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CONCEPTUALIZATION OF ONTOLOGY OF RETURN ON INVESTMENT IN ORDER TO GENERATE IT IN TOPIC MAP STANDARD

Abstract: During the analysis of economic ratios, assessing an enterprise's activity, information resulting from existing between them relations is essential. One of proposed solutions, which allows to show various connections (including semantic) between economic indicators, is topic map. Research on using topic map as a useful tool to organize the information in order to preserve the knowledge of economical ratios and semantic associations existing between them is carried out. In the paper the emphasis was put on conceptualization of ontology of return on investment (ROI) indicator. In order to build ontologically important terms, the classes, their hierarchy and relations were defined. The ontology of ROI indicator presented in the paper will be implemented in order to continue research on using standard of topic map to visualize semantic associations between indicators.

Keywords: ontology of economic indicators, return on investment indicator, topic map.

1. Introduction

Decision-makers must analyse various economic indicators assessing functioning of an enterprise. Data for these analyses are taken from different analytical applications. However, available information systems concentrate mainly on providing information reflecting hierarchic relations between examined indicators. Decision-makers expect also possibilities of inspecting rates on account of semantic associations existing between them. Such an analysis of indicators can potentially ease and shorten time needed, inter alia, to identify chances of advancement and threats of breakdown connected with leading activity.

One of suggested solutions, which allows to present various associations between economic ratios, is the standard of topic map (see [ISO/IEC 13250:2000]). Besides traditional information retrieval approaches, the use of semantic technologies like topic map is also becoming more important (see [Wurzer, Smolnik 2008, p. 169]).

The aim of the research is adaptation and verification of the standard of topic map as data model about semantic associations between different economical ratios. Thanks to visualization users can more swiftly notice and understand various structural and semantic relations. As empirical research carried out by S.M. Falconer shows, visualization increases comprehension of ontology, causing that "users performed better on the conceptual task of actually understanding and describing the semantics of a given concept" [Falconer 2009, p. 136].

In this article the conceptualization of ontology of indicators return on investment for the topic map application is discussed. The elaboration is structured as follows. In the next section the topic map standard as a model of knowledge representation is presented. In section 3 a research problem connected with creating ontology of rates used in economic analysis is briefly described. In section 4 the conceptualization stage of ontology of ROI indicator is described. Finally, in the last section a summary of this work is given and a future research projects are indicated.

2. Topic map as a model of knowledge representation

Topic map is a relatively new form of presentation of knowledge, which put emphasis on data semantics and ease of finding desired information (see [Ahmed, Moore 2006; Freese 2001; Newcomb 2002]). Topic Map is "model of knowledge representation, and its main purpose is to organize the information through semantic linkage in the data, concepts, and sources" (see [Pimentel et al. 2009, p. 30]). Usually a topic map is a semantic graph which contains definitions of a set of topics and a set of associations between topics called ontology of a domain (see [Korczak, Dudycz 2009, p. 86]). Seven basic benefits of creating a topic map application for the organization of information in existing information in a company can be shown [Dudycz 2009, pp. 70-71]:

- topic maps are saved as computer files in the open standard, so they are not limited to the concrete form of data presentation shown here,
- topic map is characterized by flexibility, i.e., it can be freely modified by adding new topics and connections between them,
- once the topic maps have been built, a user can easily merge data from one topic map to another,
- topic maps offer the alternative of indexing and searching for topic names, and then using topic occurrences to present links to all contents related to the topics found by the search,[1]

[1] Such searching is more efficient than that based on basic hierarchic structure (see [Garshol 2004; Yi 2008, p. 1899]). The results of this Yi's study shows that relationships-based query searches using this topic maps-based information retrieval system resulted in better recall and shorter search times than did those for fact-based query searches (see [Yi 2008, p. 1910]).

– the layer of topics is separated from the layer of resources,[2]
– topic maps can be used to combine topic information received from multiple separate sources into a single functioning topic map,
– for topic map standard a large set of tools from various vendors becomes available, like query languages, graphic visualization, portal integration, content management, workflow, natural language querying.

One of the topic map applications used in initial researches to visualize semantic associations between different indicators, which have impact on calculating the profit sharing indicators (see [Korczak, Dudycz 2009; Dudycz, Korczak 2009]), points out the possibility of using topic map as a data model for any area of economic analysis. Such a solution can also serve to integrate data which are located in many information systems functioning in an enterprise.

