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Use of Fuzzy Logic in the Corporate Reputation Assessment: Stock Market Investors' Perspective

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***Abstract*—**The growing importance of reputation in building enterprise value and achieving long-term competitive advantage creates the need for its measurement and evaluation for the management purposes (effective reputation and its risk management). The paper presents practical application of self-developed corporate reputation assessment model from the viewpoint of stock market investors. The model has a pioneer character and example analysis performed for selected industry is a form of specific test for this tool. In the proposed solution, three aspects - informational, financial and development, as well as social ones - were considered. It was also assumed that the individual sub-criteria will be based on public sources of information, and as the calculation apparatus, capable of obtaining synthetic final assessment, fuzzy logic will be used. The main reason for developing this model was to fulfill the gap in the scope of synthetic measure of corporate reputation that would provide higher degree of objectivity by relying on "hard" (not from surveys) and publicly available data. It should be also noted that results obtained on the basis of proposed corporate reputation assessment method give possibilities of various internal as well as inter-branch comparisons and analysis of corporate reputation impact.

***Keywords*—**Corporate reputation, fuzzy logic, fuzzy model, stock market investors.

I. Introduction

IN the current information era, dominated by a very dynamic technical and technological progress and the increasing globalization processes, the sources of success and competitive advantage of the enterprises shift from tangible to intangible resources, related to knowledge and modern information technologies. Reputation of the enterprise is considered as the most valuable intangible asset of strategic character. Good reputation builds and strengthens customers' loyalty, allows acquiring the best employees, attracts attractive investors, helps establish cooperation with the best suppliers and contractors. These benefits translate into measurable results in the form of increased sales, lower marketing and capital costs, as well as higher profits and higher potential growth [1]. This is also reflected in the company's market value [2], [3], where it is estimated that reputation makes up to 60% [4]. It can be concluded that for some time we are dealing with the transition to build enterprise value based on reputation capital.

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According to [5], the growing importance of organization's reputation in recent years is not only the result of growing importance of intangible assets in building the value of the enterprise, but also a growing force of stakeholders in influencing the decisions and actions of the business world units (imperative stakeholders), progressive processes of globalization and technological and media revolution. Therefore, to build and maintain high positive reputation - reputation management - is becoming one of the most important and also the most difficult challenges for today's enterprises. In these circumstances, the question of particular importance is the fair assessment and measurement of reputation. The need to measure and to monitor the reputation has been recognized by the companies themselves by implementing appropriate programs and procedures. According to a study conducted at the turn of the XX and XXI century in 1998, the formal systems for measuring reputation existed in 19% of the surveyed companies, while in 2000 such systems were indicated by 42% of respondents [6]. Therefore, the reputation should be skillfully built and maintained, to manage effectively. Reputation management requires its measurement according to the principle that you can only manage what can be measured.

The variety of already used methods for assessing and measuring the reputation makes that the results are not reliable and cannot be used for inter-, cross-sectorial, and over time comparisons. In addition, the lack of generally accepted universal method of measuring reputation makes it difficult, or even impossible, to examine the relevant relationship between reputation and financial performance or the market value of the different entities. Therefore, the main purpose of the article is to indicate the proposal of the new procedure for assessing a company's reputation taking into account the use of quantitative and qualitative (descriptive) criteria coming from public sources.

II. Implications of Reputation Measurement and Conditions for Corporate Reputation Assessment Model Development

The complex nature of reputation creates serious consequences on the issues of its assessment and measurement. Particularly important implications relate to several key attributes resulting from the generally accepted definition. Reference [7] following [8] and [9] suggests that the reputation measurement should take into account its essential attributes resulting from the generally accepted definition.

Firstly, the reputation should be measured as a perception,

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the perception of the organization by stakeholders and not as objective facts, e.g. market share [10] or winning competitions [11]. These are objective measures which interfere with the perceptual nature of reputation. However, the study of stakeholders' perception requires the use of survey methods what leads to methodological difficulties, which can make the results questionable and unreliable. These include such issues as: The selection of a representative sample, the ability to reach all selected respondents, getting their credible opinion which depends on many factors (even momentary mood), the choice of the appropriate method of measurement survey, potential measurement errors, measurement frequency and related costs.

Secondly, in most definitions [12], [13], [7], including the most popular [14], reputation is defined as an aggregate perception of the organization, the way it is perceived by all the stakeholder groups. Apart from the above-mentioned difficulties of measuring perception of different stakeholder groups, the problem is how in practice make its aggregation. In this context, the question of relativism is revealed in the construction of reputation, understood as an opinion of different stakeholders on the company. Each interest group has a different relationship with the company, different needs, priorities and expectations and thus evaluates it from a different perspective. It is possible to have more than one reputation by a company and each one of them may be different. For example, if some retailer offers attractive retail prices at the expense of margins drain at intermediaries, it can gain a good reputation among customers, but much worse among wholesalers. The questions arise, whose opinion is more important? Is it necessary to take into account the point of views of all stakeholders? Or should it be assumed some hierarchy, e.g. proportional weights for each group separately? Is it assessing the importance of individual groups for a particular industry or perhaps one organization? Who would set the weights? This reputation attribute appears to reveal the biggest gap between theoretical reputation recognition and its measuring capabilities in practice.

Thirdly, reputation is the opinion formulated about the company all the time, so it has a relatively permanent nature. It may vary due to a variety of events, predictable and unpredictable in both directions; it can be improved or worsen. At this point the questions arise, how often should it be measured? Regularly or occasionally? It is worth noting that the frequency of measurement is associated with the costs. To resolve these and other reputation measurement dilemmas various suggestions and proposals are formulated. For example, [15] put forward the following two conclusions:

- There are multiple stakeholders whose assessments aggregate into collective judgments,
- There are different but overlapping financial and social criteria according to which stakeholders judge companies.

Therefore, a true reputation index can only result from sampling a representative set of stakeholders on a conceptually relevant set of criteria.

According to another concept, the problem of aggregate reputation assessment can be solved by measuring two components of reputation: The identity and image, assuming that the identity is based on the perception of internal stakeholders (managers and employees), and the image on the perception of external stakeholders (clients, customers, competitors, communities, government etc.). Reputation represent the sum of all individual grades [16].

