O P E R A T I O N S R E S E A R C H A N D D E C I S I O N S
No. 3 2016
DOI: 10.5277/ord160301

Przemysław DOMINIAK[1]
Jacek MERCIK[2]
Agata SZYMAŃSKA[3]

A SYNTHETIC INDICATOR OF A COMPANY'S LEVEL OF INTELLECTUAL CAPITAL AS A HIDDEN VALUE

The authors of the paper analyzed 21 common methods of measuring a company's intellectual capital, finding that none of them meet all 6 demands that a model indicator should satisfy. As a result, a new method was developed, which meets the conditions for a model indicator. Using the chosen expert method, a synthetic indicator of a company's level of intellectual capital (*WPKI*) has been determined. The authors of the paper determine the *WPKI* indicator for public construction companies using the algorithm defining a hidden value.

Keywords: *company's intellectual capital, methods, measuring, hidden values*

1. Introduction

The term intellectual capital was first used in 1958 by two stock market analysts in reference to small IT companies. These analysts arrived at the conclusion that a high level of intellectual capital in such companies results in high stock exchange quotations. Thomas Stewart defines intellectual capital as follows: (…) *the activity of any company depends on patents, processes, managerial skills, technology, information regarding clients and suppliers and on experience. This complex knowledge creates intellectual capital* [27]. In this paper, intellectual capital is understood according to the definition of Peder Hofman-Bang and Henrik Martin: *all factors crucial to the future success of a company that are not presented in a traditional balance sheet* [8]. According to this definition, intellectual capital can be treated as all aspects not included in traditional

[1]Colian Sp. z o.o., e-mail: przemyslaw.dominiak@gmail.com
[2]Wrocław School of Banking and Gdansk School of Banking, e-mail: jacek.mercik@wsb.wroclaw.pl
[3]Toyota Motor Industries Poland Sp. z o.o., e-mail: agata.szymanska3@gmail.com

financial reports (not counting legal and intangible assets) and simultaneously constituting a component of the real value of a company, as well as determining its market survival and success.

In this paper, the authors present their own original method of measuring intellectual capital that meets all 6 demands that a model indicator should satisfy ([5], p. 98–101), unlike 21 commonly used methods of measuring intellectual capital [4] that do not meet these demands. These demands state that any measure of intellectual capital should:

D1. Be applicable to both comparisons of companies and to managing a company. Methods of measuring intellectual capital have two main applications, i.e. as external measures for comparing companies and as internal measures for managing the intellectual capital of a company [25].

D2. Use mainly non-financial data. Financial data constitutes mainly a company's book value, i.e. its tangible and material assets. In contrast, intellectual capital shows the intangible assets of a company.

D3. Take into consideration all the main elements of intellectual capital. As stated in the specialist literature, the components of intellectual capital are as follows: human capital, structural capital [3, 6, 18, 28] (organizational structure capital [9]/organizational capital [1]) and relation capital [3, 9] (structural capital of relations [9]/client capital [1, 18, 28]/market capital [26]). Structural capital is created by intellectual property [9, 22] (innovation capital [6]) and processes [9] (process capital [6, 26], infrastructural assets [22]), and relation capital – clients and networks of mutual connections [1, 3], i.e. relations with suppliers and other cooperating strategic partners. So the basic elements of intellectual capital are as follows: human capital, intellectual property with processes (structural capital), as well as clients and co-operators with their networks of mutual connections (relation capital).

D4. Be robust to different modes of choosing and describing measurement parameters (indicators), as well as their market fluctuations – in practice, the following can be reasons for the instability of measures of intellectual capital, which may result in measurement paradoxes:

- accepting the market value of a company quoted on the stock exchange on a particular day,
- assuming different rates of return and discount,
- the impact of various events or managerial actions,
- a company's individual and subjective choice of indicators defining elements of intellectual capital,
- performing unspecified and often subjective corrections to accounts.

D5. Define a synthetic measure of a company's total intellectual capital. This is important for at least the three following stated reasons:

1. Synthetic measurements of companies' intellectual capital (in the form of monetary values or other numerical values with clearly defined scales) can be used for comparing companies [12].

2. A company's management can view a large and increasing synthetic value of intellectual capital as an indicator of investments in knowledge assets being repaid [14].

3. Creating a synthetic indicator of intellectual capital ensures immediate progress in analysing a long list of indicators, because it requires that companies understand the priorities and relations between different measurements [2].

D6. Perform a weighted estimation of a company's intellectual capital**. T**he input of the components of intellectual capital and its elements in the intellectual capital of a company should be weighted, because they have different contributions to a company's (market) value (in particular, according to the specific profile of a company in a specific business field or sector) [2].

We will present the construction of a synthetic *WPKI* based on details of public construction companies. This indicator will be treated as a hidden value which can only be estimated indirectly based on other directly measurable values.

