

# Process of Ontology Design for Business Intelligence System

Helena Dudycz<sup>(✉)</sup> and Jerzy Korczak

Wrocław University of Economics,  
Komandorska 118/120, 53-345 Wrocław, Poland  
{helena.dudycz, jerzy.korczak}@ue.wroc.pl

**Abstract.** Business Intelligence systems tend more and more towards semantically rich functionalities. One of the main artefacts to create a semantic network is the ontology. There are many methods describing the procedure of creating ontology for information solutions. The article presents the approach to the conceptualisation of the financial knowledge for a Business Intelligence system. The content of the knowledge is focused on essential financial concepts and relationships related to the management of small and medium enterprises (SME). That includes the illustration of the process of conceptualization of the financial ontology, which can be implemented in the Business Intelligence system.

**Keywords:** Financial knowledge · Ontology · Financial indicators · Decision support system · Business Intelligence system

## 1 Introduction

Useful, adequate and easy to interpret information is a key prerequisite in the process of decision-making. However, available information systems concentrate mainly on providing information reflecting semantic relationships between examined economic and financial indicators. In order to facilitate the process of data analysis, the usage of the ontology is proposed as a model of financial knowledge about the analysis of indicators.

The decision-makers of small and medium enterprises (SMEs), in comparison to managers of big companies, may not have access to all essential strategic information. Usually, financial expertise is either not available or too expensive. Big companies have at their disposal strategic consultation and possess standard procedures to solve problems in the case of essential changes in the business environment. For financial and personnel reasons, most SMEs cannot afford these types of facilities. It should be noted that SMEs operate in a definitely more uncertain and risky environment than big enterprises, because of a complex and dynamic market that has much more important impact on SMEs' financial situation than on big companies [1].

In general, most existing Business Intelligence (BI) and Executive Information Systems (EIS) provide various functionalities for data aggregation and visualization. Many reports and papers in this domain underline that decision makers expect new ICT solutions to interactively provide not only relevant and up-to-date information on the

financial situation of their companies, but also explanations that take into account the contextual relationships.

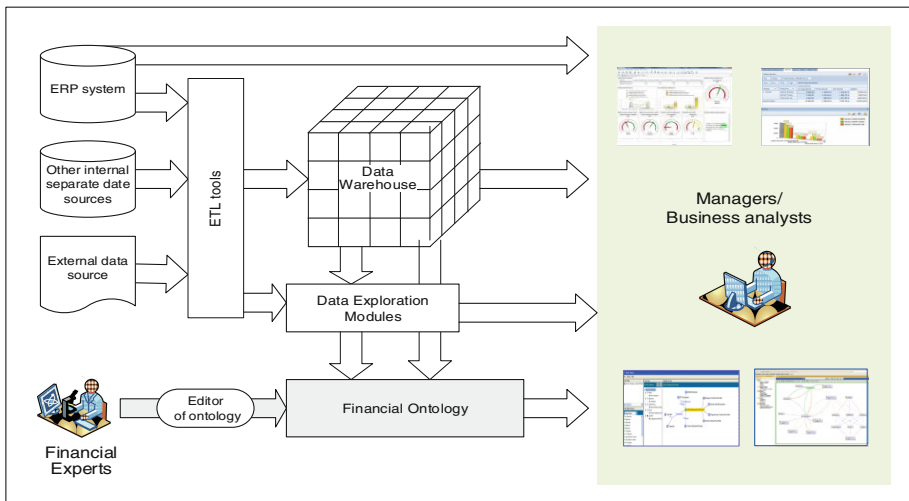
Our research concentrates on two essential issues: the conceptualization of financial ontology and the use of the semantic network in decision making. The structure of the paper is as follows. In the next section, the functional schema of the BI system with ontology applications is discussed. Section 3 describes the process of ontology development, in particular the actual design of the ontology. This concept of the presented method is based on: (1) a critical analysis of literature, (2) built ontologies of economic and financial indicators, which were realized during the period 2012–2013. A case study in Sect. 4 illustrates an example of design and use of financial ontology. To show the reasoning, a case for explanation of financial data is specified. In the conclusion, the future research directions are indicated.