Reference [17] suggests, that the full company's reputation measurement should include:

- Assessing reputation separately in different groups of stakeholders,
- Comparing the reputation of the company with competitors' reputation in the relevant market,
- Comparing the company's reputation with the ideal company's business model reputation in a given industry (or sector within the meaning of M. Porter).

The first postulate regards the fact that company's reputation is assessed by the various entities which use different criteria. It may therefore happen that one group will evaluate the company very high (e.g. investors for the very good financial results), while another group may express very different opinions (e.g. staff who will assess the company negatively due to unfavorable conditions of the employment contract).

Second and third suggestions concern the need to evaluate the company's reputation against the reference point, which may be the reputation of a competitor or a model company in the industry. Low assessment of company's reputation in the absolute sense does not necessarily mean low assessment comparing to others, or to the model, since industries are "burdened" objectively with negative assessment (e.g. cigarette, chemicals manufacturers). Then, the best grade will be much lower than in other industries.

Discussed reputation attributes arising from its commonly accepted definition and questions and suggestions regarding the measurement and assessment put forward by the various authors support the thesis that the complex structure and amorphous nature make it difficult to develop a universal methodology and its reliable measurement or assessment.

Due to the methodology of obtaining final result reputation assessment or measurement, methods used nowadays (*Overall Reputation Score* by [18], *Reputation Quotient* by [16], *Reputation Index* [19], *SPIRIT* by [20] or *Reputation Index* by [21]) are characterized by a high level of subjectivity and are subjected to potential errors, which are characteristic for the survey measurement. In addition, due to the selection of assessment criteria and the respondents, they do not really evaluate company's reputation or in general, taking into account the views of all stakeholders, and either in narrowed terms, to the point of view of a particular group of stakeholders. As for the applicable criteria for assessing reputation, they are often not clear enough, duplicated, overlap each other and are dominated by the financial aspects. All this makes that not only these methods are difficult for general use and expensive, but at the same time generated results may not be accurate and reliable. These imperfections of the currently used methods for assessing company's reputation were the reason for developing basic assumptions of the enterprise

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reputation assessment fuzzy model from the viewpoint of stock market investor, which is presented in this article.

The corporate reputation model, developed by using the fuzzy sets, model of company's reputation has the following characteristics, which allow to partially minimize the imperfections of presented earlier methods:

- Combination of analytical and synthetic reputation assessment, achieved through the use of sub-criteria, then aggregated to more general assessments;
- Combination of quantitative and qualitative approach to reputation assessment, manifested in the quantitative dimension of the used reputation indicators and qualitative method to determine the diversity of reputation (descriptive characteristics of individual criteria: Low, medium, high);
- The use in assessment process data contained in public sources of information, in particular enterprises periodic reports;
- Ensuring reliability and flexibility simultaneously, through the use of qualitative and quantitative data;
- The ability to carry out the assessment by external and internal stakeholders without the use of advanced computational techniques.

III. Basic Assumptions and Corporate Reputation Assessment Model Structure

Based on the community interview among the stock market investors on the Polish capital market and analyzes on expectations of investors, which were presented in [22], in the proposed solution for the needs of corporate reputation assessment three main aspects were taken into account, which are relevant from the viewpoint of capital market participants:

- Informational aspects, regarding reporting by the listed companies;
- Financial and development aspects, regarding possible financial benefits of listed companies' shareholders;
- social aspects, taking into account relations between Company's shareholders, as well as company's relations with the surrounding.

Application of fuzzy sets for detailed calculations of companies' reputation assessment entails the construction of the so-called fuzzy model, based on expert knowledge. Information necessary to achieve this goal should be acquired through the interview questionnaire, which should be addressed to stock market investors, in particular, those specializing in fundamental analysis of the companies. It should also be noted that in a situation where a given person has a good knowledge in the scope of the analyzed category he or she may develop an original model, which will not be a resultant knowledge of many different investors.

As the basic source of information in assessing companies' reputation, it is assumed to use publicly disclosed information presented by the listed companies in their periodic reports, mainly annual reports and CSR reports (if published), prospectuses and corporate websites. Such choice of information sources is dictated in particular the perspective of reputation assessment (stock market investors) in the presented method. However, regardless of above, it allows the use of large amount of various (both quantitative and qualitative, i.e. descriptive) concrete criteria for reputation assessment, relating to the actual situation of enterprises, without the need to support the research with survey results. It is also important that the interim (usually quarterly) automatic updates of the basic data used in the proposed reputation assessment method arises from the statutory deadlines for publication of interim reports by the listed companies.

Specific criteria for reputation assessment in the developed model were separated taking into account opinions obtained during the community interview with stock market investors, several years of experience of the author in the field of fundamental analysis of companies and investments in the capital market, as well as the capacity of the information of interim reports published by the listed companies. In accordance with previously adopted general division of enterprises reputation factors from the viewpoint of stock market investors in three basic dimensions, detailed assessment criteria are broken down into information, financial and development, as well as social aspects.

First assessment criteria in the **scope of information** have been characterized taking into account the quality of reporting and financial results forecasts. Within both of the abovementioned areas were selected more specific assessment categories. In case of ***assessment quality*** these are assessment of *financial reporting*, viewed through the prism of transparency (complete positions in individual elements of the financial statement) and reliability (if once published data is corrected in subsequent periods or not, and if so, to what extent) the financial data and assessment of *descriptive information*, viewed through the prism of presentation form (pdf?, text document?, photocopying?) and wide information in published reports (except for the financial data is there an extended commentary from the management board, regarding also intellectual capital, innovation activity including R&D, markets and market offer?). On the other hand, in case of ***financial results forecasts*** were taken into account the issue of *forecasts disclosure* (systematically?, occasionally?, never?) and their *accuracy.*

Within financial and development dimension it was decided to base reputation assessment on ***financial situation and development perspectives*** and ***company's dividend policy.*** Regarding the first of these areas, the assessment focuses on *financial situation of the company*, seen through the prism of the financial efficiency and results (revenues from sales, net profit from sales, cost level ratio, return on equity capital ratio growth and its changes in time based on semi-deviation) and solvency (company's ability to regulate short-term and long-term liabilities and its changes in time based on semi-deviation) and *innovativeness*, where were taken into account both, the quality of innovative potential (amortization ratio of fixed and intangible assets and human capital level), and engagement in its development (human capital training, fixed and intangible assets growth) as well as the results of innovation activity (i.e. implementation of new solutions). On the other hand, the second area of reputation assessment

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focuses on the *amount of dividends paid* (dividend yield and its changes in time based on semi-deviation) and its *regularity* (never?, occasionally?, systematically?).

