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COMPARATIVE ANALYSIS OF METHODS OF MEASURING COMPANY'S INTELLECTUAL CAPITAL

Intellectual capital is, in general, considered to be a component of a company's market value, which is not always reflected in its financial statements. The authors analyzed 21 of the most common methods of measuring company's intellectual capital. Detailed analysis of these methods made it possible to identify a set of 7 basic criteria that clearly distinguish them. The paper presents a comparative matrix of methods of measuring intellectual capital in terms of all the considered criteria. It is shown that, among the best known methods of measuring intellectual capital, there is no so-called "standard measure", i.e. one which fulfils all the criteria at the same time.

Keywords: *intellectual capital, methods of measuring a company's intellectual capital, comparative analysis*

1. Introduction

The term "intellectual capital" was first used in 1958 by two stock analysts with reference to small companies from the computer science sector. These analysts came to the conclusion that the intellectual capital of these companies determined their high ratings on the stock market ([12], p. 79). Thomas Stewart defines intellectual capital as follows: (...) *every company depends increasingly on knowledge – patents, processes, management skills, technologies, information about customers and suppliers, and old-fashioned experience. Added together, this knowledge is intellectual capital* [16]. As

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Axtle-Ortiz highlights, the importance of the components and elements of the intellectual capital of individual companies varies and depends mainly on different cultural contexts in which these organizations are located [2]. Intellectual capital is an intangible asset of a company, the value of which is the second, after the value of a company's tangible assets (the company's book value), main component of the company's market value.

The purpose of this paper is to design a comprehensive comparative matrix of methods of measuring intellectual capital, which will allow to determine the area in which they can be applied. The emergence of so-called "standard measures", i.e. that meet all the comparative criteria at the same time, is also significant in this aspect or an indication of the need to create such universal measures of intellectual capital in the future.

In this paper, 21 of the most common methods of measuring company's intellectual capital were examined. These methods belong to the division proposed by Sveiby, who assigned all the methods of measuring intellectual capital to four groups [18]:

Market Capitalization Methods (MCM) – these methods consider the value of intellectual capital based on the simple difference between the market value and the book value of a company. The methods include: MV/BV index (Market-to-Book Value), Tobin's q index, IAMV™ model (Investor Assigned Market Value).

Return on Assets Methods (ROA) – using these methods, company's return on its assets (ROA) is compared to the average for the sector. The difference obtained is multiplied by the average value of tangible assets and that gives the average annual earnings of intangible assets. Then this amount is divided by the average cost of company's capital, which gives the total value of intellectual capital. The methods include: the KCE™ method (Knowledge Capital Earnings), EVA™ method (Economic Value Added), VAIC™ method (Value Added Intellectual Coefficient), CIV method (Calculated Intangible Value).

Direct Intellectual Capital Methods (DIC) – using these methods, components and elements of intellectual capital are identified and their monetary value is evaluated. The methods include: the Technology Broker model, IAV model (Intangible Assets Valuation), TVC™ model (Total Value Creation), AFTF model (Accounting for the Future), Value Explorer™ model, IVM™ model (Inclusive Valuation Methodology), Citation-Weighted Patents index.

Scorecard Methods (SC) – these methods also (like the DIC methods) identify elements of intellectual capital, but these elements are measured using a set of non-monetary indicators. The methods include: the Skandia Navigator™ model, IC Rating™ model, Value Platform model, Intangible Assets Monitor model, Balanced Scorecard model, VCS™ model (Value Chain Scoreboard), IC-Index (Intellectual Capital Index).

A detailed analysis of eight selected methods of measuring a company's intellectual capital (MV/BV index, Tobin's q index, KCE™ method, EVA™ method, Tech-

nology Broker model, IAV model, Skandia Navigator™ model and Intangible Assets Monitor model) is presented in [5].

2. Comparative criteria of methods of measuring intellectual capital

The considered methods of measuring intellectual capital were compared in terms of 7 criteria. This assessment was carried out on a dichotomous scale: 1 – the method meets the given sub-criterion/the given one-dimensional criterion, 0 – the method does not meet the given sub-criterion/the given one-dimensional criterion.

