ (3)
118   where:
119   $z_{0j} = max(z_{ij})$ for variables that are stimulants,
120   $z_{0j} = min(z_{ij})$ for variables that are destimulants.
121   This formula can be defined by the best observed value or on the basis of expert knowledge by
122   adopting arbitrary values of the standard.
123   For the destimulant, you can transpose variables into stimulants using below formula (4):
124                              $2\bar{x} - x_{ij}$ (4)
125   In the further stage of the research, for each analysed object, the distance from development
126   model P_{0j} should be determined. The Euclidean distance formula (Shraddha, Suchita, 2011) (or its
127   square) is most commonly used (5):
128

$$d_{i0} = \sqrt{\sum_{j=1}^{k}(z_{ij} - z_{0j})^2}, \text{ for } i = (1,2…,m) \text{ and } j = (1,2…,k), \tag{5}$$

130   where:
131   z_{ij}– normalized value of j variable for i object,
132   z_{0j}– normalized development index model value for j variable.

133 Then a relative taxonomic development index measure for individual objects is calculated in order to
134 normalize the coefficient d_{i0}:

$$z_i = 1 - \frac{d_{i0}}{d_0} \qquad (6)$$

136 where:

137 $d_0 = \bar{d}_0 + 2S_0$,   (7)

138 $\bar{d}_0 = \frac{1}{m}\sum_{i=1}^{m} d_{i0}$,   (8)

139 $S_0 = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(d_{i0} - \bar{d}_0)^2}$,   (9)

140 $\bar{d}_0$ – the arithmetic average of the designated distances from the development model,
141 S_0 – standard deviation from the determined distances from the development model.
142

143   The higher the value of the distance, the more object is closer to the pattern and the better is its'
144 situation. A result close to zero indicates a very unfavourable situation of the analysed object. On the
145 basis of the value of taxonomic development measure, it is possible to set in order the objects due to
146 the level of PE/VC market development.
147   On the basis of the calculated synthetic measure, a linear arrangement of objects is made. The
148 determination of Hellwig's synthetic development index can be additionally supplemented by
149 division of units into clusters (Grabiński, Wydymus, Zeliaś 1989), using the arithmetic average and
150 standard deviation from the relative value of the development measure. The objects can be divided
151 into four typological groups: from very good to insufficient. It should be noted that the proposed
152 assessments are relative, i.e. only within countries taken into account in the analysis and due to
153 available diagnostic variables (Warzecha 2013).
154

155 *2.2. Identifications of factors for analysis*

156   The concept of "level of development" is characterized by the structure and therefore it should
157 be verified to what extent certain results for the factors considered to be relevant in given case, have
158 been achieved (Grajewska 2013). Proper market specification is extremely important as it allows a
159 better understanding of the mechanisms affecting its development. The particular features were
160 selected on the basis of substantive and statistical prerequisites. The selection of indicators for the
161 study was made taking into account different spheres of the PE/VC market, so that the final result
162 allowed to determine which of the European countries belong to the group with very high, high,
163 moderate and low level of development of the analysed market.
164   Due to the fact that the aim of the study was to determine the level of PE/VC market
165 development, by key factors there were considered to be those that determine its shape, form and
166 condition. Thus, the study contains information that characterizes the market, i.e. its size, dynamics
167 of development, industry structure, investment structure due to stage of enterprises development,
168 etc. Because external factors, which determine the country's economic, technological and social level,
169 also have an (indirect) impact on the PE/VC market, they could not be completely neglected.
170 However, it is important not to introduce too many external factors that could "flatten" the results of
171 the research and bring them to the general economic dimension. External factors affecting the PE/VC
172 market in European countries have been identified by using own econometric method   and earlier
173 analyses and researches conducted by, among others, Artur Zimny (Zimny 2013).
174   The study covered a period of six years, until 2015, due to the fact that the most recent statistical
175 yearbooks published by Invest Europe, have a new structure of calculations and only part of data for