Finally, in the third reputation assessment dimension - **the social dimension** – there were taken into account company's shareholding issues and the relations between the company and the surrounding. In the case of the ***shareholding*** on the one hand, the focus was on its *structure* (spread shareholding?, with the treasury?, with investor or financial investors?, with a dominant share of one entity?) and on the other on the *assessment of possible abuse by shareholders holding privileged position* (e.g. the treasury or the dominant investor). Regarding ***relations between the company and the surrounding*** the assessment includes the issues of *judicial proceedings* and *adjudicated penalties*, including the amounts and frequency of such events, as well as co*mpany's activity in the area of corporate social responsibility*, perceived through actions towards friendly work environment and overcome (or compensate) adverse effects of its activities on the environment and local community.

In accordance with earlier presented approach, the overall corporate reputation assessment from the viewpoint of stock market investors is the result of three dimensions described above, i.e. informational, financial and development and social. The general structure of the proposed company's reputation assessment model consistent with this approach is shown in Fig. 1.

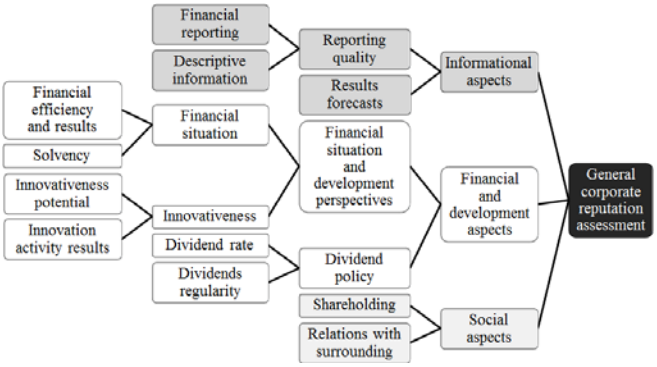


Fig. 1 General structure of corporate reputation assessment model from the viewpoint of stock market investors

In the proposed model, first it is predicted to obtain partial assessment within the basic criteria of reputation assessment. These assessments will result from the calculated ratios based on data from financial statements or in case of failing to perform such calculations, the qualitative assessment (descriptive) resulting from the description/characteristics of the given criterion in the interim report of the surveyed subject (such situation might apply in partial criteria within information and social dimension). Then, on this basis, using fuzzy logic, which is one of the approximate reasoning methods [23], it is assumed to obtain increasingly aggregated assessments until reporting quality, results forecasts, current financial situation and development perspectives, dividend policy, shareholding and relations with surrounding. These assessments will be the basis for the calculation of the overall reputation measurements, regarding information, financial and development, as well as social dimensions, in order to obtain in the final stage an overall reputation assessment of the entity from the viewpoint of stock market investors.

IV. Methodology of Corporate Reputation Assessment Fuzzy Model Construction

The procedure in the process of building the fuzzy model of corporate reputation assessment was carried out in four main stages (Fig. 2), based on the Mamdani approach [24].

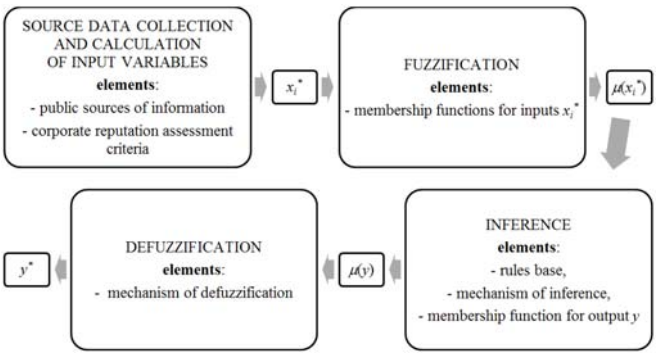


Fig. 2 Construction scheme of corporate reputation assessment fuzzy model

In the first stage, it is assumed to gather source data and calculate input criteria x_i^* to model. According to previously adopted assumptions, the basic criteria for assessing corporate reputation are based entirely on public data, which may be obtained by analyzing the content of interim reports and financial statements published by the companies.

For the needs of the "fuzzification" module, in the second stage there is the need to determine the form of the fuzzy sets for respective input variables, and also for these variables the basic terms set and the division of their value spaces. Due to similarities in the expression of natural language assessments of the individual variables, for the purpose of this fuzzy model it was adopted the same linguistic dictionary and division of values space for the respective groups (input and output variables) – in the case of input variables, into three fuzzy sets {low, medium, high} and for output variables, in order to obtain more accurate results, into five fuzzy sets {low, low-medium, medium, medium-high, high}. Moreover, because of the ease of use and great versatility of both variable groups, it was adopted the triangular shape of the membership function for each fuzzy set and equal division of their value spaces (Figs. 3 and 4). The characteristic points describing the membership functions of each fuzzy set for input variables can be set arbitrarily and for the output variables, due to the fact that they all take values from 0 to 1, every 0.25.

Membership function values at intermediate points of triangular fuzzy sets can be determined through the use of linear interpolation method.

Stage 3 involves creating relevant rules bases for the needs of the inference" module, determining the mechanism of

inference and defining the output membership function of the model.