## 2 Domain Knowledge in Business Intelligence Systems

The Business Intelligence (BI) system is used for the analysis of all basic areas of an enterprise's activities, such as, e.g., finance and accounting, manufacturing, logistics, marketing, sales, and customer relationships. These applications provide many reports containing valuable information in each statement. Retrieval information from these reports is eased by the use of appropriate forms of its presentation, and of a friendly and easy user interface. Nowadays, decision-makers want not only to look at static reports or even ad hoc reports, but want also easy-to-use tools to assess goals and key performance indicators to identify any chances of advancement and threats of breakdown. The usefulness of the BI system is not related to the amount of generated information, but to the provision of required information at the right moment. These were basic motives for developing and applying a new technology and knowledge representation in the BI system. In the literature, the development of BI systems towards BI 2.0 (using semantic search) is described (see [2–4]). This system is focused on the semantic analysis of data, using data and information from multiple sources (including external sources). One of the main artifacts to create a semantic network is the ontology, because the architecture of BI 2.0 has new components, such as ontologies and service ontologies (see [2]). The ontologies are used to create the necessary knowledge models for defining and explaining functionalities in analytical tools. Using ontologies and semantic networks for a visual interface to support an information search in the BI system may help to reduce the following weaknesses of management information systems (see [4, 5]):

- lack of support in defining business rules for getting proactive information and support in consulting in the process of decision making;
- lack of a semantic layer describing relations between different economic topics;
- lack of support in presenting the information of different users (employees) and their individual needs;
- difficulty in rapidly modifying existing databases and data warehouses in the case of new analytic requirements.

In Fig. 1, a functional architecture of the information system is presented, with ontology applications. Various mechanisms can be seen for extracting source data from transactional systems (ETL), the data warehouse, and external sources. However, the available solutions – in particular the standard analyses, reports and analytical statements generated by the system – are complemented by economic and financial knowledge (most importantly ontologies). This enables a dynamic, interactive analysis of key economic and financial indicators. Such an architecture concept was used in the project InKoM<sup>1</sup> (a wide review of the issue is presented in: [6, 7]). This solution will significantly extend existing BI and EIS functionalities.



**Fig. 1.** Functional architecture of information system with ontology applications (source: based on [1, p. 57]).

To support the analysis, SME decision makers need economic and financial knowledge. The scope of required knowledge in the Intelligent Dashboard for Managers was arbitrarily divided by experts into six selected areas, namely: Cash Flow at Risk, Comprehensive Risk Measurement, Early Warning Models, Credit Scoring, Financial Market, and General Financial Knowledge [6].

The system that enables semantic information retrieval should be intuitive to use or easy to understand. For managers, the presentation layer is the most critical aspect of a BI system, since it broadly shapes their core understanding of the data displayed [8]. The basic assumption of navigation is that managers should be able to view focus and

<sup>1</sup> This research was supported by the National Research and Development Centre within the Innotech Program (track In-Tech), grant agreement no. INNOTECH-K1/IN1/34/153437/NCBR/12. The name of this project, called was the Intelligent Dashboard for Managers, which was conducted by a consortium led by the Wrocław University of Economics, Poland, and the other principal member is the company UNIT4 TETA BI Center. The project was realized during the period 2012–2014.

context areas at the same time to present an overview of the whole knowledge structure [9].

The ontology of financial knowledge is the foundation of creating a semantic network. In our project, special attention was paid to the role of the visualization of a semantic network, which is not only a tool for presenting data, but also provides an interface allowing interactive visual information retrieval (see inter alia [10, 11]). Working from the displayed semantic structure of a built-in ontology of financial and economic knowledge, it is possible to interactively choose topics or relations, to change the area of presented details, and to access relevant source data.