176 previous years has been adapted to the new criteria. Joining most recent data to the analysis, where
177 part of factors were calculated on slightly different basis, would deprive the possibility of making
178 comparisons with previous years.
179   Considering the above findings, for the study there were initially proposed 37 indicators
180 determining the level of PE/VC market development (creating a potential set of features) divided into
181 four following segments:
182 1.   General features of PE/VC market;
183 2.   PE/VC market environment;
184 3.   Industry structure of PE/VC market (Sectoral Classification 2016);
185 4.   Structure of PE/VC investments due to the company development phases.
186   The statistical data were gathered based on EVCA (Invest Europe) Yearbooks (Yearbook 2016)
187 and reports with dataset on all European countries (Yearbook Dataset 2015), as well as, Eurostat
188 database such as patent applications to the European patent office (Patent applications 2016), and
189 human resources in science and technology – HRST (Human resources 1995 & 2016). In order to solve
190 the problem of variable weighing, there was made the assumption on the same importance of each
191 analysed feature. In the next stage of the study, the character of each traits was determined,
192 distinguishing among them stimulants (a diagnostic variable where a higher value means better
193 situation of the object) and destimulants (where a higher value means worse situation of the object),
194 taking into account the substantive meaning of individual features. They were marked with the
195 letters [S] and [D] respectively. It was assumed, that in some cases the higher value means
196 deterioration (weakening) of the level of PE/VC market development. Thus destimulants were:
197 •   share of PE/VC investments financed by public entities (the higher the level of PE/VC market
198   development makes it more independent from state funds);
199 •   share of domestic PE/VC investments of total PE/VC investment (the developed PE/VC market
200   should attract foreign capital.) The market, which is financed only by domestic capitals, is a
201   closed market, which may affect its slower growth);
202 •   share of PE/VC investment in agriculture (this sector is relatively low innovative and not
203   technology driven in comparison with others).
204   The differences and correlations between individual variables were verified in the study and
205 diagnostic variables were selected, reducing the original set of features by the following indicators:
206 X3, X4, X6, X8, X9, X13, X14 (see table 1). The remaining variables were used in the Hellweg synthetic
207 index assessment of the level of PE/VC market development in Europe. From among mentioned
208 indicators, there were finally included 30 variables in the study. Table 1 below presents a list of
209 variables, with an indication of which were included in the study.
210
211   **Table 1.** Variables defined for the Hellwig method after initial verification, with the specification
212   of stimulant/ destimulant

Group	In the analysis	Designation and name of the feature	Stimulant/ Destimulant
1	Yes	X1 – The value of PE/VC investment in Europe [a] (investment by location of PE offices investing in European companies) in relation to GDP per capita	S
1	Yes	X2 – The change of PE/VC investment value compared to the previous year	S
1	No	X3 – The total number of PE/VC companies / funds	-
1	No	X4 – The total number of enterprises receiving PE/VC funding	-
1	Yes	X5 – The share of PE/VC investments financed by public entities	D
1	No	X6 – The share of PE/VC investments financed by private and mixed entities	-
1	Yes	X7 – The share of PE/VC investments made by domestic entities	D
1	No	X8 – The share of PE / VC investments made by domestic entities from outside EU	-

1	No	X9 – The GDP per capita	-
2	Yes	X10 – The share of PE/VC investments in GDP	S
2	Yes	X11 – The total European patent applications to the European Patent Office (EPO)[b] (regardless of whether they are granted or not) in relation to GDP per capita (Patent applications 2016)	S
2	Yes	X12 – The human resources in science and technology (HRST) as a share of the active population in the age group 25-64 (Human resources 1995 & 2016)	S
2	No	X13 – The corporate income tax rate CIT	-
2	No	X14 – The interest rate on 10-year state securities	-
3	Yes	X15 – The share of PE/VC investments in agriculture	D
3	Yes	X16 – The share of PE/VC investments in business and industrial products	S
3	Yes	X17 – The share of PE/VC investments in business and industrial services	S
3	Yes	X18 – The share of PE/VC investments in chemicals and materials	S
3	Yes	X19 – The share of PE/VC investments in communications	S
3	Yes	X20 – The share of PE/VC investments in computer & consumer electronics	S
3	Yes	X21 – The share of PE/VC investments in construction	S
3	Yes	X22 – The share of PE/VC investments in consumer goods & retail	S
3	Yes	X23 – The share of PE/VC investments in consumer services	S
3	Yes	X24 – The share of PE/VC investments in energy & environment	S
3	Yes	X25 – The share of PE/VC investments in financial services	S
3	Yes	X26 – The share of PE/VC investments in life sciences [c]	S
3	Yes	X27 – The share of PE/VC investments in real estate	S
3	Yes	X28 – The share of PE/VC investments in transportation	S
3	Yes	X29 – The share of PE/VC investments in unclassified sectors	S
3	Yes	X30 – The share of PE/VC investments in high-tech (total)	S
4	Yes	X31 – The share of PE/VC investments in seed phase [seed capital]	S
4	Yes	X32 – The share of PE/VC investments in start-up phase [start-up capital]	S
4	Yes	X33 – The share of PE/VC investments in later venture phase [later stage venture]	S
4	Yes	X34 – The share of PE/VC investments in growth phase [growth capital]	S
4	Yes	X35 – The share of PE/VC investments in rescue phase [rescue/ turnaround]	S
4	Yes	X36 – The share of PE/VC investments in replacement phase [replacement capital]	S
4	Yes	X37 – The share of PE/VC investments in buyout phase [buyout capital]	S