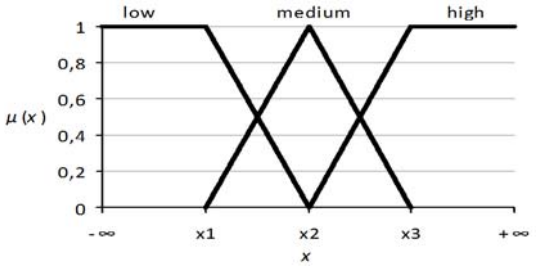


Fig. 3 The general form of the input variables membership function $\mu(x)$ to distinguished fuzzy sets

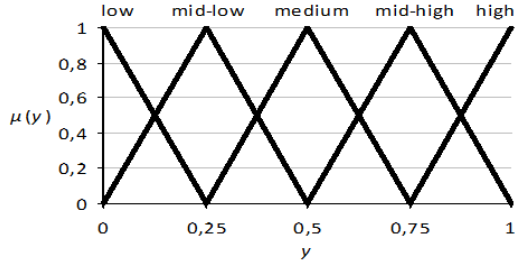


Fig. 4 The output variables membership function $\mu(y)$ to distinguished fuzzy sets

The basic mean which allows to present dependencies between adopted linguistic variables are fuzzy conditional sentences. In most basic form a conditional sentence can be written as [25]:

$$\text{IF } x \text{ is } A \text{ THEN } y \text{ is } B,$$

where the expression "x is A" is called the "*predecessor*", which contains a set of conditions (rules), and the expression "y is B" means "*successor*" or conclusion.

Predecessor of the rule can also have the character of complex sentence, where generally it is accepted, that it is a conjunction of a certain fuzzy sentences:

$$\text{IF } x_1 \text{ is } A_1 \text{ AND } \ldots \text{ AND } x_m \text{ is } A_m \text{ THEN } y \text{ is } B.$$

Typically, the relation between the same variables is described not by a single rule, but by so called (base) rules bank of form:

R_1: IF x_1 is A_1^1 AND ... AND x_m is A_m^1 THEN y is B^1

.

.

R_m: IF x_1 is A_1^K AND ... AND x_m is A_m^K THEN y is B^K

Rules bank is treated in a fuzzy inference process as a whole – a subsystem which cumulative effects are subjected to further processing. In inference process for the data inputs are activated all the rules contained in the bank, and the results of their actions are then merged into the resulting fuzzy set, which is the value of the y variable. The given rules bank may describe the relation between the input and output of the entire system, or it may be part of a more a complex hierarchical structure.

Taking into consideration the model structure, which in general form was presented in Fig. 1, 35 knowledge (rules) bases in the form of IF – THAN were created.

Due to large volume of all knowledge (rules) bases included in the proposed model, below are presented only the last four of them.

Rules base for assessment in the area of informational aspects – *IA* (*RQ* – assessment of reporting quality, *RF* – assessment of results forecasts):

R1: IF *RQ* is low AND *RF* is low THEN *IA* is low
R2: IF *RQ* is low AND *RF* is medium THEN *IA* is low
R3: IF *RQ* is low AND *RF* is high THEN *IA* is mid-low
R4: IF *RQ* is medium AND *RF* is low THEN *IA* is mid-low
R5: IF *RQ* is medium AND *RF* is medium THEN *IA* is medium
R6: IF *RQ* is medium AND *RF* is high THEN *IA* is mid-high
R7: IF *RQ* is high AND *RF* is low THEN *IA* is mid-high
R8: IF *RQ* is high AND *RF* is medium THEN *IA* is high
R9: IF *RQ* is high AND *RF* is high THEN *IA* is high

Rules base for assessment in the area of financial and development aspects – *FDA* (*FSDP* – assessment of financial situation and development perspectives, *DP* – assessment of dividend policy):

R1: IF *FSDA* is low AND *DP* is low THEN *FDA* is low
R2: IF *FSDA* is low AND *DP* is medium THEN *FDA* is mid-low
R3: IF *FSDA* is low AND *DP* is high THEN *FDA* is mid-low
R4: IF *FSDA* is medium AND *DP* is low THEN *FDA* is mid-low
R5: IF *FSDA* is medium AND *DP* is medium THEN *FDA* is medium
R6: IF *FSDA* is medium AND *DP* is high THEN *FDA* is mid-high
R7: IF *FSDA* is high AND *DP* is low THEN *FDA* is mid-high
R8: IF *FSDA* is high AND *DP* is medium THEN *FDA* is high
R9: IF *FSDA* is high AND *DP* is high THEN *FDA* is high

Rules base for assessment in the area of social aspects – *SA* (*Sh* – assessment of shareholding, *RS* – assessment of relations with surrounding):

R1: IF *Sh* is low AND *RS* is low THEN *SA* is low
R2: IF *Sh* is low AND *RS* is medium THEN *SA* is low
R3: IF *Sh* is low AND *RS* is high THEN *SA* is mid-low
R4: IF *Sh* is medium AND *RS* is low THEN *SA* is mid-low
R5: IF *Sh* is medium AND *RS* is medium THEN *SA* is medium
R6: IF *Sh* is high AND *RS* is low THEN *SA* is medium
R7: IF *Sh* is medium AND *RS* is high THEN *SA* is mid-high
R8: IF *Sh* is high AND *RS* is medium THEN *SA* is high
R9: IF *Sh* is high AND *RS* is high THEN *SA* is high

Rules base for assessment in the area of general corporate reputation – *CR* (*IA* – informational aspects, *F&DA* – financial and development aspects, *SA* – social aspects):

R1: IF *IA* is low AND *FDA* is low AND *SA* is low THEN *CR* is low
R2: IF *IA* is low AND *FDA* is low AND *SA* is mid THEN *CR* is low
R3: IF *IA* is low AND *FDA* is mid AND *SA* is low THEN *CR* is low
R4: IF *IA* is mid AND *FDA* is low AND *SA* is low THEN *CR* is low
R5: IF *IA* is low AND *FDA* is low AND *SA* is high THEN *CR* is mid-low
R6: IF *IA* is low AND *FDA* is mid AND *SA* is mid THEN *CR* is mid-low
R7: IF *IA* is low AND *FDA* is mid AND *SA* is high THEN *CR* is mid -low
R8: IF *IA* is low AND *FDA* is high AND *SA* is low THEN *CR* is mid -low
R9: IF *IA* is low AND *FDA* is high AND *SA* is mid THEN *CR* is mid-low