3. Creating ontology of economic ratios – research problem

The essence of examining and assessing functioning of an enterprise consists in appropriate calculating and using economic and/or financial ratios coming from various financial reports. These ratios make the relation between different connected quantities which are established in order to obtain assumed cognitive values (see [Waśniewski, Skoczylas 2002, p. 158]). Considering the degree of data aggregation it can be synthetic or partial rates, where synthetic indicators can make sum, difference, product or quotient of partial rates. It means that every single indicator is an arithmetic result of prior rates or arithmetic factor affecting following indicators (see [Vollmuth 2007, p. 168]).

In literature the attention is paid to such drawbacks of the analysis of rates as: lack of indicating reasons of appearing of disadvantageous phenomena, and possibility of wrong interpretation of indicators (see [Rutkowski 2007, pp. 102-103]). Searching for reasons of appearing of undesirable phenomena and noticing positive factors can facilitate examining source data through the analysis of semantic associations between economic ratios. These tasks can be streamlined by visualisation of these various connections.

N. Noy and D.L. McGuiness underline that during creating the ontology of economic ratios it is necessary of being aware that: "There is no single correct ontology for any domain. Ontology design is a creative process and no two ontologies designed by different people would be the same" [Noy, McGuinness 2005]. However, B. Smith notes that "information systems ontologists have thus far not been able to

[2] When building semantic layers there is no need to modify subsystems or to duplicate content and logic of subsystems. The architecture of a semantic integration layer for transparent access to relational data sources through the use of topic maps was described in [Neidhart et al. 2009]. A wide review of the architecture of information system with topic map application is also presented in [Korczak, Dudycz 2009, pp. 88, 89].

develop an algorithm for the automatic conversion of income statements and balance sheets prepared on the basis of the two sets of standards" [Smith 2004]. Despite these problems, it is necessary to undertake researches connected with building ontology of economic ratios in order to create topic map application for them.

Between economical ratios there are various hierarchic and semantic connections. Analysis of semantic relations often has essential impact on formulation of accurate conclusions from the economic analysis assessing the functioning of an enterprise. Topic map standard allows to show not only taxonomic relations, but also semantic connections both binary and *n*-nary. Creating topic maps, which include relations between different data influences on calculating indicators, allows understanding the way of calculating of the final indicator. The usage of topics map enables also dynamic, interactive visualisation of rates and semantic associations existing between them. Thanks to that decision-makers will receive tool the use of which can result in easier acquiring of needed information from that existing in enterprise databases.[3]

The conception of the usage of the topic map as a model of knowledge concerning indicators has the advantage that created model of ontology can be relatively easily modified and simultaneously it is possible to use multiple applications based on different ontologies of a particular area. This is essential, because there is no single universal system of economic ratios, which would be used in all economic organizations. In addition topic map application is separated from an enterprise information system which processes data about all aspects of operational business activities. There is no need to modify subsystems or to duplicate content and logic of subsystems when building semantic layers.

There are many methods describing the procedure of creating ontology for information solutions. But so far there is no single approach to its creating recommended by everyone. Basing on analysis of existing methodologies (a wide review of the issue is presented in [Gomez-Perez et al. 2004; Noy, McGuinness 2005]) and analysis of determinants linked with creating of ontology of ROI, a procedure of creating ontology of economic ratios was proposed. In this procedure the following stages were distinguished:

1. Determine the domain and scope of the ontology.
2. Consider reusing existing ontologies.
3. Conceptualization of ontology.
4. Entering ontology.
5. Evaluation and verification of created ontology.

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[3] Nowadays "the challenge is therefore no longer to obtain information, but rather to use it effectively and efficiently by specifically identifying relevant information from the large mass of information available" (see [Wurzer, Smolnik 2008, p. 169]). On the other hand L. Garshol notices that the information system in an enterprise created according to Service-Oriented Architecture (SOA) approach is not the most effective solution to obtain information. A more flexible and dynamic approach, where semantic technologies can help, is needed (see [Garshol 2010, p. 117-118]).

Presented procedure requires further work verifying its usefulness in creating the ontology of economic ratios.

4. The conceptualization of ROI indicator

One of the stages of creating ontology of ROI indicator is the conceptualization stage. During this stage occur: enumeration of important terms in the ontology, defining the classes and the class hierarchy, modelling of associations and indicating occurrence. It is not only important, but also difficult stage for constructing topic map application for ontology of ROI indicator.[4]

On account of various approaches to the pyramidal analysis of ROI, both in literature and in practice the following procedure was established. The ontology of ROI indicator was built on the grounds of basic literature and consultation with an expert in the area of finance. Then correctness of this ontology was assessed by another expert in this field.