### 3 Design Process of Financial Ontology

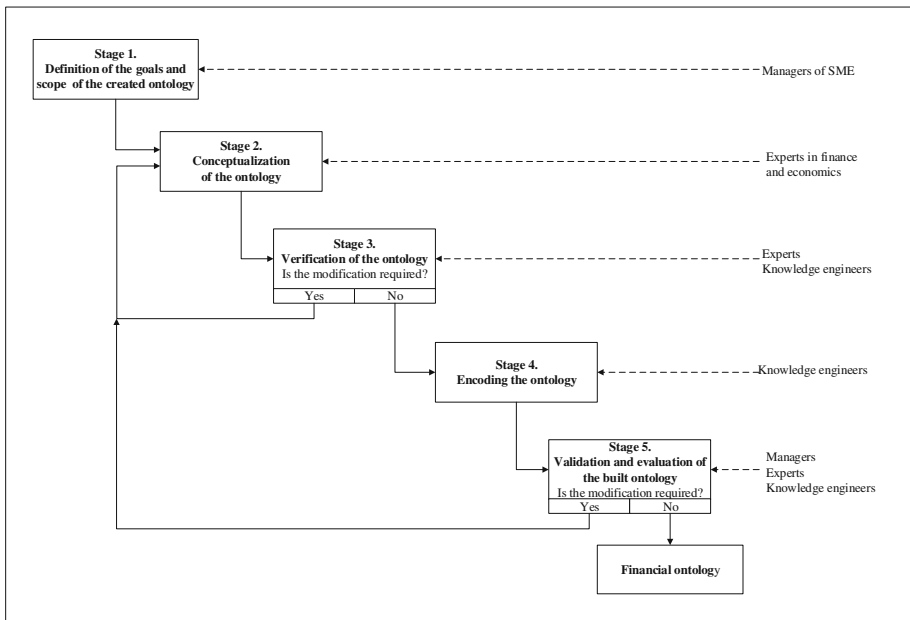
In the literature many different approaches to design of an ontology can be found (a broad review of the issue is presented in: [12]). There are many methods describing the methods of creating ontology for information systems. These are, inter alia: Cyc, KBSI, TOVE, EMA, HOLSAPPLE, HCONE, System KACTUS, SENSUS, UPON, METHAONTOLOGIA, On-To-Knowledge method (a wide review of the issue is presented in: [13, 14]). But so far there is no single approach accepted by all.

Based on the analysis of existing methodologies and our research, a method of creating an ontology of financial indicators has been proposed. In this method, the following stages are distinguished (see also: [1, 6, 15, 16]):

1. Definition of the goals, scope, and constraints of the created ontology. While creating an ontology, assumptions about the created model of knowledge that will apply during its building have to be provided. That requires an answer to the question: *what will the created ontology be used for?* The result of this stage is a definition of the scope of developed ontology and its required level of detail.
2. Conceptualization of the ontology. Independently of the field that is to be modeled by using an ontological approach, it is the most important stage in creating a model based on ontology (see inter alia [17, p. 2036]). It includes the identification of all concepts, definition of classes and their hierarchic structures, modeling relations, identification of instances, specification of axioms, and rules of reasoning. The result of this stage is the ontology's model of the defined area of financial knowledge.
3. Verification of the ontology's correctness by experts. In this stage, the constructed ontology is verified by experts who did not participate in the process of conceptualization. Verification is carried out in two steps. The first concerns a formal verification of the specified ontology (e.g. incorrect relations are indicated) with the use of a given editor. The second step is carried out by experts from the given field and concerns content verification, which includes verification of the correctness of topics' definitions, correctness of taxonomic topics, and correctness of relational dependences between topics. In the proposed method of financial knowledge, the verification and the validation were separated in accordance with the approach used in software engineering (see [18]). The result of this stage is the verified ontology.

4. Encoding the ontology concerns the knowledge description, using a formal language or an editor of ontology. Two basic stages of encoding of ontology are: (1) entering all topics and creating a taxonomy of these topics, and (2) entering all other types of relations between topics. The result of this stage is the encoded ontology.
5. Validation and evaluation of the built ontology. In this stage, the encoded ontology is checked against the needs of the managers. Validation is carried out in three areas. Firstly, validation of usefulness and correctness of the created ontology is provided by experts (managers) who will potentially use it. Secondly, evaluation of the application with a created ontology is carried out by managers. Finally, the validation of predefined use cases is carried out. That requires an answer to the question: *will the created ontology be useful for the managers who will use it?* The result of this stage is validated ontology of financial knowledge.

Figure 2 shows the design process of an ontology of financial knowledge. The presented method is characterized by iterative design.