213   [a] The value of PE/VC investment taken from aggregate tables for European countries (not individual country
214   tables). Such a choice results from the fact that the data included in collective summaries are more comparable.
215   [b] The total European patent applications refer to requests for protection of an invention directed either directly
216   to the European Patent Office or filed under the Patent Cooperation Treaty and designating the EPO (Euro-PCT),
217   regardless of whether they are granted or not. The data shows the total number of applications per country.
218   [c] life sciences - in the context of human health. This industry includes: medicine, pharmacy and healthcare.
219
220   The author is aware that the proposed indicators do not exhaust the multidimensional approach
221   of assessing the level of PE/VC market development. The number of variables can be added almost
222   infinitely. However, the features proposed and characterized were considered to be the most
223   important from the point of view adopted in the study. In addition, the lack of uniformity of obtained

224 data and the limited availability of some variables have reduced the number of factors that could
225 have been used in the proposed study.

3. Results

227   The aim of the study was to create one synthetic indicator that would contain information on
228 many variables regarding the PE/VC market. The created index allowed to build the rank of European
229 countries according to the level of PE/VC market development. The cluster analysis carried out for
230 the nine-year period (2010-2015) brought the results indicated in the following Table 2. To improve
231 the visualization, international two-element codes of countries were used . For the purpose of
232 marking groups of countries analyzed in the study, the following abbreviations were used: Bal –
233 Baltic countries (Lithuania, Latvia, Estonia); CEE – Central and Eastern Europe: former Yugoslavia
234 and Slovakia (Croatia, Slovakia, Slovenia).

236   **Table 2.** The values of the Hellwig synthetic index measure of PE/C market development for European
237   countries in 2010-2015

Country code	2010	2011	2012	2013	2014	2015	Country code	2010	2011	2012	2013	2014	2015
AT	0,075	0,086	0,096	0,115	0,099	0,105	LU	0,077	0,054	0,101	0,085	0,101	0,085
Bal	0,108	0,077	0,078	0,081	0,091	0,075	NL	0,122	0,083	0,147	0,115	0,102	0,102
BE	0,120	0,077	0,117	0,105	0,112	0,109	NO	0,077	0,069	0,11	0,042	0,086	0,083
BG	0,032	0,025	0,014	0,008	0,036	0,038	CEE	0,061	0,028	0,039	0,053	0,051	0,047
CZ	0,060	0,038	0,040	0,045	0,057	0,050	PL	0,044	0,039	0,085	0,069	0,05	0,054
DE	0,131	0,067	0,123	0,091	0,089	0,105	PT	0,057	0,063	0,096	0,112	0,086	0,117
FI	0,080	0,058	0,095	0,055	0,089	0,060	RO	0,028	0,047	0,033	0,062	0,037	-0,004
FR	0,135	0,134	0,15	0,122	0,147	0,150	ES	0,092	0,059	0,107	0,071	0,062	0,105
DE	0,146	0,111	0,126	0,102	0,106	0,126	SE	0,107	0,056	0,111	0,077	0,071	0,117
GR	0,044	0,032	-0,02	-0,013	-0,020	0,005	CH	0,09	0,056	0,107	0,113	0,118	0,115
HU	0,075	0,047	0,031	0,043	0,028	0,051	UA	-0,035	0	0,057	0,022	0,015	0,048
IE	0,083	0,058	0,103	0,053	0,118	0,089	UK	0,15	0,124	0,169	0,119	0,129	0,156
IT	0,109	0,030	0,101	0,047	0,055	0,050							

239   It is also worth to analyse the descriptive characteristics for synthetic variables being the result
240 of the study, which are presented in the below Table 3. There were used:
241 •   location measures (including: arithmetic average, median, quartiles 1 and 3),
242 •   differentiation measures (among others: standard deviation, range),
243 •   asymmetry measures (among others: asymmetry coefficient). A positive value of this coefficient
244   indicates a right-sided asymmetry (the larger part of the population takes values above the
245   average), while a negative one is left-sided (the larger part of the population takes values below
246   the average).