These comparative criteria (features) of methods of measuring intellectual capital were selected through a detailed and separate analysis of each of these methods, and also through a detailed study of the literature. As previously mentioned, making comparisons of methods of measuring a company's intellectual capital is of great importance because it allows us to determine the area in which they can be applied (which really makes it easy to select a concrete method according to, inter alia, the goal of the analysis or the available data) and to award the best or even standard measures of intellectual capital from a broad spectrum. In this way, the following comparative criteria (features) of methods of measuring a company's intellectual capital were formulated:

K1. The area of method's application – is considered in the perspective of managing a company (sub-criterion K1.1) and comparisons between companies (sub-criterion K1.2). It is, therefore, a two-dimensional criterion, consisting of two separately evaluated sub-criteria (K1.1 and K1.2). For example, if a given method is used for comparisons between companies but is not used for management of intellectual capital, the evaluation of sub-criterion K1.2 takes the value 1, and the evaluation of sub-criterion K1.1 takes the value 0. This criterion is compatible with the division of methods of measuring intellectual capital into two categories proposed by Shaikh [14], i.e. *external measures*, used for comparisons between companies, as well as *internal measures*, used for the management of intellectual capital or of the whole company.

K2. Availability of the data required by a method outside of an organisation – this criterion informs whether the data required by a given method are also available outside of an organization (criterion's evaluation takes the value 1) or not (criterion's evaluation takes the value 0). It is, therefore, a one-dimensional criterion. The external data required by methods of measuring intellectual capital originate mostly from: financial statements published by companies, quotations of companies' shares on the stock exchange, share emission prospectuses of stock companies, sectoral information (published by e.g. the Central Statistical Office (EUROSTAT, GUS, etc.), commercial and non-commercial business information agencies), data from the National Court

Register on economic activity and possibly the insolvency proceedings of enterprises, media reports etc.

K3. The type of data required by the method – this is a two-dimensional criterion. The data required by the method may be financial (K3.1), i.e. expressed in monetary units and clearly reflected, inter alia, in financial statements published by the company, or non-financial (K3.2), i.e. not expressed in monetary units. For example, if the given method uses only financial data, then the evaluation of sub-criterion K3.1 takes the value 1, and the evaluation of sub-criterion K3.2 takes the value 0.

K4. Elements of intellectual capital included in the method – this criterion allows us to specify which basic elements of intellectual capital are included in the method. The components of intellectual capital normally defined in the literature (e.g. by Edvinsson, Stewart Saint-Onge, Bontis, Lev and others), are: human capital, structural capital [3, 7, 11, 17] (organisational structural capital [8]/organisational capital [1]) and relational capital [3, 8] (relational structural capital [8]/customer capital [1, 11, 17]/market capital [15]). Structural capital is formed by intellectual property [8, 13] (innovation capital [7]) and processes [8] (process capital [7, 15], infrastructure assets [13]), and relational capital – by customers and networks of interconnections [1, 3], i.e. relationships with suppliers and other co-operators and strategic partners. Thus, the basic elements of intellectual capital are: *human capital* (K4.1), *intellectual property* (K4.2), *processes* (K4.3) (structural capital), *customers* (K4.4) and *networks of interconnections* (K4.5) (relational capital). It is, therefore, a five-dimensional criterion. For example, if a given method takes into account human capital, intellectual property and processes, but it does not include customers or networks of interconnections, the evaluations of sub-criteria K4.1, K4.2 and K4.3 take the value 1 and the evaluations of sub-criteria K4.4 and K4.5 take the value 0.

K5. Stability of the method – this criterion is based on whether the method is robust to the way of selecting and determining the measurement parameters and market fluctuations in these parameters (indicators) (the evaluation of this criterion takes the value 1) or not (the evaluation of this criterion takes the value 0). It is, therefore, a one-dimensional criterion. The analysis of methods of measuring intellectual capital allow us to identify five main causes of the instability of these methods which can generate paradoxes of measurement [4]. Paradoxes in the measurement of a company's intellectual capital may occur as a result of:

- taking the market value of company quoted on the Stock Exchange on a particular day (e.g. MV/BV index, Tobin's q index, IAMVTM model),
- assuming different return and discount rates (e.g. KCETM method, CIV method, IAV model, TVCTM model, AFTF model, Value ExplorerTM model),
- simulations of the impact of different events or the effects of different actions (e.g. TVCTM model, IVMTM model),

- individual and subjective selection of indicators characterizing the components of a company's intellectual capital (e.g. IAMV™ model, Skandia Navigator™ model, Intangible Assets Monitor model, Balanced Scorecard model, VCS™ model),
- making a variety of imprecise and often subjective accounting corrections (e.g. EVA™ method, AFTF model).