After perusing literature about economic analysis the following principles concerning the creation of the ontology of ROI were established:

1. Procedure for calculating ROI is a system of *indicator* according to Du Pont model (*system of financial control*).[5]

2. Decomposition of indicators in established model comes to the level of rates, for which source data can be taken from the profit and loss account or balance.[6]

3. Created ontology of ROI should not mirror some specific enterprise or business. This model ought to be flexible enough so that it could be easily adapted to a specificity of company, by carrying out further decomposition of indicators.

Established Du Pont model of analysing ROI both in economic practice and in various theoretical studies was modified many times. Creating ontology in this project is based on models described in works of A. Rutkowski [2007, p. 107] and H.J. Vollmuth [2007, pp. 163-169][7].

Usefulness of the ontology built to support a search for information by decision-makers depends largely on appropriate defining of the taxonomy of terms (that is classes and their hierarchy) and semantic associations between them.

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[4] There are a number of problems with the definition of ontology as a specification of a conceptualization (a wide review of the issue is presented in [Smith 2004]).

[5] In literature many different models of calculating ROI can be found. A wide review of the issue is presented in [Sierpińska, Niedbała 2003, pp. 285-299].

[6] In this stage of carried research, this assumption is dictated by accessibility of source data in order to carry out studies verifying, inter alia, usefulness of topic map for notation of ontology of chosen area of economic analysis.

[7] The model described in mentioned works Du Pont is based on the system of costs defined as *General costs*, which mostly dominates in production enterprises. However in companies (e.g. trade), but also in many production enterprises, the system of costs named *Operating expenses* is used.

To build taxonomy of terms the following approaches can be used: top-down, bottom-up and middle-out. During the creation of the ontology of ROI the approach middle-out was used. Firstly, most detailed terms, and then general terms were identified. At the end by repeated iteration terms acting as subclasses were assigned. Among identified terms following classes were set apart: *Total assets*, *Fixed assets*, *Current assets*, *General costs*, *Total income*, and *Indicators*. In order to create hierarchic relationships between terms it is necessary to analyse them to identify associations between them. In created ontology the following taxonomic relations were identified:[8]

– *Subclass-Of* for class: *Indicators*[9],
– *Partition* for classes: *Total assets*, *Fixed assets*, *Current assets*, *General costs*, and *Total income*.

Taxonomic relations between mentioned classes and terms are illustrated for two classes *Indicators* and *Total assets* on Figures 1 and 2.

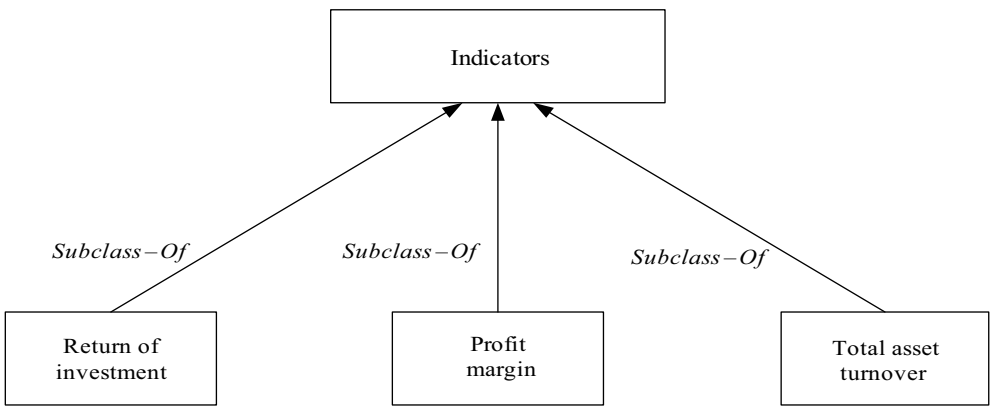

Figure 1. Taxonomic relation *Subclass-Of* for class *Indicators*

The next stage of creating the ontology was the identification of semantic associations. For clarity of the analysis these relations will be presented in three groups. The first group consists of relations that can be identified when examining relations between terms, conducting analysis in Du Pont model top-down this pyramid, that is starting with ROI indicator. The first group includes the following relations:

– sum of rates,
– difference of rates,

[8] In literature the following four taxonomic relations likely to occur are described: *Subclass-Of*, *Disjoint-Decomposition*, *Exhaustive-Decomposition*, and *Partition* (see [Gomez-Perez et al. 2004]).

[9] For designed ontology the class Indicator includes those terms the value of which can be taken neither from profit and loss account nor from balance.