**Fig. 2.** Design process for an ontology of financial knowledge. source: own elaboration.

The important stage in the described process is the conceptualization of financial indicators. This is carried out by an expert, or in collaboration with an expert, responsible for creating the model of knowledge (see inter alia [17, p. 2036]). In the literature [13, 14]) the following phases in the conceptualization of the ontology of financial knowledge are shown (see also: [6]):

- a. Identification and definition of all topics. A topic, representing any concept, is “a syntactic construct that corresponds to the expression of a real-world in a computer system” [10, p. 60]. A topics’ list is determined by experts in a given domain of economic knowledge. These topics include, beside their names, also their synonyms and descriptions.
- b. Creating a taxonomy of topics. Specification of taxonomic relations between distinguished topics and defining classes and subclasses. In general, these relationships describe the topics generalization. The description of a taxonomy can be presented in graphic or tabular form. An interesting approach to creating a taxonomy is proposed in METHONTOLOGIA (see i.e. [13]).
- c. Definition of all other types of relations between topics, notably the basic relationships aggregate of (Aggregate – Member), was defined. Moreover, within each ontology, additional relations can be defined.
- d. The list of all the individual relationships existing in the ontology. The list includes: the name of the relationship, source topic, and target topic.
- e. Description of functions and rules. This description contains: name, input, output, initial and final conditions, and definition of operations.
- f. Description of usage scenarios. Usage scenarios, also called use case views, describe demonstration analyses of economic topics occurring in this ontology.

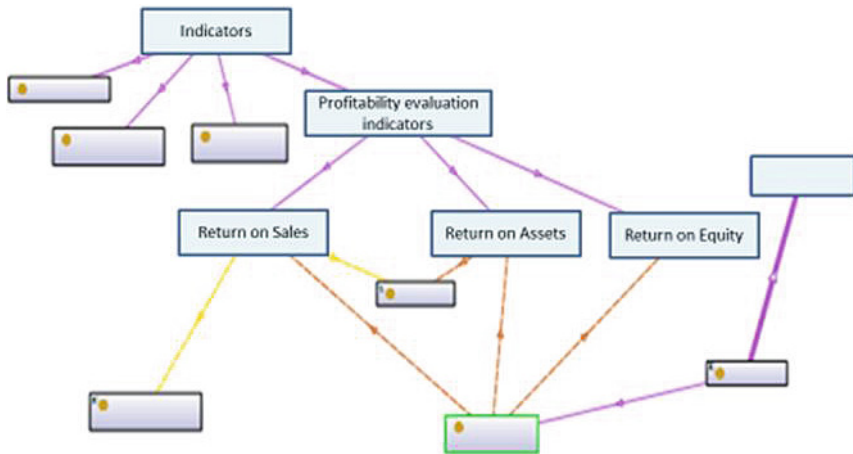
Building an ontology always denotes analysis and organization of knowledge. That work has required multi-domain expertise, both theoretical and practical, in economics, finance, and informatics. The following important features have been specified:

- type of relations: to define taxonomic and semantic relations;
- instances: the sources of data instances for the topics used by the information system;
- axioms/functions/rules: to define axioms, functions or rules, so ontology can be used in inferring knowledge from information system;
- use cases; to describe examples of using the ontology in decision making.

The process presented here of conceptualizing the ontology of financial knowledge is closest to the conceptualization in METHONTOLOGY. Except for a similar approach to the conceptualization of the ontology, our proposed method of creating an ontology of financial knowledge is completely different from the METHONTOLOGY.

## 4 Case Study – Design and Use of Financial Ontology

To illustrate the process of ontology design a case of sales analysis was chosen. Assume that the company’s efficiency is evaluated using the Return on Sales (ROS) indicator. This measure is helpful to management by providing insight into the profit structure of sales. The manager knows that the increase of ROS indicates that the company is growing more efficiently, while the decrease of ROS signals financial troubles. Managers also use the ROS indicator to identify market opportunities and areas where they could increase the volume of sales.



**Fig. 3.** Space of profitability indicators (source: own elaboration).

**Table 1.** The example of topics list (source: own elaboration).

Name	Synonym	Description
Return on sales	ROS	A ratio widely used to evaluate a company's operational efficiency. ROS is also known as a firm's "operating profit margin". It is computed using the formula: $\text{Net\_profit} / \text{Revenues\_from\_sales}$
		Recommendation: Compare a company's ROS over time to look for trends, and compare it to other companies in the same sector.