2. Proposed method of measuring a company's intellectual capital

Intellectual capital is generally described in the literature as having three main components: human capital, organizational capital (structural capital) and relation capital (Fig. 1). Another component, business capital, can also be added. In the IC Rating™ model, apart from the basic components of intellectual capital, i.e. management and employees (human capital), intellectual property and processes (organizational structural capital), as well as clients, networks of mutual connections and brand name (structural relations capital), there is also an additional component, namely the recipe for business.

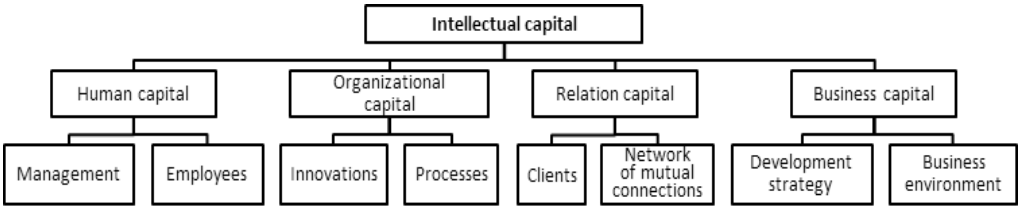

Fig. 1. Proposed elements and components of intellectual capital.
Source: authors' elaboration based on: [1, 3, 6, 9, 18, 22, 28, 29]

This is the strategic context of a new enterprise defined by a business concept and the strategy applied to accomplish it [9]. We believe that the importance of this component should be raised to achieve the status of being the fourth component of intellectual capital, due to its relevancy to any company. Business capital involves the business environment in which any company undertakes its activity and its development strategy. The business environment component defines the quality of a business concept via an analysis of business environment risk, operation risk and the quality of the competition. A strategy for company development is a set of strategic assumptions which are present in the specific activities and investments undertaken by a company in order to survive in a changing environment.

Table 1. Indicators used to measure a company's intellectual capital.
Factors of the level of intellectual capital

Component	Factor
Management	managers' qualifications
	a company's abilities to attract talented employees
	personnel and functioning of the directors' board and supervisory board
	salaries policy for managers and share holders
Employees	employees' productivity
	stability and skills of employees
Innovations	investments in research and development ($R + D$)
	efficiency of research and development ($R + D$)
	value of licences, patents and other intellectual property rights owned by a company (trademarks, industrial designs, copyrights, trade secrets)
Processes	quality of internal processes and procedures and organizational effectiveness
	existence and comprehensiveness of information and informatics systems supporting company management
Clients	market share
	clients' profitability review
	clients' satisfaction and loyalty
	analysis of relations with clients
Network of mutual connections	value of strategic alliances and cooperation within consortia and with subcontractors
	stability of strategic alliances and cooperation within consortia and with subcontractors
	importance and quality of suppliers and subcontractors
	stability of cooperation with suppliers and subcontractors
Development strategy	quality and comprehensiveness of development strategy
	investments resulting from the development strategy
	effectiveness of development strategy
Business environment	analysis of risk factors related to the market environment
	analysis of risk factors related to company operations
	quality of competition and company competitiveness
	dominance in competition

Source: authors' elaboration.

The proposed indicator of a company's intellectual capital is based on a set of 26 individually evaluated indicators. These indicators, called factors of a company's level of intellectual capital, describe 8 main components of intellectual capital (Fig. 1). Table 1 presents the factors of a company's level of intellectual capital, along with the components of capital to which they relate.

These indicators can be assessed from the perspective of companies, based on internal operational data, as well as from the perspective of external stakeholders, based on data from the emission prospectuses of public companies. A prospectus is a document compiled by an issuer in relation to preparing a public offer or the intention to emit financial securities onto a regulated market. Such a document is one of many sources of information based on which investors evaluate the attractiveness of an issuer's offer. Prospectuses are, however, a problematic source of information. Since they are published by the issuer, there may be doubts about the correctness of the information they contain. Hence, prospectuses are considered only being credible to a limited extent [20].

Table 2. Measuring a factor of the level of intellectual capital: Personnel and functioning of directors board and supervisory board (X3), based on a prospectus of a stock market company

Detail's weight $1/n_i$	Detail	Emission prospectus	Assessment	
			On the scale {0; 0,5; 1}	Weighted (2×5)
0.333	1. Description of personnel and functioning of directors' board and supervisory board	personnel of directors' board and supervisory board and members résumé, partial information on the boards functioning	0.5	0.167
0.333	2. Presence of independent non-executive directors according to stated independency criteria	no	0	0.000
0.333	3. Presence of specialized commissions (roles and functions of the committee)	yes – an audit commission has been constituted within the supervisory board (monitoring, e.g. the reliability of financial information and , internal control systems) and commission on salaries (e.g. determining directors' salaries)	1	0.333

$s = 0.5$

Source: the authors' elaboration.