248   **Table 3.** Descriptive characteristics of synthetic index measures describing the level of PE/VC market
249   development in European countries in 2010-2015

Measurement	2010	2011	2012	2013	2014	2015
Average	0,0828	0,0606	0,0886	0,0718	0,0767	0,0816

Quartile 1	0,0584	0,0384	0,0482	0,0456	0,0506	0,0502
Median	0,0805	0,0581	0,1008	0,0710	0,0862	0,0846
Quartile 3	0,1148	0,0772	0,1139	0,1083	0,1042	0,1118
Minimum	-0,0351	-0,0002	-0,0198	-0,0125	-0,0199	-0,0041
Maximum	0,1501	0,1336	0,1691	0,1222	0,1470	0,1563
Range	0,1851	0,1338	0,1889	0,1347	0,1669	0,1603
Standard deviation	0,0414	0,0303	0,0443	0,0359	0,0383	0,0401
Asymmetry coefficient	0,0557	0,0829	-0,2746	0,0209	-0,2493	-0,0751

250

251   The analysis of the distribution of the coefficient value indicates that in the years 2010-2011 and
252 2013, there was a right-side asymmetry. This means that the functioning of PE/VC market in Europe
253 in that period was disturbed, through e.g. an economic slowdown, which has increased the gap
254 between countries. The greater part of European countries obtained higher than the average level of
255 the coefficient (countries with a very low factor had a strong impact on the average value). In the
256 remaining years there was left-sided asymmetry. The majority of countries obtained a lower than
257 average coefficient value. The ratings of some countries, such as the United Kingdom, France or
258 Netherlands, have improved significantly, which again influenced the enlargement of differences
259 between the countries in the level of PE/VC market development. In 2015, this asymmetry lost its
260 strength. The above is also confirmed by the range of variability of the synthetic variable (range,
261 standard deviation), which fluctuated throughout the analysed years.
262   To visualize deviations from the synthetic index, there were constructed radar charts (Figure 1).

263

264   **Figure 1.** The distance of the synthetic index for particular European countries from the Hellwig
265   development formula in 2010-2015

266   These graphs can be described as linear, in which the axis "x" is represented by the central point,
267 and the values of individual objects are marked on separate axes "y". In the following radar charts on
268 the y-axes there were marked the values of the synthetic measure of PE/VC market development in
269 European countries in particular years, according to the results of Hellwig's analysis. According to
270 the above radar charts, over the 6 analysed years, some countries, such as France, United Kingdom,
271 Germany, Netherlands, were distinguished by the highest value of the measure, while Greece,
272 Bulgaria, Ukraine and Romania by the lowest. Although some pattern can be observed in the case of
273 the countries indicated, there were relatively significant changes in the level of PE/VC market
274 development among other European countries. Therefore, more detailed analysis is necessary.

275   On the basis of the calculated synthetic index, European countries have therefore been ranked
276 in a linear manner, according to the obtained measures, from countries with the best condition of the
277 PE/VC market, to those in which the market is still underdeveloped. In addition, countries were
278 grouped into four clusters separated by an arithmetic average and standard deviation for a relative
279 development measure. This way, four categories of countries were selected, as presented in Table 4.
280
281   **Table 4.** The rules of grouping European countries based on the criteria used in Hellwig method

Gr.	Level PE/VC of development	Boundary condition 1	Boundary condition 2
G1	Very high	Average + Standard deviation < z_i	$z_i < 1$
G2	High	Average < z_i	z_i < Average + Standard deviation
G3	Moderate	Average– Standard deviation < z_i	z_i < Average
G4	Low	$0 < z_i$	z_i < Average – Standard deviation

282
283   The results of the conducted ranking and assignment to the distinguished groups are presented in table 5.
284 The typological grouping of countries based on the average and standard deviation provided groups of different
285 size. It should be noted that the proposed assessments are relative, i.e. within analysed countries and due to
286 available diagnostic variables. In Table 5 appropriate groups, for a clear distinction, are marked in colour
287 according to the division rules presented in Table 4.