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R10: IF *IA* is mid AND *FDA* is low AND *SA* is mid THEN *CR* is mid-low
R11: IF *IA* is mid AND *FDA* is low AND *SA* is high THEN *CR* is mid-low
R12: IF *IA* is mid AND *FDA* is mid AND *SA* is low THEN *CR* is mid-low
R13: IF *IA* is high AND *FDA* is low AND *SA* is low THEN *CR* is mid-low
R14: IF *IA* is high AND *FDA* is low AND *SA* is mid THEN *CR* is mid-low
R15: IF *IA* is low AND *FDA* is high AND *SA* is high THEN *CR* is medium
R16: IF *IA* is mid AND *FDA* is mid AND *SA* is mid THEN *CR* is medium
R17: IF *IA* is mid AND *FDA* is high AND *SA* is low THEN *CR* is medium
R18: IF *IA* is high AND *FDA* is low AND *SA* is high THEN *CR* is medium
R19: IF *IA* is high AND *FDA* is mid AND *SA* is low THEN *CR* is medium
R20: IF *IA* is mid AND *FDA* is mid AND *SA* is high THEN *CR* is mid-high
R21: IF *IA* is mid AND *FDA* is high AND *SA* is mid THEN *CR* is mid-high
R22: IF *IA* is mid AND *FDA* is high AND *SA* is high THEN *CR* is mid-high
R23: IF *IA* is high AND *FDA* is mid AND *SA* is mid THEN *CR* is mid-high
R24: IF *IA* is high AND *FDA* is mid AND *SA* is high THEN *CR* is mid-high
R25: IF *IA* is high AND *FDA* is high AND *SA* is low THEN *CR* is mid-high
R26: IF *IA* is high AND *FDA* is high AND *SA* is mid THEN *CR* is high
R27: IF *IA* is high AND *FDA* is high AND *SA* is high THEN *CR* is high

In order to carry out fuzzy inference and to implement conjunction conditions in individual rules (calculating veracity degrees of predecessors), it is proposed to apply the operation PROD given in [24]:

$$h = \mu_{A1\cap A2}(x_1, x_2) = \mu_{A1}(x_1) \cdot \mu_{A2}(x_2), \quad (1)$$

for cases with two input variables, or

$$h = \mu_{A1\cap A2\cap A3}(x_1, x_2, x_3) = \mu_{A1}(x_1) \cdot \mu_{A2}(x_2) \cdot \mu_{A3}(x_3), \quad (2)$$

for cases with three input variables.

In comparison to other t-norm operators, e.g., MIN operator, the PROD operator responds to the changes in all inputs xi model with low computation burden. On the other hand, to find the resulting fuzzy sets for respective rules (i.e., reducing the accuracy of the successor rules using the veracity of its predecessor) and merging rules action in one output set, it is recommended to perform in accordance with the SUM-MIN scheme [24]:

$$\mu_{B*}(y) = \mathrm{MIN}(\mu_B(y), h), \quad (3)$$

$$\mu_{res}(y) = \mathrm{SUM}(\mu_{B*1}(y), \ldots, \mu_{B*K}(y)) = \sum \mu_{B*K}(y) \quad (4)$$

The basic advantage of using the SUM-MIN scheme in the inference process is taken into account when calculating the resulting $\mu_{res}(y)$ function of all component functions $\mu_{Bi*}(y)$ from the respective rules and not, as in the case of the MAX-MIN scheme, only this function, where the degree of membership for a given y output value is the biggest.

For the needs of the "defuzzification" module, in the fourth and final stage, it should be determined a method of converting the outputs of the model from the fuzzy values to the accurate (non-fuzzy) figures. It was decided to use the simplified method of sums center. In this case, the resulting value of the fuzzy model output (y^*) is expressed with [24]:

$$y^* = \frac{\sum_{i=1}^{l} y_i \sum_{K=1}^{m} \mu_{B*K}(y_i)}{\sum_{i=1}^{l} \sum_{K=1}^{m} \mu_{B*K}(y_i)}, \quad (5)$$

where: l – number of elements of the discrete basic set Y, m – number of rules of fuzzy model.

As a result, it is received a ready to use fuzzy model of corporate reputation assessment. The intermediate and final assessments generated by the model take values in the range between 0 and 1, where from the viewpoint of analysed issue, values closer to 1 mean a very favourable results (better corporate reputation), while values closer to 0 indicate a results less favourable (worse corporate reputation).

V. Application of Developed Fuzzy Model to Corporate Reputation Assessment in Polish Banking Sector

A. Special and Detailed Assumptions of Corporate Reputation Assessment Fuzzy Model Construction

In order to verify proposed fuzzy model, the corporate reputation assessment was conducted for nine banks listed on the Warsaw Stock Exchange with at least 7 years history of public reporting and listing:

- BOŚ Bank – BOS,
- Bank Zachodni WBK – BZW,
- Bank Handlowy – BHW,
- Getin Noble Bank – GNB,
- ING Bank Śląski – ING,
- mBANK – MBK,
- Bank Millennium – MIL,
- Bank PEKAO – PEO,
- Bank PKOBP – PKO.

Due to the specific nature of financial reporting by banks, application of developed fuzzy model required to make some special assumptions:

- As revenues from sales were taken the sum of interests revenues and fees and commissions revenues;
- Net profit from sales was calculated as follows: EBIT – other operational revenues + other operational costs;
- Cost level ratio was calculated as quotient of general revenues (interests revenues, fees and commissions revenues, net trading, hedging and fair value income, dividends and other income from equity investments) and basic activity costs (interests cost, fees and commissions costs, payroll and other administrative costs);
- As the solvency measure was taken the general capital adequacy ratio;
- Work efficiency ratio was calculated as a quotient of sales revenues and average number of employees;
- Efficiency of intangible and fixed assets was calculated as quotient of revenues from sales and average net value of intangible and fixed assets, where intangible and fixed assets are the sum of intangible assets without goodwill and property, plant and equipment.

To the above assumptions was also added one, that refers to the long term character of the corporate reputation – all of the assessment criteria used in the model were calculated or described in 7 years period, to take into account probable period of growth and economic downturn.

The characteristic points describing the membership functions of each fuzzy set for input variables were set

arbitrarily, basing on the distribution of analysed variables values and author's years of experience in the area of companies fundamental situation analysis (Table I).

All calculations related to the presented fuzzy model were based on the self-developed structure of formulas in MS Excel.