Various factors of a company's level of intellectual capital consist of separately evaluated details. Each factor of a company's level of intellectual capital is defined to be in the range [0; 1] and all the details of a factor have the same weight, i.e. $1/n_i$, where n_i is the number of details of factor X_i. Each detail is evaluated based on official company documentation (for example, based on a prospectus for the emission of shares) on

a three-level scale: 0 – a company does not meet the criterion related to a particular detail, 0.5 – a company partially meets this criterion, and 1 – a company fully meets this criterion[4]. The final evaluation of each factor of a company's level of intellectual capital is the weighted sum of the products of the weights and evaluations of its all details.

Table 2 presents an example of the measurement of the component personnel and functioning of the directors' board and supervisory board (X3).

3. Synthetic indicator of a company's level of intellectual capital (*WPKI*)

The *WPKI* is assessed using an expert method by assigning weights to all the factors. The concept of a hidden value is particularly useful for this purpose – for phenomena that are not directly observable. A phenomenon is unobservable if there is no method that can be used to measure its effects. It is obvious that such a lack of effects forces a researcher to look for methods of measuring the phenomenon in question in an indirect way. This approach consists of measuring other phenomena which somehow reflect the one in question. These phenomena are often called diagnostic or explanatory. After an expert has defined the factors influencing a chosen unobservable phenomenon and their direction of influence, the "real" values of a hidden value (Y) should be estimated (e.g. as was done in [10]). These estimated values of a hidden value enable us to build a regression model (a linear model would be best) for the hidden value of an unobservable phenomenon, denoted $\hat{Y}$, which in this particular case takes the following linear form:

$$\hat{Y} = \beta_1 X_1 + \beta_2 X_2 + ... + \beta_m X_m + \beta_0 \tag{1}$$

where: $\hat{Y}$ – function defining a company's level of intellectual capital Y, $\beta_0, \beta_1, ..., \beta_m$ – the model's structural parameters, $X_1, X_2, ..., X_m$ – factors of a company's level of intellectual capital.

In order to interpret such a variable, it may be convenient to define a synthetic variable which takes values in the interval [0;1], so we decided to introduce the following logistic transformation:

$$\hat{Z} = \frac{e^{\hat{Y}}}{1 + e^{\hat{Y}}}, \qquad \left(\hat{z} \in (0;1)\right) \tag{2}$$

[4]Such a simplification is of course related to the illustrative nature of this example. In the general model, any set of valid weights can be assigned to the particular components.

For the practical purpose of estimating the values of such a hidden variable, we used the method of creating a hidden variable devised by Anna Krefft [10] for assessing phenomena which cannot be measured in a direct way[5]. This method requires information from an expert about the explanatory variables (independent variables) of a hidden phenomenon and their correlation with this phenomenon (specifically, whether the association is negative or positive), to generate the missing values of the dependent variable *Y*. The algorithm for the statistic modelling of such a hidden phenomenon consists of two stages: firstly simulating a sample of realizations of a random variable from a given distribution (the standard Gauss distribution in this case[6]) and then creation of the statistic material, [*Xy*], essential to identifying the model (see formula 1). In the first stage, "partial" realisations of the dependent variable (Y_i), $i = 1, 2, \ldots, n$, are consecutively added to the left of the vector of independent variables (*X*). Initially, these are independent realizations from the standard Gaussian distribution. Each of the *n* columns added (*n* – number of independent variables) are then individually shuffled, so that the ranks of the realizations of Y_i correspond to the ranks of X_i (note: here we assume, without loss of generality, that X_i is positively associated with *Y*). These "partial" realisations of the dependent variable (Y_i) now constitute simulations of the association of the particular independent variables (X_i) with the hidden variable *Y*. In the second stage, the vector $\mathbf{y}^*$ is derived as the arithmetic mean of the "partial" vectors y_i^*. This transformation takes into account the combined association of the *n* independent variables with the dependent variable. In this way, the necessary statistical material, [*Xy*], is generated and later used in the process of constructing the econometric model.

4. Intellectual capital of public construction companies

In our assessment of intellectual capital (*WPKI*), we assumed that the data would be derived from companies' prospectuses. So the research data were 59 prospectuses of

[5]This algorithm can be used in modelling phenomena which are not directly observable and a matter of interest in different fields of knowledge, in particular: the social-economic sciences (e.g. hidden factors in group decisions [16], the attractiveness of companies on the stock market [17], the real revenue of a farm [11], the effectiveness of teaching foreign languages [13], the degree of development of cities' social infrastructure [10], the degree of similarity of import and export structures for particular product groups in different countries [10], universities' level of intellectual capital as assessed by demand [30]) and medicine (e.g. level of risk of progress in pediatric brain paralysis [7, 23], degree of mother-child relationship [24], acceptance degree for organ and tissue transplants amongst residents [15], etc.), but also other fields of knowledge, including theology (a person's level of religious knowledge [21]). We believe that the verifiability of the applicability of Krefft's algorithm is a good argument for applying this model to estimating hidden values of companies' levels of intellectual capital.