288
289   **Table 5.** The hierarchy of European countries due to the level of PE/VC market development based on the
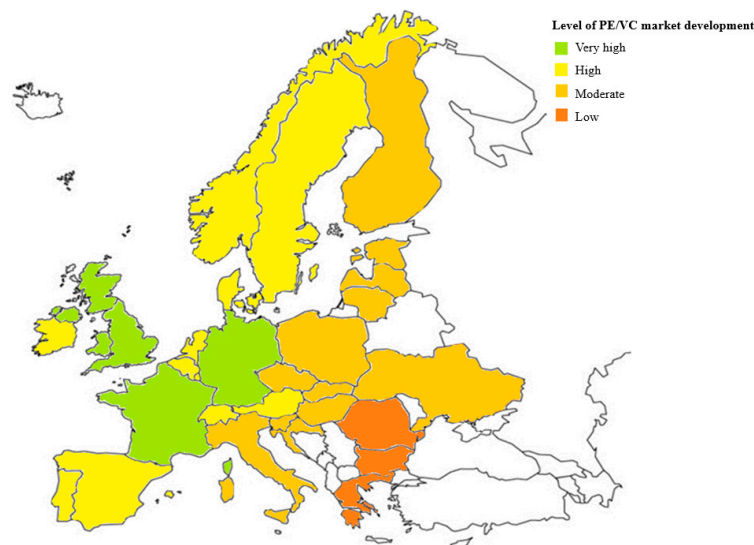290   Hellwig synthetic index value

2010	2011	2012	2013	2014	2015
UK	FR	UK	FR	FR	UK
DE	UK	FR	UK	UK	FR
FR	DE	NL	AT	CH	DE
DK	AT	DE	NL	IE	SE
NL	NL	DK	PT	BE	PT
BE	BE	BE	CH	DE	CH
IT	Bal	SE	BE	NL	BE
Bal	NO	NO	DE	LU	DK
SE	DK	CH	DK	AT	AT
ES	PT	ES	LU	Bal	ES
CH	ES	IE	Bal	FI	NL
IE	FI	LU	SE	DK	IE
FI	IE	IT	ES	PT	LU

LU	CH	PT	PL	NO	NO
NO	SE	AT	RO	SE	Bal
HU	LU	FI	FI	ES	FI
AT	RO	PL	CEE	CZ	PL
CEE	HU	Bal	IE	IT	HU
CZ	PL	UA	IT	CEE	IT
PT	CZ	CZ	CZ	PL	CZ
PL	GR	CEE	HU	RO	UA
GR	IT	RO	NO	BG	CEE
BG	CEE	HU	UA	HU	BG
RO	BG	BG	BG	UA	GR
UA	UA	GR	GR	GR	RO

Analysis of the PE/VC market using the taxonomic method, which is a Hellwig synthetic development measure, gives the opportunity to determine the current level of PE/VC market development by using a single numerical value and the classification of countries from those with the highest level to those with the lowest level of development. It enables and facilitates the comparison between countries. Conducting detailed analyses for individual years gives a broader picture of what constitutes a very high, high, moderate or low level of PE/VC market development in Europe. The following Figure 2 presents the division in 2015.

Figure 2. The map of Europe with an indication of the level of PE/VC market development in Europe based on the Hellwig synthetic index measure, in 2015

4. Discussion

The Hellwig method enabled creation of the ranking of countries and classify them into groups. Analysis of particular groups of similar countries, gives the opportunity to formulate general characteristics of the PE/VC market in Europe. These characteristics including the size of investments, their share in GDP, source of origin, industry structure etc., were presented in a tabular form in Table 6 below. Such an analysis, using taxonomic methods were not presented in researches yet.