The design of the financial ontology related to the ROS indicator can be done as follows:

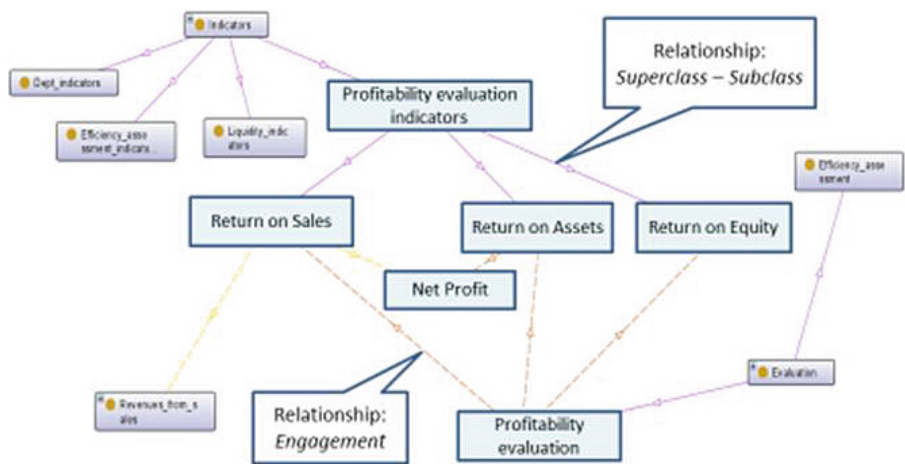
1. Identification and definition of all topics. Figure 3 shows the start of identification and definition of the domain of profitability evaluation indicators. Table 1 presents the example of the description of the topics list.
2. Creating a taxonomy of topics. Table 2 presents the taxonomy for topic *Indicators* and topic *Profitability evaluation indicators*.
3. Definition of all other types of relations between topics. In this ontology, the basic relationship *aggregate of* (*Aggregate – Member*) is defined. Moreover, additional relations are defined, for example: *potential growth*, *proportional positive/negative change*, *is the sum*, *is the quotient*, *engagement*.
4. The list of all the user defined relationships existing in the ontology. The description of a taxonomy can be presented in graphic or tabular form. Table 3 presents the example of the description of the relationships. Figure 4 shows the definition of the domain of profitability evaluation indicators. In this figure there are two types of lines between topics: (1) the solid line represents a relation *Subclass – of* and (2) the dashed line represents the experts' defined relations.

**Table 2.** The taxonomy for topic *Indicators* and topic *Profitability evaluation indicators* (Source: own elaboration).

Superclass	Subclass
Indicators	Debt indicators
	Liquidity indicators
	Profitability evaluation indicators
Profitability evaluation indicators	Return on Sales
	Return on Assets
	Return on Equity

**Table 3.** The example of the description of the relationships: *engagement* (Source: own elaboration).

Name	Synonym	Description
Engagement	Profitability evaluation	Return on Sale
Engagement	Profitability evaluation	Return on Assets
Engagement	Profitability evaluation	Return on Equity



**Fig. 4.** The domain definition of profitability evaluation indicators (source: own elaboration).

5. Description of functions and rules. The definition describes how to compute and interpret their values. This description can contain: name, input, output, initial and final pre-conditions, and definition of formula (see also: [9]). The following description specifies the example of the indicator *Return on Sales*:



**Name:***Indicator Return on Sales (ROS)***Input:***Result of Net profit (NP)**type: value extracted from Balance Sheet**Revenues from sales (RS)**type: number, value extracted from Balance Sheet***Output:***Return on Sales***Description/formula:**
$$ROS = NP / RS$$
**Final conditions:***if (ROS < value\_1)**Interpretation\_1**else if (value\_1 > ROS < value\_2)**Interpretation\_2**else if ....**....**else if ( ROS > value\_n)**Interpretation\_n*

6. Description of usage scenarios. One of the important questions is: *what is the performance of sales management?*

- a. The most common way is to look at the sales reports. From the BI system the manager receives the values of the Revenues on Sales in 2013 and 2014 (Fig. 5).
- b. To better understand the situation of the company, he searches in the ontology the concept of Profitability evaluation indicators. One of the available indicators is Return on Sales.