K6. Synthetic valuation of the total quantity of a company's intellectual capital – this criterion is based on whether a given method introduces a synthetic measure of the total value of a company's intellectual capital (the evaluation of this criterion takes the value 1) or not (the evaluation of this criterion takes the value 0). It is, therefore, a one-dimensional criterion. Such a synthetic measure can be expressed in monetary values or in the form of other numerical measures belonging to well-defined scales.

K7. Inclusion of the weights of the components and elements of intellectual capital in its valuation – this criterion is based on whether the method ascribes different weights to the components and elements of intellectual capital (the evaluation of this criterion takes the value 1) or not (the evaluation of this criterion takes the value 0). It is, therefore, a one-dimensional criterion.

3. Comparative matrix of methods of measuring intellectual capital

Tables 1, 2 present an evaluation of methods of measuring intellectual capital in terms of all 7 considered criteria. As mentioned above, this assessment has been carried out on a dichotomous scale: 1 – the method meets the given sub-criterion/the given one-dimensional criterion, 0 – the method does not meet the given sub-criterion/the given one-dimensional criterion. In the case of multi-dimensional criteria, i.e. composed of separately evaluated sub-criteria, their scores are defined to be the arithmetic means of the evaluations of all their sub-criteria. In the case of one-dimensional criteria, their scores coincide with their evaluations.

From the total score of each method in terms of the 7 considered criteria (Tables 1, 2), it is clear that among these methods there is no so-called “standard measure”, i.e. one which fulfils all the criteria at the same time. Moreover, looking at the partial evaluations, it is recognized that, in the case of each method of measuring intellectual capital, some criteria are only partially met. The worst method of measuring intellectual capital in terms of the total score for the 7 considered criteria is the economic value added EVA™ method, which obtained only 14.3% of all the points. Methods which were also rated poorly are the market-to-book value MV/BV index and Tobin's q index, which obtained 28.6% of all the points. The best methods in terms of the total score for the considered criteria are: the value added intellectual coefficient VAIC™ method, which obtained 72.9% of all the points, as well as the

technology broker model, IC Rating™ model and IC-Index, which obtained 64.3% of all the points. The IAMV™ model was also fairly highly rated (61.4% of all the points).

Table 1. Comparative matrix of methods of measuring a company's intellectual capital. Criteria K1–K3

Method		1	Criteria of evaluation							
			K1		S1	K2	S2	K3		S3
			K1.1	K1.2				K3.1	K3.2	
MCM	MV/BV index	2	0	1	0.5	1	1	1	0	0.5
	Tobin's q index	3	0	1	0.5	1	1	1	0	0.5
	IAMV™ model	4	1	0	0.5	0	0	1	1	1
ROA	KCE™ method	5	1	1	1	1	1	1	0	0.5
	EVA™ method	6	1	0	0.5	0	0	1	0	0.5
	VAIC™ method	7	1	1	1	1	1	1	0	0.5
	CIV method	8	1	1	1	1	1	1	0	0.5
DIC	Technology Broker model	9	1	0	0.5	0	0	1	1	1
	IAV model	10	1	0	0.5	0	0	1	1	1
	TVC™ model	11	1	0	0.5	0	0	1	1	1
	AFTF model	12	1	0	0.5	0	0	1	1	1
	Value Explorer™ model	13	1	0	0.5	0	0	1	1	1
	IVM™ model	14	1	0	0.5	0	0	1	1	1
	Citation-Weighted Patents index	15	1	0	0.5	0	0	1	1	1
SC	Skandia Navigator™ model	16	1	0	0.5	0	0	1	1	1
	IC Rating™ model	17	1	0	0.5	0	0	1	1	1
	Value Platform model	18	1	0	0.5	0	0	1	1	1
	Intangible Assets Monitor model	19	1	0	0.5	0	0	1	1	1
	Balanced Scorecard model	20	1	0	0.5	0	0	1	1	1
	VCS™ model	21	1	0	0.5	0	0	1	1	1
	IC-Index	22	1	0	0.5	0	0	1	1	1

S1–S3 – scores for criteria K1–K3, respectively, for meaning of other symbols see text.