TABLE I
VALUES OF FUZZY SETS CHARACTERISTIC POINTS FOR THE PARTICULAR INPUT VARIABLES OF CORPORATE REPUTATION ASSESSMENT MODEL

Variable	Unit	x1	x2	x3
Transparency of financial data*	-	0	0.5	1
Credibility of financial data*	-	0	0.5	1
Form of presentation*	-	0	0.5	1
Information scope*	-	0	0.5	1
Financial results forecast*	-	0	0.5	1
Accuracy of forecasted results*	-	0	0.5	1
Average revenues from sales growth**	%	0	3	6
Semi-deviation of revenues from sales growth**	%	0	3	6
Average net profit from sales growth **	%	0	4	8
Semi-deviation of net profit from sales growth**	%	0	4	8
Average cost level ratio**	-	0.5	0.7	0.9
Semi-deviation of cost level ratio**	-	0	0.1	0.2
Average return on equity capital ratio**	%	0	7	14
Semi-deviation of return on equity capital ratio**	%	0	3.5	7
Average capital adequacy ratio**	%	12	14	16
Semi-deviation of capital adequacy ratio**	%	0	1	2
Average salaries per 1 employee**	000' PLN	50	80	110
Semi-deviation of salaries per 1 employee**	000' PLN	0	15	30
Average work efficiency**	000' PLN/employee	0	300	600
Semi-deviation of work efficiency**	000' PLN/employee	0	150	300
Average amortization ratio of intangible and fixed assets**	-	0	0.5	1
Semi-deviation of intangible and fixed assets amortization ratio**	-	0	0.25	0.5
Average efficiency of intangible and fixed assets**	-	0	3	6
Semi-deviation of intangible and fixed assets efficiency*	-	0	1.5	3
Average intangible and fixed assets growth**	%	0	5	10
Semi-deviation of intangible and fixed assets growth**	%	0	5	10
Investment in human capital*	-	0	0.5	1
Innovation activity results*	-	0	0.5	1
Average dividend yield**	%	0	4	8
Semi-deviation of dividend yield**	%	0	4	8
Dividends regularity**	-	0	0.5	1
Average reserves on judicial proceedings and penalties payed to equity capital**	%	0	5	10
Semi-deviation of reserves on judicial proceedings and penalties payed to equity capital**	%	0	2.5	5
Corporate social responsibility*	-	0	0.5	1
Shareholding*	-	0	0.5	1

* Descriptive source data;
** Quantitative source data.

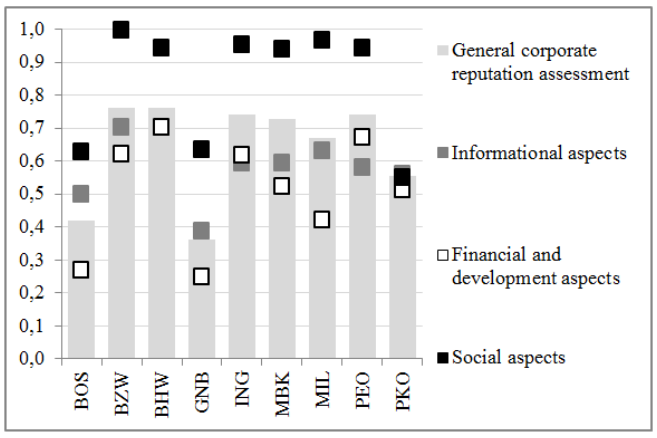


Fig. 5 General corporate reputation assessment

B. Obtained Results

According to the adopted methodology, the basis for the corporate reputation assessment of mentioned earlier banks were data acquired from the annual reports published by them in the years 2010-2016. The results obtained during the research are presented in Table II and for better illustration on Figs. 5-8.

Taking into account carried out research it can be seen (Fig. 5) that the highest corporate reputation assessments were obtained by BZW and BHW. In both cases the informational aspects were assessed similarly (Fig. 6), but BZW presented slightly better in social aspects due to relations with surrounding (Fig. 8) and BHW in financial and development ones due to better dividend policy (Fig. 7). Only slightly lower reputation assessments, than the above-mentioned two, were

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received for ING, MBK and PEO, mainly due to a weaker reporting quality than BZW and BHW. After them was ranked MIL and then PKO. MIL was a bit better in informational and social aspects than ING, MBK and PEO, but much worse in financial and development ones. PKO on the other hand was much worse in informational and social aspects than earlier mentioned banks, but slightly better than MIL in financial and development area.