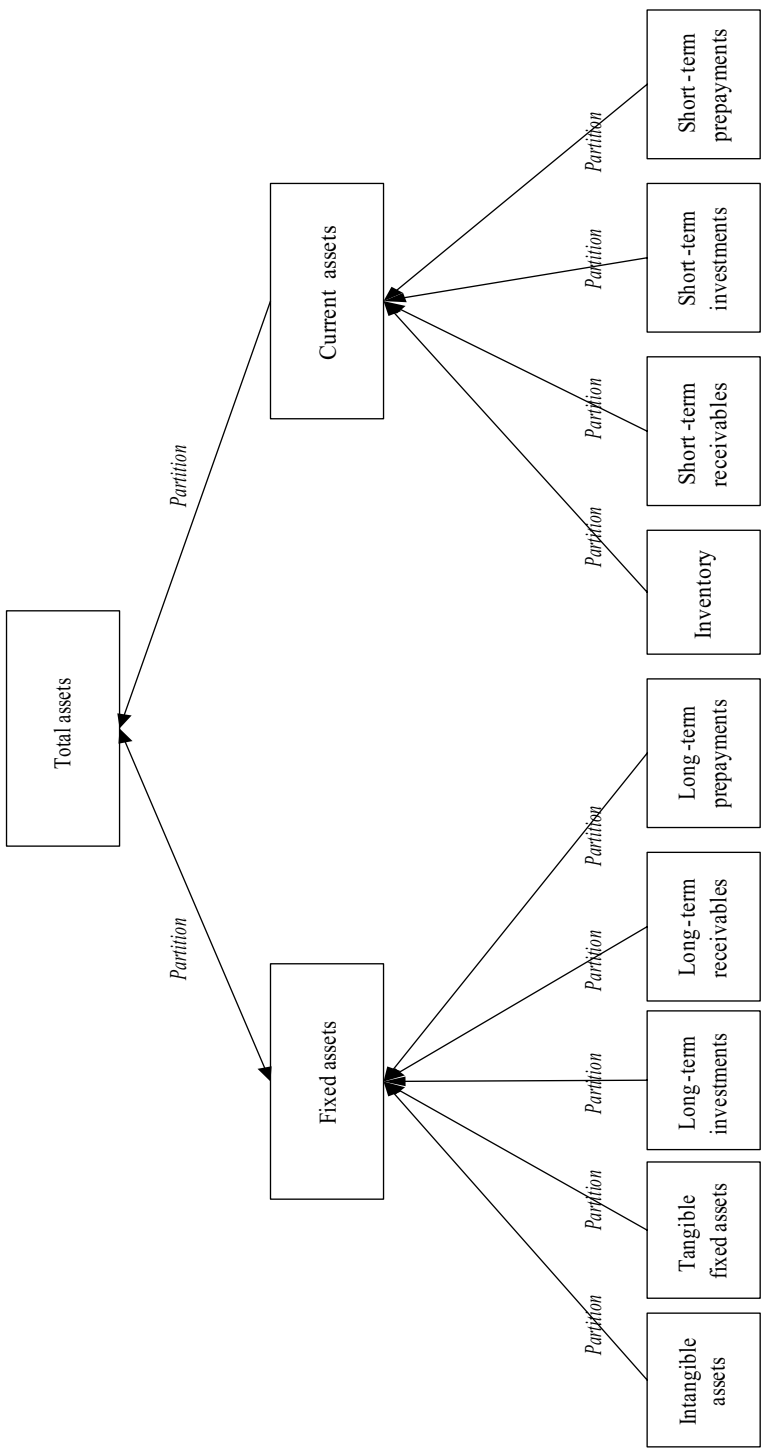

Figure 2. Taxonomic relation *Partition* for classes *Total assets*

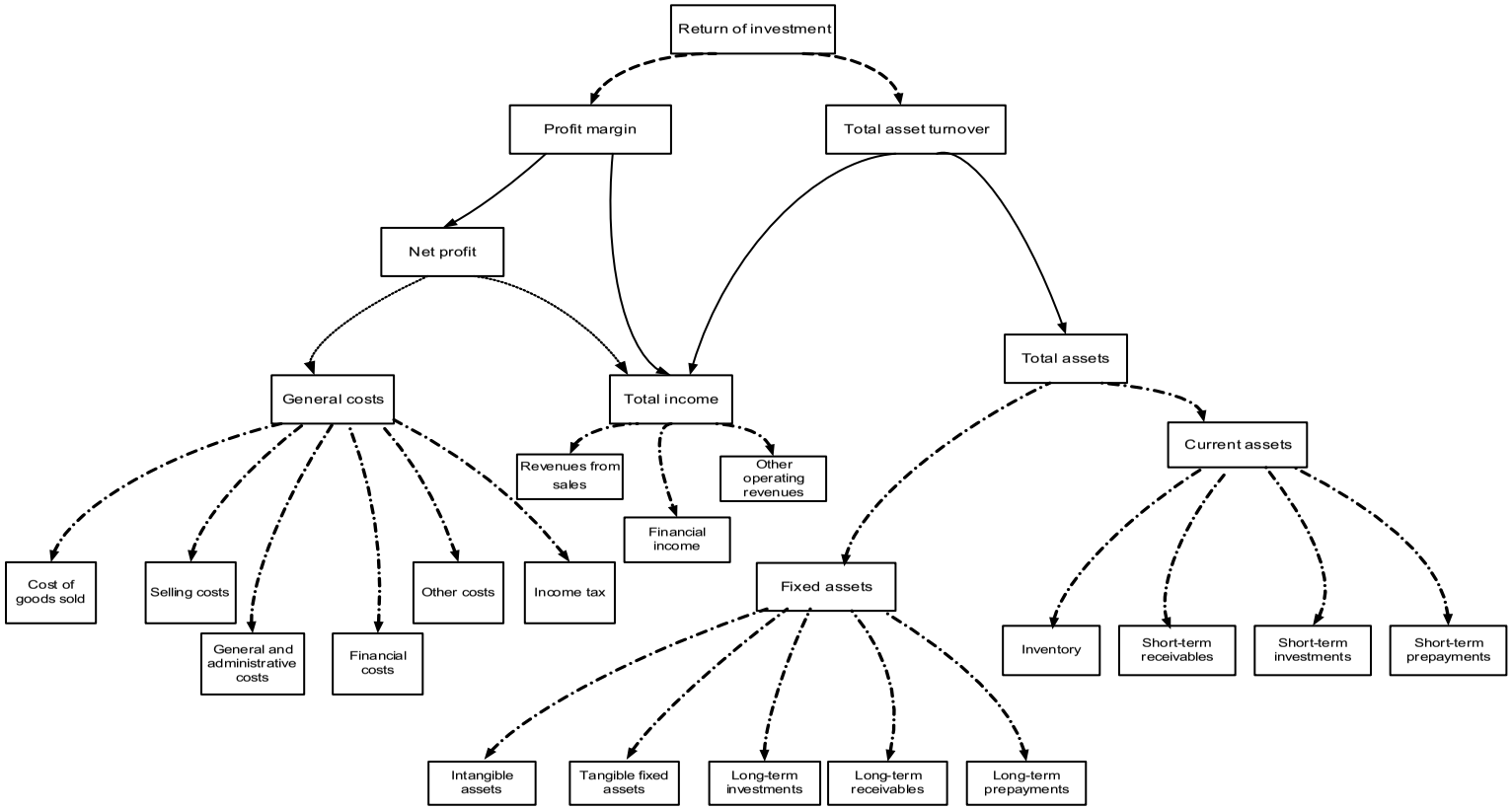

Figure 3. Binary relations