[6]In cases there is an argument for using another probability distribution, the algorithm can be modified.

construction companies who entered the Warsaw Stock Exchange between 1991 and 2010. Based on these prospectuses, various factors of intellectual capital level have been assessed.

Next, using the NewKrefft program[7], which carries out Krefft's algorithm to define a hidden value, the form of the function defining *WPKI* was determined. It was assumed that all the 26 factors of the level of intellectual capital have a linear and positive relationship with the *WPKI*.

In the process of creating models of the *WPKI* for public construction companies, some of the correlations between the factors X_i and Y ("real" values of the *WPKI*) and the structural parameters associated with some variables X_i were found to be insignificant. Unfortunately, eliminating these statistically insignificant factors from the analysis (according to their insignificant correlation with Y or insignificant structural parameters) did not improve the situation – other factors in the resulting model now turned out to be statistically insignificant. The reason for this situation was the strong collinearity caused by strong mutual correlations between the factors of the level of intellectual capital. The variance of each parameter estimate in the regression model depends on the vector of the coefficients of mutual correlation between the factors. If such a coefficient is not much smaller than 1, then strong collinearity exists between variables and the variance of the corresponding parameter estimate has a high value ([31], p. 180–181).

Table 3. Multiple correlation coefficients for each variable with respect to the other independent variables

Factor of the level of intellectual capital	Multiple correlation coefficient	Factor of the level of intellectual capital	Multiple correlation coefficient
X1	0.705501423	X14	0.895492518
X2	0.811967673	X15	0.892667274
X3	0.790962462	X16	0.891534817
X4	0.616295775	X17	0.908361583
X5	0.790560671	X18	0.747293282
X6	0.759202099	X19	0.653375260
X7	0.960308721	X20	0.727935957
X8	0.961431351	X21	0.758318926
X9	0.725650352	X22	0.810663826
X10	0.663144697	X23	0.844248556
X11	0.745153912	X24	0.769192319
X12	0.811978097	X25	0.919121432
X13	0.759872571	X26	0.933419856

Source: authors' calculations (using NewKrefft).

[7]This program was developed as an updated version of the Syntmed program ([10], p. 108).

All the values in the vector of multiple correlation coefficients for each factor of intellectual capital in regard to the 25 other factors were indeed high. In every case, this coefficient exceeded the value of 0.6. Also, more than a half of these correlations (14 out of 26) exceeded the value of 0.79 and approximately a third (8 out of 26) exceeded 0.89. Hence, collinearity between the variables was strong and surely influenced the variance of the estimates of the structural parameters and, as a result, their statistical significance (see Table 3).

Taking into consideration the strong collinearity between the factors of a company's level of intellectual capital, it was assumed that the final choice of the model for *WPKI* should be based on the adjusted value of the determination coefficient and the collective significance of the parameter estimates. A multiplicative model was developed consisting of 24 factors of a company's level of intellectual capital (the factors X7 Investment in research and development, and X10 Internal processes, procedure quality and organizational effectiveness have been omitted). The statistical characteristics of this model are presented in Tables 4 and 5.

Table 4. Test for the collective significance of the coefficients for the multiplicative 24-factor model

R^2	Snedecor's *F*-statistic	Degrees of freedom	Significance level
0.9406	9.89494	23	0.000001

Source: authors' calculations (using NewKrefft).

Table 5. The form of the 24-factor multiplicative model (variables and coefficients) and tests for the significance of the parameter estimates and correlation of the independent variables with the dependent variable

Factor	Correlation with *Y*	Students t-statistic	Correlation's significance level	*B*	Students t-statistic	Parameter's significance level
X1	0.5586	4.152	**0.000**	3.2163	2.573	**0.022**
X2	0.2352	1.492	0.145	0.6056	0.169	0.869
X3	0.3744	2.489	**0.018**	0.0763	0.344	0.736
X4	0.2442	1.552	0.129	1.8630	2.361	**0.033**
X5	0.2320	1.470	0.150	1.2801	1.437	0.172
X6	0.2142	1.352	0.185	0.8542	1.807	**0.091**
X8	0.1210	0.751	0.458	–0.0717	0.116	0.910
X9	0.3334	2.180	**0.036**	0.8542	0.818	0.427
X11	0.4439	3.054	**0.005**	0.2478	0.367	0.719
X12	0.3161	2.054	**0.047**	–0.1280	–0.082	0.937
X13	0.3520	2.318	**0.026**	0.9442	1.098	0.290
X14	0.5720	4.299	**0.000**	0.1544	–0.037	0.971
X15	0.5387	3.942	**0.000**	3.1654	2.330	**0.035**