Table 6. Comparison of individual features defining the level of PE/VC market development in Europe, based on analyses for 2010-2015, in G1-G4 groups determined by the Hellwig method

Group	G1	G2	G3	G4
The level of PE/VC development in Europe	Very high	High	Moderate	Low
The range of PE/VC investment value in total [in million euro]	2.000 – 20.000	100 – 6.000	15 – 1.500	1 – 100
The range of PE/VC share in GDP	0,2% - 0,7%	0,2% - 0,7%	0,0% - 0,5%	0,0% - 0,1%
The range of share of domestic PE/VC in all PE/VC capital invested	45% - 90%	60% - 95%	55% - 100%	90% - 100%
Averaged share of industries attracting the most PE/VC investments*	14% cg&r 14% ls 14% b&is	16% ls 14% cg&r 13% b&ip	15% ls 13% cg&r 11% c	31% c 15% cg&r 14% c&ce
The range of the investment share of high-tech in general PE/VC invested	5% - 25%	5% - 45%	1% - 30%	0% - 40%
The PE/VC capital structure due to company's development phases (order: seed + start-up / growth / buyout)	8% 15% 65%	10% 20% 60%	10% 25% 50%	20% 30% 40%

* b&ip – business & industrial products; b&is – business and industrial services; c – communications; c&ce – computer and consumer electronics; cg&r – consumer goods & retail; ls – life sciences.

The results of the analysis shows that unquestionable leaders of the European PE/VC market are: Great Britain, Germany and France. It is not surprising, as these countries constitute the core of PE/VC investment covering over 70% of all PE/VC investments in Europe (76% in 2015 - total 33622917 thousand euro). What's more, according to the International Innovation Index (a global index measuring the level of innovation of a country, produced jointly by The Boston Consulting Group - BCG), these countries are in the world top 20 countries with the highest level of innovation (Dutta, Lanvin 2013). The level of economy innovativeness has a very strong impact on the pace of PE/VC market development and vice versa. The first group includes, in some years, also countries such as the Netherlands, Austria, Portugal and Switzerland. These countries were characterized by the highest level of PE/VC investments in Europe and their high share in GDP in 2010-2015. 55% of the PE/VC funds invested in that period were foreign capitals. The industry structure was diversified - all market sectors received private equity financing, but the sectors that gained the most capital were: life sciences, consumer goods & retail and business & industrial services. Up to 25% of invested PE/VC funds supported high-tech projects. Investments in the final phases of companies development dominated in that group of countries (more than half of the PE/VC resources went to companies at buyout stage), while the financing of businesses in the early stages of development was negligible. These countries presented a strong share of human resources employed in science and technology and the high number of patent applications reaching the EUP.

The second group, associating countries with a high level of PE/VC market development, is relatively diverse and consists of, among others, from: Belgium, Luxemburg, the Netherlands, Austria, Denmark, Sweden and Switzerland. In some years there were also included the Baltic countries, Portugal, Spain, and Norway. Although depending on the year of the study countries change places in the hierarchy within the group, the overall structure remains relatively stable. These countries are also included in the first 20 countries with the highest International Innovation Index. Although the structure of PE/VC market is similar to the previous group G1, most of the analysed

340   factors reach slightly lower values. However, in that group more PE/VC funds support projects
341   concerning modern technologies.
342   The third group includes countries where the level PE/VC market of development is assessed as
343   sufficient/moderate. It includes mainly Poland, the Czech Republic, Italy, Spain and Finland. Also
344   Romania and other Central and Eastern European countries (CEE) have appeared several times in
345   this group. In the case of G3 group, the situation is not as stable as in the G1. A relatively strong
346   displacement occurs in the rankings, depending on the year. This situation is influenced by the fact
347   that in the case of countries from that group, investment values and other indicators are not
348   significant, thus each positive signal from the market (small investment growth, increase in the
349   number of patents or participation in the high-tech sector even by a unit) strongly affects the value
350   of the synthetic indicator of a given country. Hence, countries that are on the border of clusters
351   relatively often change their position within the group. As for the characteristics described in the
352   above tables, the countries of this group show average values. This group is characterized by a greater
353   interest of investors in projects in the growth phase.
354   The last group G4, with the lowest rating of the level PE/VC market development in   Europe,
355   consists mainly of the following countries: Bulgaria, Greece, Ukraine, Romania and Hungary. These
356   countries (with the exception of Hungary) are at the last places of the International Innovation Index
357   for European countries. Due to the low maturity of the PE/VC market, they were characterized by a
358   significant share of domestic capital and increased investments in companies in the early stages of
359   development. The level of employment in science and technology in these countries, and hence the
360   number of patent applications in the European Patent Office, were lower here than in the other
361   countries. In this group there was a strong focus of investors on a small number of industries/sectors
362   in a given year.