between the terms within the first group

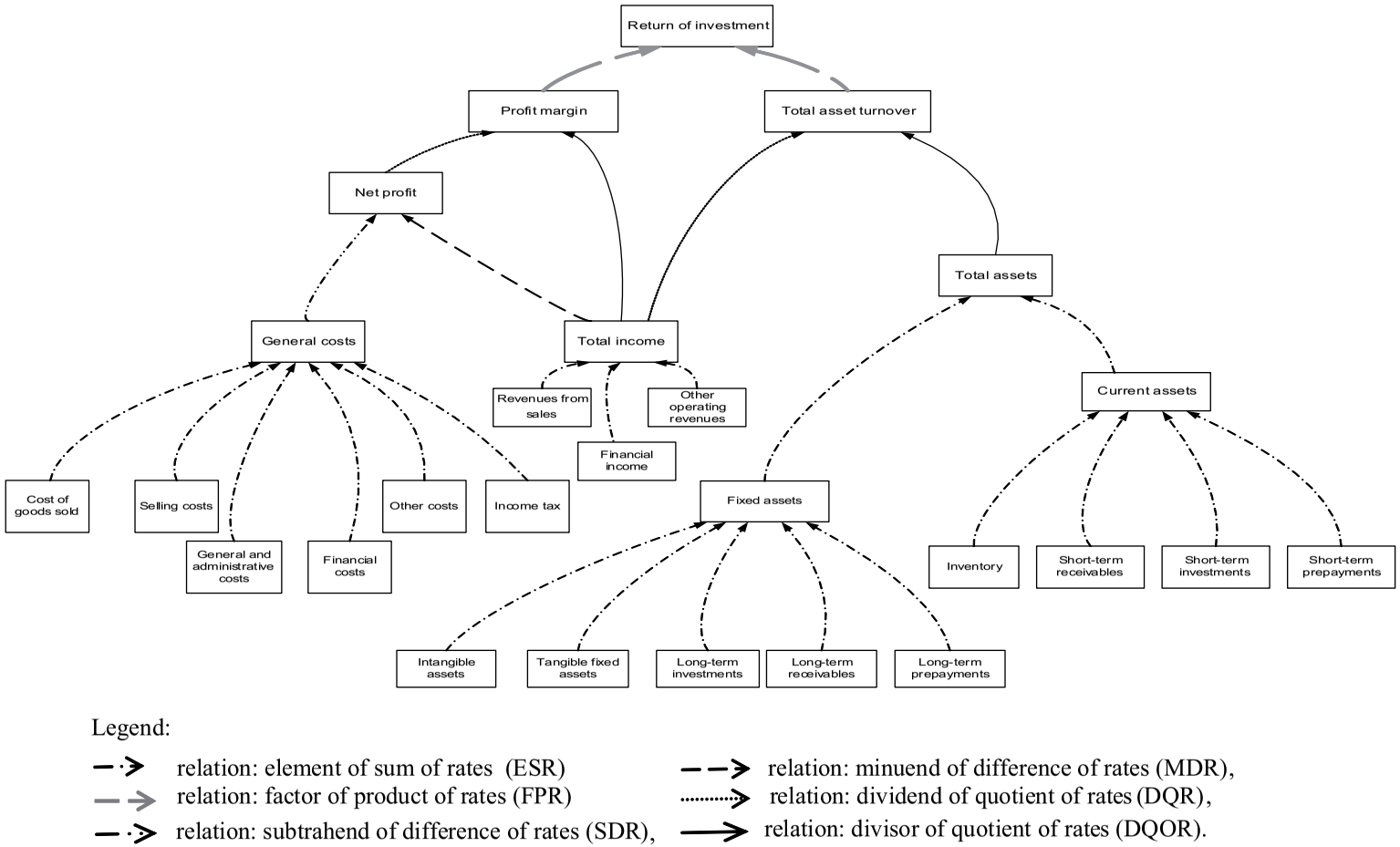

Figure 4. Binary relations between the terms within the second group

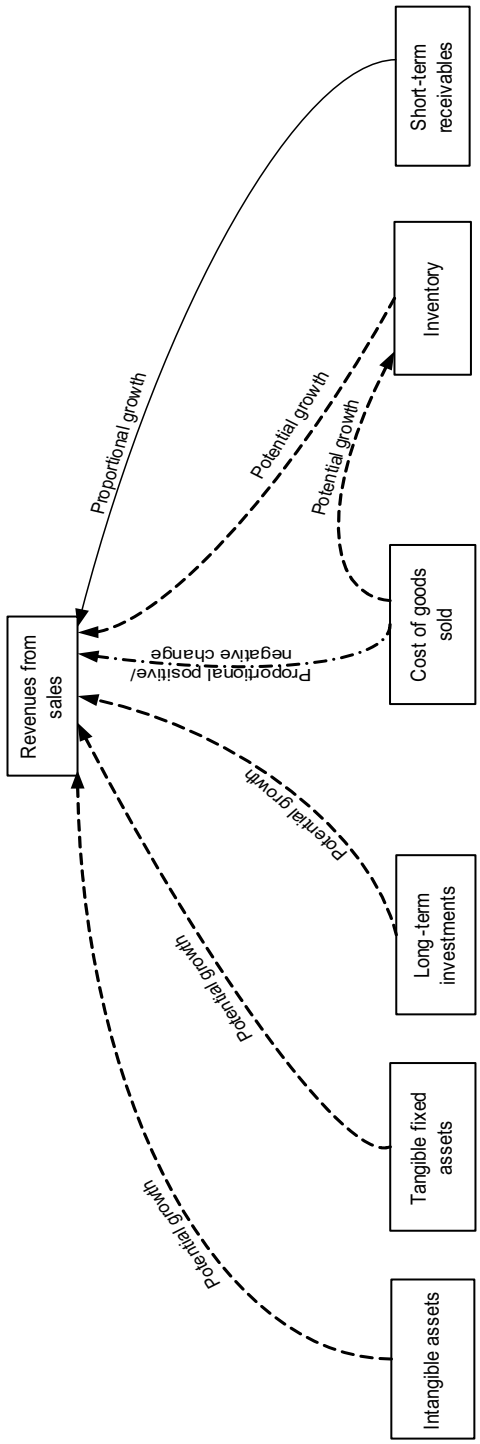

Figure 5. Binary relations between the terms within the third group

– product of rates,
– quotient of rates.

Listed relations between terms are shown in Figure 3.