Factor	Correlation with *Y*	Students t-statistic	Correlation's significance level	*B*	Students t-statistic	Parameter's significance level
X16	0.3618	2.392	**0.022**	–0.2493	0.086	0.933
X17	0.3402	2.230	**0.032**	0.5001	–0.055	0.957
X18	0.5029	3.587	**0.001**	0.4980	–0.054	0.958
X19	0.4496	3.103	**0.004**	0.9688	0.914	0.376
X20	0.3298	2.154	**0.038**	3.2100	3.080	**0.008**
X21	0.2366	1.501	0.142	0.4616	0.573	0.576
X22	0.4540	3.141	**0.004**	2.2800	0.908	0.379
X23	0.5350	3.904	**0.000**	0.9786	0.959	0.353
X24	0.3368	2.205	**0.034**	0.0242	–0.282	0.783
X25	0.5263	3.816	**0.001**	4.4731	3.175	**0.007**
X26	0.3206	2.086	**0.044**	–0.8102	–0.570	0.577
Constant				–11.2470		

Source: authors' calculation (using NewKrefft).

This 24-factor multiplicative model was distinguished as having the highest adjusted coefficient of determination (greater than 0.94) and in the collective test it showed high statistical significance, the *p*-value is equal to $\alpha = 0.000001$. Unfortunately, as in the case of previous models, some of the structural parameters and the correlations of some of the independent variables with the dependent variable turned out to be statistically insignificant at the assumed significance level of $\alpha = 0.1$. In the group of 24 independent variables, 6 variables were insignificantly correlated with the dependent variable and 18 variables had insignificant estimates of the structural parameters. However, taking into consideration the influence of multiple correlation on the variance of the parameter estimates and excellent fit of the multiplicative model to the estimated values of the dependent variable, it was accepted that this model is the best in illustrating the form of the indicator of the level of intellectual capital (*WPKI*) for the public construction companies.

The *WPKI* for public construction companies takes the following form:

$$\begin{aligned} WPKI = {} & \mathrm{e}^{-11.2470} \left(X_1+1\right)^{3.2163} \left(X_2+1\right)^{0.6056} \left(X_3+1\right)^{0.0763} \left(X_4+1\right)^{1.8630} \\ & \left(X_5+1\right)^{1.2801} \left(X_6+1\right)^{0.8542} \left(X_8+1\right)^{-0.0717} \left(X_9+1\right)^{0.8542} \\ & \left(X_{11}+1\right)^{0.2478} \left(X_{12}+1\right)^{-0.1280} \left(X_{13}+1\right)^{0.9442} \left(X_{14}+1\right)^{0.1544} \\ & \left(X_{15}+1\right)^{3.1654} \left(X_{16}+1\right)^{-0.2493} \left(X_{17}+1\right)^{0.5001} \left(X_{18}+1\right)^{0.4980} \\ & \left(X_{19}+1\right)^{0.9688} \left(X_{20}+1\right)^{3.2100} \left(X_{21}+1\right)^{0.4616} \left(X_{22}+1\right)^{2.2800} \\ & \left(X_{23}+1\right)^{0.9786} \left(X_{24}+1\right)^{0.0242} \left(X_{25}+1\right)^{4.4731} \left(X_{26}+1\right)^{-0.8102} \end{aligned} \tag{3}$$

where: $X_1, ..., X_6, X_8, X_9, X_{11}, ..., X_{26}$ are the factors of the level of intellectual capital of a given company.

Note that when using a multiplicative model, one was added to all the values of each factor of a company's level of intellectual capital level, because for particular companies these factors were often equal to 0 and in such a case the value of the whole function (i.e. analogous to formula 3) would either equal 0 (when the corresponding exponents were all positive) or would be impossible to evaluate (when at least one of the corresponding exponents was negative), and it does not influence the ranking of the values of the multiplicative function. Adding 1 to the values of the factors is also necessary when we transform the multiplicative model into linear form by taking logarithms.

The linear form of the *WPKI* of the public construction companies is as follows:

$$\begin{aligned} WPKI' = &-11.2470 + 3.2163X_1' + 0.6056X_2' + 0.0763X_3' + 1.8630X_4' \\ &+ 1.2801X_5' + 0.8542X_6' - 0.0717X_8' + 0.8542X_9' \\ &+ 0.2478X_{11}' - 0.1280X_{12}' + 0.9442X_{13}' + 0.1544X_{14}' \\ &+ 3.1654X_{15}' - 0.2493X_{16}' + 0.5001X_{17}' + 0.4980X_{18}' \\ &+ 0.9688X_{19}' + 3.2100X_{20}' + 0.4616X_{21}' + 2.2800X_{22}' \\ &+ 0.9786X_{23}' + 0.0242X_{24}' + 4.4731X_{25}' - 0.8102X_{26}' \end{aligned} \tag{4}$$

where:

$$WPKI' = \ln WPKI,\ X_1' = \ln\left(X_1 + 1\right),\ \ldots,\ X_6' = \ln\left(X_6 + 1\right),$$

$$X_8' = \ln\left(X_8 + 1\right),\ X_9' = \ln\left(X_9 + 1\right),\ X_{11}' = \ln\left(X_{11} + 1\right),\ \ldots,\ X_{26}' = \ln\left(X_{26} + 1\right)$$