TABLE II
PARTIAL CORPORATE REPUTATION ASSESSMENT CRITERIA VALUES AND RESULTS OBTAINED

	BOŚ	BZW	BHW	GNB	ING	MBK	MIL	PEO	PKO
Transparency of financial data	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Credibility of financial data	0,80	1,00	1,00	0,70	1,00	0,90	1,00	0,90	0,90
Financial reporting	**0,77**	**1,00**	**1,00**	**0,67**	**1,00**	**0,88**	**1,00**	**0,88**	**0,88**
Form of presentation	1,00	1,00	1,00	1,00	0,75	1,00	1,00	1,00	1,00
Information scope	0,60	0,90	0,90	0,40	0,80	0,80	0,70	0,75	0,65
Descriptive information	**0,78**	**0,93**	**0,93**	**0,62**	**0,75**	**0,87**	**0,82**	**0,84**	**0,80**
Reporting quality	**0,75**	**0,95**	**0,95**	**0,64**	**0,84**	**0,84**	**0,88**	**0,83**	**0,81**
Financial results forecast	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Accuracy of forecasted results	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Results forecasts	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Informational aspects	**0,50**	**0,70**	**0,70**	**0,39**	**0,59**	**0,59**	**0,63**	**0,58**	**0,56**
Average revenues from sales growth	2,32	8,11	-6,01	1,02	1,42	2,10	0,34	-4,36	1,68
Semi-deviation of revenues from sales growth	7,08	5,78	3,96	9,55	3,97	4,95	5,49	6,19	7,04
Revenues from sales	**0,22**	**0,52**	**0,05**	**0,11**	**0,24**	**0,27**	**0,07**	**0,00**	**0,17**
Average profit from basic activity growth	2,53	11,59	-2,81	1,81	8,07	8,57	6,25	-1,27	2,38
Semi-deviation of profit from basic activity growth	2,99	6,62	3,85	10,71	4,08	5,06	11,84	4,36	5,94
Profit from basic activity	**0,40**	**0,59**	**0,01**	**0,14**	**0,74**	**0,68**	**0,39**	**0,02**	**0,27**
Financial results	**0,32**	**0,55**	**0,05**	**0,16**	**0,49**	**0,48**	**0,25**	**0,02**	**0,24**
Average cost level ratio	0,89	0,63	0,64	0,70	0,72	0,69	0,76	0,64	0,62
Semi-deviation of cost level ratio	0,02	0,02	0,02	0,04	0,02	0,03	0,05	0,02	0,03
Cost level ratio	**0,23**	**0,76**	**0,75**	**0,66**	**0,65**	**0,69**	**0,49**	**0,76**	**0,76**
Average return on equity capital ratio	3,27	16,02	11,53	10,92	12,35	11,26	8,78	12,49	13,72
Semi-deviation of return on equity capital ratio	2,53	1,70	1,54	4,17	0,96	3,07	3,30	1,16	1,89
Return on equity capital ratio	**0,33**	**0,85**	**0,77**	**0,59**	**0,84**	**0,67**	**0,58**	**0,83**	**0,82**
Financial efficiency	**0,30**	**0,77**	**0,74**	**0,62**	**0,73**	**0,67**	**0,53**	**0,77**	**0,76**
Financial efficiency and results	**0,33**	**0,66**	**0,39**	**0,39**	**0,61**	**0,57**	**0,39**	**0,39**	**0,50**
Average capital adequacy ratio	13,14	14,55	17,44	11,46	13,84	16,05	14,27	17,46	13,41
Semi-deviation of capital adequacy ratio	0,47	0,11	0,50	1,21	1,04	1,85	1,19	0,50	0,57
Capital adequacy ratio	**0,33**	**0,61**	**0,84**	**0,04**	**0,46**	**0,54**	**0,49**	**0,84**	**0,38**
Financial situation	**0,34**	**0,59**	**0,45**	**0,24**	**0,54**	**0,54**	**0,44**	**0,45**	**0,44**
Average salaries per 1 employee	92,63	101,29	129,16	58,32	104,09	101,46	87,87	97,12	83,95
Semi-deviation of salaries per 1 employee	3,27	3,62	7,22	2,87	7,42	1,36	4,85	3,40	6,03
Salaries per 1 employee	**0,84**	**0,87**	**0,85**	**0,71**	**0,82**	**0,92**	**0,79**	**0,85**	**0,75**
Average work efficiency	457,60	536,62	494,12	733,16	546,64	657,28	534,64	480,76	501,95
Semi-deviation of work efficiency	37,44	26,28	17,24	70,11	30,38	26,40	31,25	25,86	44,22
Work efficiency	**0,79**	**0,87**	**0,85**	**0,85**	**0,88**	**0,94**	**0,86**	**0,83**	**0,81**
Human capital	**0,78**	**0,84**	**0,82**	**0,76**	**0,82**	**0,90**	**0,80**	**0,81**	**0,76**
Average amortization of intangible and fixed assets ratio	0,47	0,68	0,65	0,49	0,63	0,55	0,78	0,65	0,51
Semi-deviation of intangible and fixed assets amortization ratio	0,04	0,02	0,01	0,04	0,01	0,02	0,01	0,02	0,01
Amortization of intangible and fixed assets ratio	**0,72**	**0,55**	**0,59**	**0,71**	**0,61**	**0,68**	**0,46**	**0,58**	**0,73**
Average efficiency of intangible and fixed assets	3,02	6,31	3,93	6,50	6,18	4,18	13,97	3,77	2,73
Semi-deviation of intangible and fixed assets efficiency	0,25	0,50	0,40	3,21	0,18	0,27	2,33	0,21	0,25
Efficiency of intangible and fixed assets	**0,71**	**0,89**	**0,74**	**0,50**	**0,96**	**0,78**	**0,61**	**0,76**	**0,67**
Intangible and fixed assets	**0,49**	**0,67**	**0,57**	**0,39**	**0,68**	**0,55**	**0,57**	**0,59**	**0,47**
Innovative potential resources	**0,64**	**0,73**	**0,69**	**0,57**	**0,72**	**0,72**	**0,67**	**0,69**	**0,61**
Average intangible and fixed assets growth	5,61	10,46	-2,73	16,50	3,24	-0,36	-8,02	-2,84	1,72
Semi-deviation of intangible and fixed assets growth	10,01	13,59	4,19	18,20	2,31	3,07	7,03	1,38	1,32
Investment in intangible and fixed assets	**0,28**	**0,50**	**0,06**	**0,50**	**0,48**	**0,13**	**0,06**	**0,21**	**0,37**
Investment in human capital	0,70	1,00	1,00	0,50	1,00	1,00	1,00	0,90	0,80
Engagement in innovative potential development	**0,49**	**0,75**	**0,53**	**0,50**	**0,74**	**0,56**	**0,53**	**0,55**	**0,59**
Innovative potential	**0,57**	**0,72**	**0,60**	**0,54**	**0,71**	**0,63**	**0,60**	**0,62**	**0,59**
Innovation activity results	0,60	0,80	0,75	0,60	0,80	0,90	0,75	0,60	0,50