The second group consists of relations that can be identified by conducting analysis in Du Pont model bottom-up this pyramid. These are:[10]

– element of sum of rates,
– minuend of difference of rates,
– subtrahend of difference of rates,
– factor of product of rates,
– dividend of quotient of rates,
– divisor of quotient of rates.

Listed relations between terms are shown in Figure 4.

Listed relations arise from the procedure of calculating indicators in Du Pont model. Analysing terms present in this ontology the following relations between them, which are not pointed in graphic Du Pont model, were identified. These are:

– potential growth, i.e., growth of value of first rate should be accompanied by increasing values of second rate,
– proportional growth, i.e., growth of value of first rate should be accompanied by proportional increasing value of second rate,
– proportional positive/negative change, i.e., growth or decrease of value of first rate causes proportional respectively increase or decrease of second rate.

Listed relations within the third group are shown on Figure 5.

5. Conclusions and future work

In the article the emphasis was put on presenting the conception of the ontology of return of investment indicator. Research problem connected with creating of the ontology of rates used in economic analysis was defined. Topic map standard was introduced as a data model of knowledge. The conceptualization stage of the ontology of ROI indicator was described.

Created ontology reflecting procedure of calculating and analysing ROI indicator will be mapped in tools for implementation of topic map standard. Resulting application allows, inter alia, to visualise semantic associations between indicators. It should be expected that information systems using field knowledge saved basing

[10] Connections assigned to the second group are so-called feedback relations of connections listed in the first group. Looking for factors having influence on obtained value of indicator ROI, an analysis of relations top-down is essential. When creating the topic map application for a model of analysis of ROI indicator it may turn out that these relations will have to be omitted. Analysis of indicators in Du Pont model is rarely being carried out beginning from indicators at the bottom of this pyramid. However, notation of these relations in the application can cause the difficulties concerning navigation in the topic maps when on the screen there is projected a big amount of topics and connections between them.

on designed ontology will be built and developed. It will be caused by the following factors: easier understanding of the content by its users, common logic platform for different languages and applications, relatively easy adaptation of the content and additional possibilities of filtering information.

Topic map application as a form of presenting knowledge allows to organize large amounts of information sources according to created semantic index of built ontology of economic ratios. The following potential profits of using topic map application for the ontology of economic ratios can be indicated:

– visualization of different connections between indicators giving chance of discovering new relations between economic ratios constituting still unknown knowledge in this area,
– streamlining process of data analysis and reporting by facilitation of obtaining data from different databases in an enterprise,
– possibility of easy extension of ontology by people not being IT specialists, e.g. by experts of economic analysis (using tools for creating topic map application).

Future work will involve a research on the use of the topic map standard as a data model of knowledge of economic ratios. This study will be continued in order to verify the usefulness of such application allowing to visualize semantic associations for particular area of economic analysis and use of topic map application as a tool of visual exploration of data. Presented ontology of ROI indicator will be implemented in TM4L and Protégé. Then research verifying usefulness of applying topic map standard as interface allowing to visually explore data concerning indicators of assessment of functioning an enterprise and usefulness of application in economical analysis will be carried out. Research will also be conducted to verify proposed in the article procedure of creating ontology for economic ratios.

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References

Ahmed K., Moore G. (2006), Applying topic maps to applications, *The Architecture Journal*, January, http://msdn.microsoft.com/en-us/library/bb245661.aspx.

Dudycz H. (2009), Problem of visualizing semantic layer of a large number of topics in topic maps, [in:] *Advanced Information Technologies for Management – AITM'2009*, Eds. J. Korczak, H. Dudycz, M. Dyczkowski, Research Papers of Wrocław University of Economics No. 85, UE, Wrocław, pp. 66-76.

Dudycz H., Korczak J. (2009), Wizualna eksploracja danych finansowych za pomocą mapy pojęć, [in:] *Systemy wspomagania organizacji SWO'2009*, tom 2, Eds. T. Porębska-Miąc, H. Sroka, Prace Naukowe Akademii Ekonomicznej, Katowice, pp. 253-263.

Falconer S.M. (2009), *Cognitive Support for Semi-automatic Ontology Mapping*, dissertation, Department of Computer Science, University of Victoria, Canada.

Freese E. (2001), Using topic maps for the representation, *Management & Discovery of Knowledge*, ISOGEN International, http://www.isogen.com.

Garshol L.M. (2004), *Metadata? Thesauri? Taxonomies? Topic Maps! Making Sense of It All*, http://www.ontopia.net/topicmaps/materials/tm-vs-thesauri.html.