Source: authors' study.

It should be noted that all the considered methods of measuring intellectual capital require financial data (the evaluation of sub-criterion K3.1 takes the value 1 for each method). Thus, sub-criterion K3.1 should be removed, because it does not differentiate between any of the considered methods of measuring intellectual capital.

In order to determine which of the considered sub-criteria/one-dimensional criteria are not redundant, it was decided to build a matrix of correlation coefficients. Yule's Φ coefficient, which measures the strength of the relationship between two dichotomous qualitative variables, seems to be suitable for this purpose. On the other hand, this coefficient has a fundamental disadvantage, i.e. its values are in the range [0; 1]

and therefore it does not indicate the direction of the relationship between two dichotomous variables*.

Table 2. Comparative matrix of methods of measuring a company's intellectual capital. Criteria K4–K7

1	K4					S4	K5	S5	K6	S6	K7	S7	Total score	Total score [%]
	K4.1	K4.2	K4.3	K4.4	K4.5									
2	0	0	0	0	0	0	0	0	0	0	0	0	2.00	28.6
3	0	0	0	0	0	0	0	0	0	0	0	0	2.00	28.6
4	1	1	1	1	0	0.8	0	0	1	1	1	1	4.30	61.4
5	0	0	0	0	0	0	0	0	1	1	0	0	3.50	50.0
6	0	0	0	0	0	0	0	0	0	0	0	0	1.00	14.3
7	1	1	1	0	0	0.6	1	1	1	1	0	0	5.10	72.9
8	0	0	0	0	0	0	0	0	1	1	0	0	3.50	50.0
9	1	1	1	1	1	1	1	1	1	1	0	0	4.50	64.3
10	1	1	0	0	0	0.4	0	0	1	1	0	0	2.90	41.4
11	0	0	0	0	0	0	0	0	1	1	0	0	2.50	35.7
12	0	0	0	0	0	0	0	0	1	1	0	0	2.50	35.7
13	1	0	1	0	0	0.4	0	0	1	1	0	0	2.90	41.4
14	1	1	1	1	1	1	0	0	1	1	0	0	3.50	50.0
15	0	1	0	0	0	0.2	0	0	1	1	1	1	3.70	52.9
16	1	1	1	1	0	0.8	0	0	1	1	0	0	3.30	47.1
17	1	1	1	1	1	1	1	1	1	1	0	0	4.50	64.3
18	1	1	1	1	1	1	0	0	0	0	0	0	2.50	35.7
19	1	1	1	1	1	1	0	0	0	0	0	0	2.50	35.7
20	1	1	1	1	0	0.8	0	0	0	0	0	0	2.30	32.9
21	1	1	1	1	1	1	0	0	0	0	0	0	2.50	35.7
22	1	1	1	1	1	1	0	0	1	1	1	1	4.50	64.3

S4–S7 – scores for criteria K4–K7, respectively, Total score [%] – as a percentage of the maximum number of points possible, for meaning of other symbols see text. Numbers 1–22 refer to Table 1.

Source: authors' study.

However, it is fairly easy to prove that, in the case of two dichotomous variables, Pearson's linear correlation coefficient r is equal in absolute value to Yule's Φ coefficient. Pearson's linear correlation coefficient r takes values from the range $[-1; 1]$ and thus it defines, as opposed to Yule's Φ coefficient, the direction of the relationship

*Sometimes, some authors report that Yule's Φ coefficient takes values from the range $[-1; 1]$. However, *de facto*, the values of this coefficient should be presented as absolute values, i.e. from the range $[0; 1]$, as the sign of this coefficient does not indicate the direction of the relationship between two dichotomous variables, since it only depends on the definition of the evaluation in the table. Thus, although Yule's coefficient indicates the strength of the relationship between two variables, it does not indicate the direction of this relationship.

between two variables. Therefore, Table 3 shows the matrix of Pearson's linear correlation coefficients between sub-criteria/one-dimensional criteria but the significances of these coefficients were assessed using the two-tailed χ^2 test for Yule's Φ coefficient at a significance level of $\alpha/2$ and the number of degrees of freedom equal to $df = 1$ ([9], p. 99–104). In this table, sub-criterion K3.1 has been omitted.