Table 6 presents the values of the *WPKI* indicator for the public construction companies sorted in descending order and also the values of the *WPKI''* indicator for these companies (see formula (2)), i.e. standardized values (using the logistic transformation) of the *WPKI* indicator in the interval (0; 1).

Table 6. Values of the indicator of the level of intellectual capital in Polish public construction companies

No.	Company	*WPKI*	*WPKI''*
1	ZUE S.A.	26.3601	1
2	Polimex Mostostal S.A.	7.69	0.9995
3	PBG S.A.	5.8968	0.9973
4	Dom Development S.A.	2.9118	0.9484
5	Trakcja-Tiltra S.A.	2.2471	0.9044
6	J.W. Construction Holding S.A.	2.0736	0.8883
7	Rank Progress S.A.	2.0351	0.8844
8	Energomontaż Południe S.A.	1.8186	0.8604

No.	Company	*WPKI*	*WPKI''*
9	Ronson Europe N.V.	1.738	0.8504
10	Erbud S.A.	1.7176	0.8478
11	Elektrobudowa S.A.	1.7114	0.847
12	ED Invest S.A.	1.6231	0.8352
13	Unibep S.A.	1.5615	0.8266
14	Bipromet S.A.	1.5577	0.826
15	Tesgas S.A.	1.5012	0.8178
16	Energoaparatura S.A.	1.4933	0.8166
17	Budimex S.A.	1.4211	0.8055
18	Echo Investment S.A.	1.3254	0.7901
19	ABM Solid S.A.	1.2206	0.7722
20	Interbud-Lublin S.A.	1.2132	0.7709
21	Celtic Property Developments S.A.	1.1681	0.7628
22	LC Corp S.A.	1.0918	0.7487
23	Mirbud S.A.	1.0214	0.7353
24	Przedsiębiorstwo Robót Inżynieryjnych POL-AQUA S.A.	1.015	0.734
25	Exbud Skanska S.A.	0.9612	0.7234
26	Mostostal Warszawa S.A.	0.9444	0.72
27	P.A. Nova S.A.	0.8738	0.7055
28	Globe Trade Centre (GTC) S.A.	0.872	0.7052
29	Elektrotim S.A.	0.8559	0.7018
30	Mostostal Płock S.A.	0.8012	0.6902
31	Herkules S.A.	0.7994	0.6898
32	Energopol-Południe S.A.	0.6944	0.6669
33	Robyg S.A.	0.6829	0.6644
34	Gant Development S.A.	0.6542	0.658
35	Przedsiębiorstwa Instalacji Przemysłowych Instal-Lublin S.A.	0.6355	0.6537
36	PIA Piasecki S.A.	0.6142	0.6489
37	Poznańska Korporacja Budowlana PEKABEX S.A.	0.61	0.648
38	Instal Poznań S.A.	0.6072	0.6473
39	Przedsiębiorstwo Elektromontażowe Przemysłu Węglowego ELKOP S.A.	0.6041	0.6466
40	Hydrobudowa Polska S.A.	0.5986	0.6453
41	Mostostal Export S.A.	0.5844	0.6421
42	Instal Kraków S.A.	0.5793	0.6409
43	Budopol Wrocław S.A.	0.5709	0.639
44	Przedsiębiorstwo Montażu Konstrukcji Stalowych i Urządzeń Górniczych PEMUG S.A.	0.5353	0.6307
45	Grupa Kapitałowa INWEST S.A.	0.497	0.6218
46	Mostostal Gdańsk S.A.	0.4865	0.6193
47	Polnord S.A.	0.4854	0.619
48	Marvipol S.A.	0.4693	0.6152
49	Przedsiębiorstwo Produkcyjno-Handlowe Elektromontaż-Export S.A.	0.4437	0.6091

No.	Company	*WPKI*	*WPKI''*
50	Mostostal Zabrze Holding S.A.	0.398	0.5982
51	Intakus S.A.	0.381	0.5941
52	Euro Bud Invest (EBI) S.A.	0.3533	0.5874
53	Projprzem S.A.	0.3452	0.5855
54	Prochem S.A.	0.3078	0.5763
55	Atlas Estates Limited	0.2271	0.5565
56	Beton Stal S.A.	0.1994	0.5497
57	Bick S.A.	0.1737	0.5433
58	TUP S.A.	0.1487	0.5371
59	Szczecińskie Przedsiębiorstwo Budownictwa Przemysłowego ESPEBEPE Holding S.A.	0.0657	0.5164

Source: authors' calculations based on companies' prospectuses (using NewKrefft).