Garshol L.M. (2010), A new approach to semantic integration, [in:] *Information Wants to Be a Topic Maps. Sixth International Conference on Topic Maps Research and Applications, TMRA 2010*, Eds. L. Maicher, L.M. Garshol, Leipziger Beiträge zur Informatik, Band XXIV, Leipzig, pp. 117-127.

Gomez-Perez A., Corcho O., Fernandez-Lopez M. (2004), *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*, Springer-Verlag, London.

ISO/IEC 13250:2000 (2000), *Information Technology – SGML Applications – Topic Maps*, International Organization for Standardization, Geneva, Corrected, 2nd edition, http://www.y12.doe.gov/sgml/sc34/document/0322_files.

Korczak J., Dudycz H. (2009), Approach to visualisation of financial information using topic maps, [in:] *Information Management*, Eds. B.F. Kubiak, A. Korowicki, Gdańsk University Press, Gdańsk, pp. 86-97.

Neidhart T., Pinchuk R., Valentin B. (2009), Semantic integration of relational data sources with topic maps, [in:] *Linked Topic Maps. Fifth International Conference on Topic Maps Research and Applications, TMRA 2009*, Eds. L. Maicher, L.M. Garshol, Leipziger Beiträge zur Informatik, Band XIX, Leipzig, pp. 185-192.

Newcomb S.R. (2002), *The Economics of the Topic Maps Reference Model*, http://www.RenderX.com.

Noy F.N., McGuinness D.L. (2005), *Ontology Development 101: A Guide to Creating Your First Ontology*, Knowledge Systems, AI Laboratory, Stanford University, http://www.ksl.stanford.edu/people/dlm/papers/ontology101/ontology101-noy-mcguinness.html.

Pimentel M.P., Suárez J., Caparrini F.S. (2009), Topic maps for philological analysis, [in:] *Linked Topic Maps. Fifth International Conference on Topic Maps Research and Applications, TMRA 2009*, Eds. L. Maicher, L.M. Garshol, Leipziger Beiträge zur Informatik, Band XIX, Leipzig, pp. 29-39.

Rutkowski A. (2007), *Zarządzanie finansami*, PWE, Warszawa.

Sierpińska M., Niedbała B. (2003), *Controlling operacyjny w przedsiębiorstwie*, Wydawnictwo Naukowe PWN, Warszawa.

Smith B. (2004), *Ontology and Information Systems*, State University of New York at Buffalo, http://ontology.buffalo.edu/ontology.pdf.

Vollmuth H.J. (2007), *Controlling. Planowanie, kontrola, kierowanie*, Agencja Wydawnicza „Placet", Warszawa.

Waśniewski T., Skoczylas W. (2002), *Teoria i praktyka analizy finansowej w przedsiębiorstwie*, Fundacja Rozwoju Rachunkowości w Polsce, Warszawa.

Wurzer J., Smolnik S. (2008), Towards an automatic semantic integration of information, [in:] *Subject-centric Computing. Fourth International Conference on Topic Maps Research and Applications, TMRA 2008*, Eds. L. Maicher, L.M. Garshol, Leipziger Beiträge zur Informatik, Band XII, Leipzig, pp. 169-179.

Yi M. (2008), Information organization and retrieval using a topic maps-based ontology: Results of a task-based evaluation, *Journal of the American Society for Information Science and Technology*, Vol. 59, No. 12, pp. 1898-1911.

KONCEPTUALIZACJA ONTOLOGII WSKAŹNIKA RENTOWNOŚCI INWESTYCJI W CELU ZAPISANIA JEJ W STANDARDZIE MAPY POJĘĆ

Streszczenie: W analizie wskaźników ekonomicznych, oceniających działalność prowadzoną przez przedsiębiorstwo, istotne są również informacje wynikające z istniejących między nimi zależności. Jednym z proponowanych rozwiązań, które pozwoli na pokazanie różnorodnych powiązań (w tym również semantycznych) między wskaźnikami ekonomicznymi, jest standard mapy pojęć. Prowadzone są badania nad zastosowaniem mapy pojęć do zapisu ontologii wskaźników ekonomicznych oraz wizualizacji istniejących między nimi powiązań semantycznych. W artykule skoncentrowano się na konceptualizacji ontologii wskaźnika rentowności inwestycji (ROI). Określono istotne dla tej ontologii pojęcia, zdefiniowano klasy oraz ich hierarchię, a także istniejące między pojęciami powiązania hierarchiczne i semantyczne. Przedstawiona w tym artykule ontologia wskaźnika ROI zostanie zaimplementowana w celu kontynuacji badań nad zastosowaniem mapy pojęć do wizualizacji powiązań semantycznych między wskaźnikami, aby ułatwić przeprowadzanie ich analizy.