Table 3. Matrix of Pearson's linear correlation coefficients between sub-criteria/one-dimensional criteria

Criterion	K1		K2	K3	K4					K5	K6	K7
	K1.1	K1.2		K3.2	K4.1	K4.2	K4.3	K4.4	K4.5			
K1.1	1.00											
K1.2	-0.58 ***	1.00										
K2	-0.58 ***	1.00 *	1.00									
K3.2	0.51 ***	-0.88 *	-0.88 *	1.00								
K4.1	0.41	-0.48 †	-0.48 †	0.59 ***	1.00							
K4.2	0.41	-0.48 †	-0.48 †	0.59 ***	0.80 *	1.00						
K4.3	0.37	-0.42	-0.42	0.52 ***	0.91 *	0.71 **	1.00					
K4.4	0.31	-0.53 ***	-0.53 ***	0.60 ***	0.75 **	0.75 **	0.83 *	1.00				
K4.5	0.23	-0.40	-0.40	0.45 †	0.55 ***	0.55 ***	0.61 ***	0.74 **	1.00			
K5	0.13	0.09	0.09	-0.04	0.32	0.32	0.35	0.16	0.29	1.00		
K6	0.46 †	-0.08	-0.08	0.22	0.07	0.07	0.00	-0.13	-0.14	0.29	1.00	
K7	0.13	-0.23	-0.23	0.26	0.04	0.32	0.08	0.16	0.00	-0.17	0.29	1.00

Correlation is significant at significance level (two-tailed test): * – 0.001, ** – 0.01, *** – 0.05, † – 0.1.

Source: authors' study.

In the matrix of Pearson's linear correlation coefficients between sub-criteria/one-dimensional criteria (Table 3), among the 66 correlation coefficients, only 28 are significant at a significance level of 10%. However, it is worth noting that 6 coefficients are very highly significant, at the level of 0.1% ($\alpha = 0.001$).

It should be noted that between the second sub-criterion of the criterion "The area of the method's application" (K1), i.e. "For comparisons between companies" (K1.2), and the one-dimensional criterion "Availability of the data required by the method

outside the organisation" (K2) there is a 100% positive correlation, significant at the level of 0.1%. It seems obvious that if a method is used for comparisons between companies (K1.2), then, at the same time, the data required by the method need to be accessible outside the organisation (K2). Therefore, it can be concluded that sub-criterion K1.2 is equivalent to the one-dimensional criterion K2. Summing up, the criterion "Availability of the data required by the method outside the organisation" (K2) should be removed from the list of the evaluation criteria for the methods of measuring a company's intellectual capital because of its redundancy, i.e. it is equivalent to the sub-criterion "For comparisons between companies" (K1.2).

The removal of the redundant criterion K2 will not cause, however, any of the 21 considered methods of measuring intellectual capital to become suddenly the "standard measure" by meeting all the criteria (Tables 1, 2). Since none of the considered methods of measuring intellectual capital meets all the criteria required of a standard measure of a company's intellectual capital, the set of 7 criteria has been limited to the most significant criteria from a statistical point of view. Using a graphical method of variable selection, a graph of connections between significantly correlated sub-criteria/one-dimensional criteria was constructed (Fig. 1).

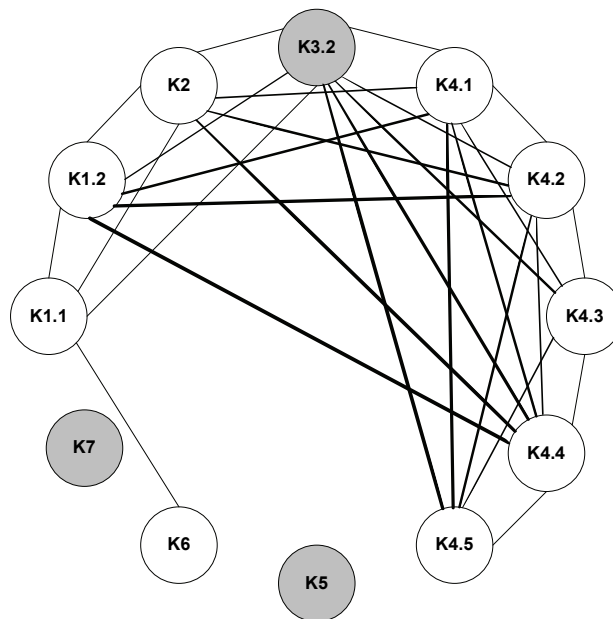


Fig. 1. Graph of connections (significant correlations) between sub-criteria/one-dimensional criteria. Source: authors' study