5. Conclusions

The values of the *WPKI* determined using the algorithm to define a hidden variable show differences in the level of intellectual capital amongst the companies researched. As intellectual capital is generally regarded a source of value, its level should be strongly associated with company's financial condition. In subsequent papers, the authors will demonstrate that the *WPKI* for public construction companies is a statistically significant and strong predictor of the bankruptcy of a company. Since the level of intellectual capital of construction companies turns out to be an important factor in their survival/bankruptcy, we can suppose that, with a high probability, intellectual capital is also an important factor in the duration (survival time) and success of most modern enterprises (including banks and other financial institutions, mobile phone and media operators, manufacturers, technology and computer science companies etc.), which often, to a greater extent than construction companies, base their activities on intellectual resources, understood in a broad sense. Therefore, the authors of this paper recommend that the management boards of companies introduce methods of monitoring, measuring and managing intellectual capital. In this context, it also seems important to remind the reader how Skandia AFS visualizes a company. It is presented in the form of a tree that has its roots – intellectual capital and fruits – financial results. According to this concept, a company's financial results are therefore the fruits of the work of intellectual capital. It also follows that in today's realities of a dynamic market economy, classic financial analysis alone, based solely on the interpretation of financial indicators, is no longer a sufficient tool to assess the condition and value of a company.

Finally, the authors of the paper would like to underline the advantages of the method proposed by them for measuring a company's intellectual capital, namely meeting the criteria for being a model indicator. This method is universal in its terms of

application (criterion D1), because it allows the measurement of detailed aspects of the functioning of enterprises based on external sources (e.g. prospectuses for share emissions). Intellectual capital represents intangible assets of a company and because of this, first of all, tangible aspects of its functioning are measured (criterion D2). In the method presented, all the components of intellectual capital commonly described in the specialist literature are measured (criterion D3). This method is robust to changes in the choice and definition of the variables measured, as well as market fluctuations in their values (criterion D4). The method also defines a synthetic measure of the level of a company's intellectual capital (the *WPKI* indicator), which provides a simple composite measure of the level of a company's intellectual capital (criterion D5). The method takes into account the diversity of companies in different industries by assigning different weights to the various factors of the level of the intellectual capital of companies with different business profiles (criterion D6). The authors of this paper would also like to emphasize that the method presented is not only designed to measure the intellectual capital of public construction companies, but can be successfully used to measure the intellectual capital of companies with different profiles.

References

[1] ALLEE V., *The art and practise of being revolutionary*, J. Knowledge Manage., 1999, 3 (2), 121.

[2] BONTIS N., *Assessing knowledge assets. A review of the models used to measure intellectual capital*, Int. J. Manage. Rev., 2001, 3 (1), 41, [after:] ROOS J., ROOS G., DRAGONETTI N.C., EDVINSSON L., *Intellectual Capital. Navigating in the New Business Landscape*, MacMillan, Houndsmills, Basingtoke 1997.

[3] BONTIS N., *Managing organizational knowledge by diagnosing intellectual capital. Framing and advancing the state of the field*, [in:] C.W. Choo, N. Bontis (Ed.), *The Strategic Management of Intellectual Capital and Organizational Knowledge*, Oxford University Press, New York 2002.

[4] DOMINIAK P., MERCIK J., SZYMAŃSKA A., *A comparative analysis of chosen methods of measuring a company's intellectual capital*, [in:] D. Zarzecki (Ed.), *Financial Management. The Valuation of Enterprises, Value Management, Risk Management*, Szczecin University, Scientific Papers, No. 761, Finance, Financial Markets, Insurance, No. 60, 2013, 611 (in Polish).

[5] DOMINIAK P., *Forecasting the bankruptcy of public construction companies with the use of a synthetic indicator of a company's level of intellectual capital*, doctoral thesis, Wrocław University of Technology, Wrocław 2013 (in Polish).

[6] EDVINSSON L., MALONE M.S., *Intellectual Capital. Realizing Your Company's True Value by Finding Its Hidden Brainpower*, Harper Business, New York 1997.

[7] GOMULSKA K., SADOWSKA L., KREFFT A., GOMULSKA K., MAZUR A., *Early forecasting of infant pediatric celebral palsy using a synthetic analysis of risk factors*, Medical Review of Rzeszów University, 2006 (1), 47 (in Polish).

[8] HOFMAN-BANG P., MARTIN H., *A comparison of the IC rating to other methods of assessing intellectual capital*, E-mentor, 2005, 4 (11), 47.