5. Conclusions

364   Determining the level of PE/VC market development and the way it operates is extremely difficult.
365   Moreover, economic turbulence has also had an impact on the volatility and transformation of this sector in
366   recent years. Their impact strongly affected the PE/VC market in Europe, that only five countries out of the 25
367   managed to achieve the size of private equity investment at least as before the crisis in 2007. Investment value
368   in 2015 in relations to 2007 in those countries were: Hungary (287%), Poland (176%), Norway (160%), Finland
369   (149%), Luxemburg (118%) (Yearbook Dataset 2015).
370   The conducted analysis using the Hellwig method allowed to determine the ranking of European countries
371   in terms of the level of PE/VC market development, which reveal some significant differences in the functioning
372   of the PE/VC market between European countries. Further detailed analysis of the designated groups of
373   European countries allowed to determine the characteristics for countries qualified to such clusters, with a
374   specific level of PE/VC market development. In the part of Central and Eastern Europe, both the industry
375   structure and the share of individual types of investors in the total amount of PE/VC investments vary less than
376   in other European countries. In Western European countries, the financing is stable and almost all sectors of the
377   economy achieves PE/VC capital, although to different extent. The value of investments in the Central and
378   Eastern Europe is also much lower than in other Western countries. This is most probably due to the fact that
379   this form of financing has been operating in the Central-Eastern part of Europe since 90'. In addition, the lower
380   level of general economic development of these countries is also reflected in the level of PE/VC market
381   development. When it comes to financing of particular stages of enterprise development, in Central-Eastern
382   Europe, mostly mature companies can gather financing from PE/VC funds. Newly founded enterprises, which

383 are most affected by the capital gap and which are often unable to exist on the market without external support,
384 receive less private equity funds.

385   The use of taxonomic methods in the PE/VC market analysis may be extremely useful in characterizing
386 this market. The analysis of this sector from the global perspective does not exclude, and even simplify, the
387 detailed research of this market in chosen countries, indicating specific reference points. An in-depth analysis
388 allows the identification of weaknesses and strengths as well as opportunities and threats related to a specific
389 stage of PE/VC market development in a given country, what gives the opportunity to determine public
390 activities that could affect the acceleration of this market development.

391   By defining the level of PE/VC market development in specific groups of European countries and
392 classifying characteristics for these groups, it is possible to compare each country to determine outliers. This
393 allows you to verify the weaknesses and strengths of the PE/VC market in particular, chosen country. The
394 example may be Polish market presented in Table 7.

395

396   **Table 7.** Assessment of the convergence level of Polish PE/VC market in relation to the designated models

Group	G1	G2	G3	G4
PE/VC investment value		X	XX	
PE/VC share in GDP			XX	XX
Share of domestic PE/VC investments in all PE/VC capitals			XX	X
Structure of PE/VC capital due to sector/industry		X	XX	
Level of investment in high-tech sector				XX
Structure of PE/VC capital due to level of investment in particular companies stage of development			XX	XX

397

398   The comparison allows the indication of the areas of possible application of remedial measures
399 to limit development barriers of the Polish market. It is clearly visible that in the areas of the value of
400 PE/VC investment, the share of domestic capitals and the level of investment in high-tech sector, this
401 market is more similar to countries with lover level of development. These areas might be treated as
402 those that need specific actions (e.g. done by government), that would improve the situation and
403 boost the PE/VC development in Poland. It is worth mentioning as well the structure of PE/VC capital
404 due to level of investment in particular companies stage of development should also be taken into
405 account when preparing the action plan. Although the structure in Poland is more similar to those
406 presented by countries with higher level of development, it does not mean, that in the current
407 situation it is convenient. Country that would like to develop the venture capital market should
408 encourage investors to focus on young, innovative companies (e.g. in the area of high-tech), instead
409 of investing mainly in final stages of companies development for capitalizing gains faster.

410   PE/VC sector is very important from the perspective of small and medium enterprises, and for
411 the total economy development. Better understanding of this market is thus crucial for the
412 government investment & legislative strategies. A separate comparing analysis, as presented for
413 Poland, may be prepared for each country to determine the proper plan for public actions.

414

417 **Conflicts of Interest:** "The authors declare no conflict of interest."

418

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