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	BOŚ	BZW	BHW	GNB	ING	MBK	MIL	PEO	PKO
General corporate innovativeness	**0,58**	**0,74**	**0,67**	**0,57**	**0,73**	**0,75**	**0,66**	**0,60**	**0,55**
Financial situation and development perspectives	**0,46**	**0,65**	**0,56**	**0,40**	**0,63**	**0,64**	**0,55**	**0,52**	**0,50**
Average dividend yield	0,00	2,04	5,93	0,00	1,61	0,88	0,61	4,38	2,86
Semi-deviation of dividend yield	0,00	1,09	0,96	0,00	1,05	0,74	0,52	1,04	1,58
Dividend yield	**0,25**	**0,45**	**0,78**	**0,25**	**0,40**	**0,33**	**0,31**	**0,70**	**0,52**
Dividends regularity	0,00	0,54	1,00	0,00	0,71	0,32	0,25	1,00	0,54
Dividend policy	**0,06**	**0,49**	**0,86**	**0,06**	**0,54**	**0,30**	**0,25**	**0,82**	**0,53**
Financial and development aspects	**0,27**	**0,62**	**0,70**	**0,25**	**0,62**	**0,52**	**0,42**	**0,67**	**0,51**
Avg. reserves on judicial proc. and penalties payed to equity cap. ratio	0,47	0,07	0,08	0,14	0,08	0,07	0,13	0,03	0,02
Semi-dev. of res. on judicial proc. and penalties payed to eq. cap. ratio	0,14	0,03	0,02	0,05	0,03	0,03	0,04	0,01	0,01
Reserves on judicial proc. and penalties payed to equity cap. ratio	**0,95**	**0,99**	**0,99**	**0,98**	**0,99**	**0,99**	**0,98**	**1,00**	**1,00**
Corporate social responsibility	0,60	1,00	0,70	0,40	0,80	0,60	0,90	0,70	0,60
Relations with surrounding	**0,76**	**0,99**	**0,82**	**0,64**	**0,86**	**0,78**	**0,92**	**0,82**	**0,78**
Shareholding	0,50	1,00	1,00	0,60	1,00	1,00	1,00	1,00	0,40
Social aspects	**0,63**	**1,00**	**0,94**	**0,63**	**0,95**	**0,94**	**0,97**	**0,94**	**0,55**
General corporate reputation assessment	**0,42**	**0,76**	**0,76**	**0,36**	**0,74**	**0,73**	**0,67**	**0,74**	**0,56**

Partial and final results generated by the fuzzy model were given in bold.

The lowest reputation assessments where in turn obtained for GNB and BOS. Both banks distinguished negatively in informational aspects (not so good reporting quality) and financial and development aspects (weak dividend policy and at best average financial situation and development perspectives).

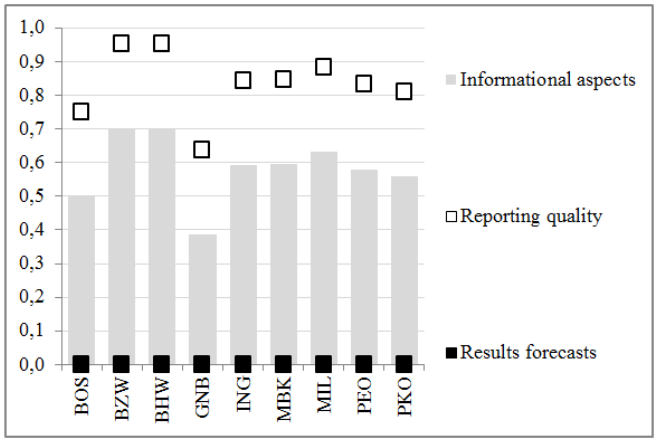


Fig. 6 Assessment in the area of informational aspects

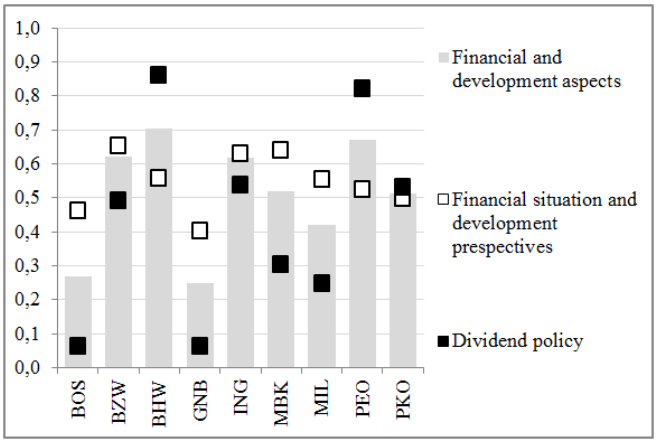


Fig. 7 Assessment in the area of financial and development aspects

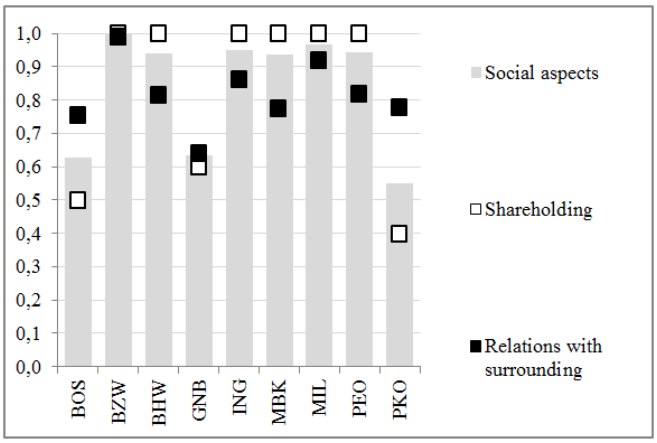


Fig. 8 Assessment in the area of social aspects

It should be also emphasized, that the proposed methodology beyond the final aggregate corporate reputation assessment enables obtaining a series of assessments on the lower level of aggregation, which allow for a more detailed comparisons of the examined entities (Table II).

VI. Conclusion

Used so far methods and concepts of corporate reputation measurement and assessment have some weaknesses, that affect the credibility and reliability of the research results. The proposed methodology for reputation assessment gives a chance to eliminate several key shortcomings of these methods:

- proposed model focuses on one point of view of this category (investor's) but in a more accurate way, providing greater reliability of the final results;
- the use of criteria based on "hard" data derived from companies reports and other documents should translate into greater objectivity of obtained reputation assessment (in most of existing methodologies mainly a survey methods are used, based on subjective opinions of selected respondents groups);

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- the choice of evaluation criteria, taking into account different aspects of companies activities and a careful selection of assessment parameters, may reduce the risk of duplication (overlapping) assessed areas;
- taking into account informational and social aspects reduces the risk of domination final assessment by financial issues.

At the same time, however, it must be emphasized, that presented concept of reputation assessment has still a working character and requires further considerations, verification of adopted criteria and detailed empirical research, including the development of knowledge (rules) bases needed to perform fuzzy inference.

In conclusion, it should be noted, that proposed method of corporate reputation assessment is not so much an alternative, as it is a complement and enrichment of already existing methodology. Therefore, beyond the capabilities of various internal and inter-branch comparisons, and analysis of corporate reputation impact an interesting direction of research could also be comparisons of companies' reputation level assessed with survey methods and proposed method.

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