[9] JACOBSEN K., HOFMAN-BANG P., NORDBY R. Jr ., *The IC Rating™ Model by Intellectual Capital Sweden*, J. Intel. Capital, 2005, 6 (4), 570.

[10] KREFFT A., *Diagnostic functions of hidden phenomena*, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 1999 (in Polish).
[11] KREFFT A., ŁOPACIŃSKA K., *Algorithms for estimating farmers' revenue from incomplete statistical data*, Wiad. Statyst., 1984 (8), 21 (in Polish).
[12] KUJANSIVU P., LÖNNQVIST A., *Investigating the value and efficiency of intellectual capital*, J. Intel. Capital, 2007, 8 (2), 272.
[13] LEWICKI E.R., *Innovation in the suggestopedic teaching of foreign languages*, Thesis, Acta Unversitatis Wratislaviensia, No. 1284, Germanica Wratislaviensia 41, Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław 1990 (in Polish).
[14] LUTHY D.H., *Intellectual capital and its measurement*, Proc. Conf. The Asian Pacific Interdisciplinary Research in Accounting (APIRA) Conference, Osaka 1998, http://www3.bus.osaka-cu.ac.jp /apira98/archives/pdfs/25.pdf, as at: 24.02.2012.
[15] MAJCHROWICZ B., SADOWSKA L., *Social problems related to studying the level of acceptance of organ and tissue transplants amongst inhabitants of the Podkarpacie Region*, Onkologia Polska, 2012, 15 (1), 9 (in Polish).
[16] MERCIK J., *Econometric estimation of hidden factors in group decision making – their impact on power index estimation*, Oper. Res. Decisions, 2007, 17 (3–4), 121.
[17] PANDEL W., *Method for supporting decision making processes in stock market investment*, doctoral thesis, Wrocław University of Technology, Wrocław 1999 (in Polish).
[18] PETRASH G., *Dow's Journey to a Knowledge Value Wrocław Management Culture*, Eur. Manage. J., 1996 (14).
[19] PIETRUSZKA-ORTYL A., *Intellectual capital as an indicator of a company's level of intangible assets*, [in:] W. Cieśliński (Ed.), *Companies as Temples of Knowledge*, Scientific Papers of Walbrzych School of Managements and Entrepreneurship, Vol. 2, Walbrzych 2002, 79 (in Polish).
[20] POŚLAD M., *Investor's Guidebook. How to Read a Prospectus*, Securities and Exchange Commission, Warsaw 2005.
[21] PREJZNER J., *Religious Knowledge in Religious Education and Ability to Overcome Difficulties in School among Youths with Motor Disorders. An Empirical and Analytical Study*, doctoral thesis, Papal Theological Faculty in Wrocław, Wrocław 2008 (in Polish).
[22] RODOV I., LELIAERT P., *FiMIAM. Financial method of intangible assets measurement*, J. Intel. Capital, 2002, 3 (3), 327.
[23] SADOWSKA L., GOMULSKA K., CHOIŃSKA A.M., PRZYGODA Ł., *An analysis of the risk of the development of pediatric cerebral palsy in the treatment of infants based on the Z_{ZRMPD} synthetic diagnostic function*, Rzeszów, Medical Review of Rzeszów University, 2008 (1), 49.
[24] SADOWSKA L., SKÓRZYŃSKA M., BLAŻEJCZYK M., CHOIŃSKA A.M., GÓRECKA B., BOBROWSKA R., FILIPOWSKI H., *Formation of emotional relationships between mothers and children with a psychosomatic disorder. Part II*, Medical Review of Rzeszów University, Rzeszów 2010 (2), 160.
[25] SHAIKH J.M., *Measuring and reporting of intellectual capital performance analysis*, J. Amer. Acad. Business, 2004, 4 (1/2), 439.
[26] SOPIŃSKA A., *Knowledge as a company's strategic asset. Analysis and measurement of a company's intellectual capital*, Oficyna Wydawnicza SGH, Warsaw 2010.
[27] STEWART T.A., *Brain Power. How Intellectual Capital is Becoming America's Most Valuable Asset*, Fortune, 03.07.1997.
[28] STEWART T.A., *The Wealth of Knowledge. Intellectual Capital and the Twenty-First Century Organization*, Nicholas Brealey Publishing, London 2001.
[29] *The Invisible Balance Sheet. Key indicators for accounting, control and evaluation of know-how companies*, Affärsvärlden-Ledarskap, Stockholm 1989.

[30] SZYMAŃSKA A., *A ranking of universities based on intellectual capital that stimulates demand and applicable in academic management*, doctoral thesis, Wrocław University of Technology, Wrocław 2014 (in Polish).
[31] THEIL H., *The Principles of Econometrics*, Wydawnictwo Naukowe PWN, Warsaw 1979 (in Polish).

Received 9 November 2015
Accepted 13 September 2016