The information regarding significant correlations was derived from the matrix of Pearson's linear correlation coefficients (Table 3). This graphical method assumes

that, from the set of variables, so-called isolated variables, i.e. uncorrelated with other variables are selected, together with the variable which is correlated with the largest number of other variables [10]. The isolated variables in this graph are criterion K5 (“Stability of the method”) and criterion K7 (“Inclusion of weights of the components and elements of intellectual capital in its valuation”). On the other hand, sub-criterion K3.2 (“Non-financial” data required by the method) is characterized by the largest number of connections (significant correlations) with other sub-criteria/one-dimensional criteria, i.e. 8 connections. Therefore, using the graphical method of variable selection, three variables were selected: K5, K7, K3.2. Table 4 presents the evaluation of methods of measuring intellectual capital in terms of these three criteria.

Table 4. Comparative matrix of methods of measuring company’s intellectual capital in terms of 3 criteria

Method		1	Criteria of evaluation							Total score	Total score [%]
			K3.	S3	K5	S5	K7	S7			
			K3.2								
MCM	MV/BV index	2	0	0	0	0	0	0	0.00	0.0	
	Tobin’s q index	3	0	0	0	0	0	0	0.00	0.0	
	IAMV™ model	4	1	1	0	0	1	1	2.00	66.7	
ROA	KCE™ method	5	0	0	0	0	0	0	0.00	0.0	
	EVA™ method	6	0	0	0	0	0	0	0.00	0.0	
	VAIC™ method	7	0	0	1	1	0	0	1.00	33.3	
	CIV method	8	0	0	0	0	0	0	0.00	0.0	
DIC	Technology Broker model	9	1	1	1	1	0	0	2.00	66.7	
	IAV model	10	1	1	0	0	0	0	1.00	33.3	
	TVC™ model	11	1	1	0	0	0	0	1.00	33.3	
	AFTF model	12	1	1	0	0	0	0	1.00	33.3	
	Value Explorer™ model	13	1	1	0	0	0	0	1.00	33.3	
	IVM™ model	14	1	1	0	0	0	0	1.00	33.3	
	Citation-Weighted Patents index	15	1	1	0	0	1	1	2.00	66.7	
SC	Skandia Navigator™ model	16	1	1	0	0	0	0	1.00	33.3	
	IC Rating™ model	17	1	1	1	1	0	0	2.00	66.7	
	Value Platform model	18	1	1	0	0	0	0	1.00	33.3	
	Intangible Assets Monitor model	19	1	1	0	0	0	0	1.00	33.3	
	Balanced Scorecard model	20	1	1	0	0	0	0	1.00	33.3	
	VCS™ model	21	1	1	0	0	0	0	1.00	33.3	
	IC-Index	22	1	1	0	0	1	1	2.00	66.7	

Total score [%] – as a percentage of the maximum number of points possible.

Source: authors’ study.

Considering the total score of each method in terms of the 3 considered criteria (Table 4), it is clear that still none of these methods meet all the criteria at the same

time. The five highest rated methods meet only two of the three criteria (66.7% of all the points), i.e. the IAMV™ model, technology broker model, citation-weighted patents index, IC Rating™ model and IC-Index.

Summing up, it should be noted that none of the 21 common methods of measuring a company's intellectual capital considered here meet all the criteria required of a standard measure of a company's intellectual capital at the same time.

4. Conclusions

The analysis of the methods of measuring a company's intellectual capital allowed us to identify 7 criteria that should be fully met by a "standard measure". Unfortunately, among the 21 considered methods there is no method that meets all these criteria at the same time. Moreover, even after reducing the number of criteria to the 3 most significant criteria from a statistical point of view, there is no method that meets all three criteria at the same time. In the future, the authors intend to develop their own measure of a company's intellectual capital that will meet all the considered criteria. A general outline of this measure is presented in [6].

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