- c. The semantic network shows that the Return on Sales indicator depends on two values: Net profit and Revenues from Sales.

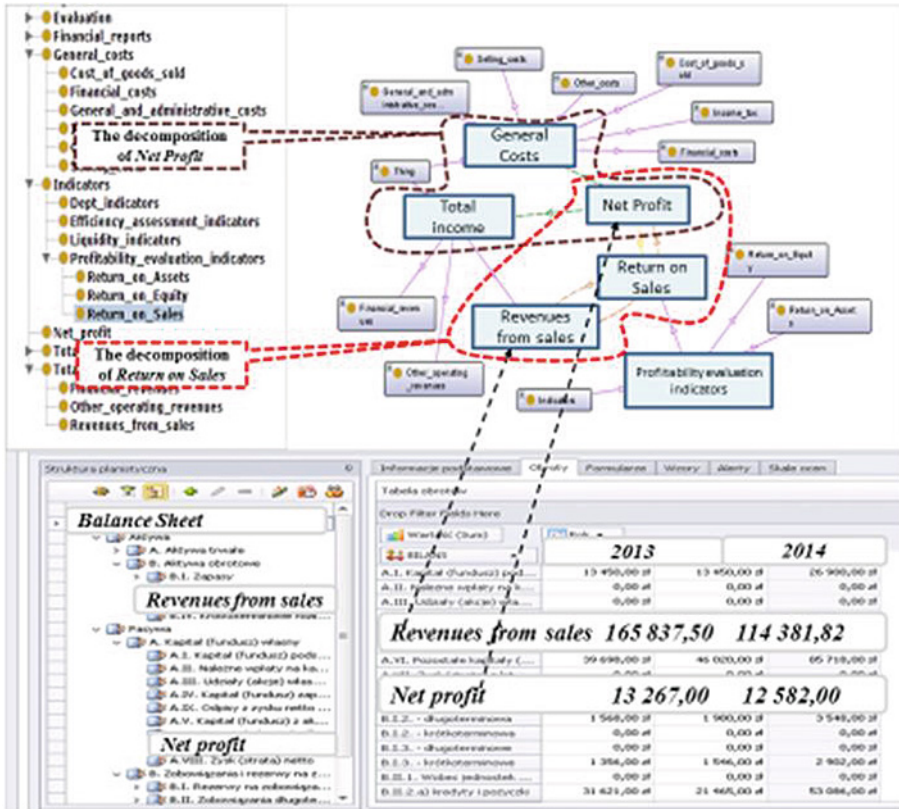
*if (ROS <= 0.10)**Poor financial situation**else if ( 0.10 > ROS <= 0.30)**Good financial situation**else**Very good financial situation*

- d. After having computed the ROS for each year, in the ontology he finds the following interpretation of ROS:

- e. Applying the rule the results are as follows:

*For 2013 year : Poor financial situation, because ROS = 0,08**For 2014 year : Good financial situation, because ROS = 0,11*

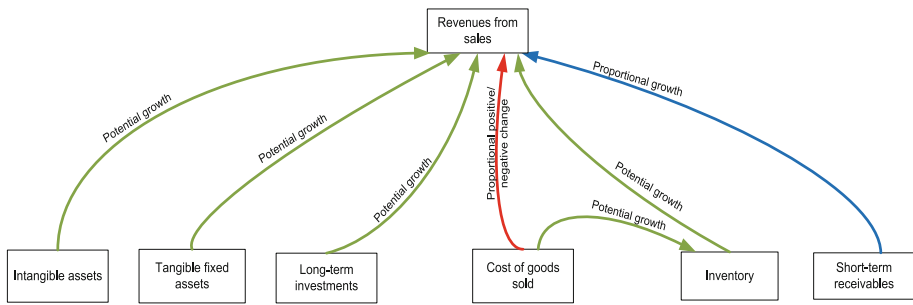
Although *Net profit* is lower in 2014 than in 2013, the company achieved a better *Return on Sales*.



**Fig. 5.** Ontology and of balance reports extracted from the TETA BI system (source: own elaboration).

- f. Using the ontology (Fig. 6) the manager can obtain more information as to which indicators and economic data have an impact on the values of Revenues from sales. This gives the manager the opportunity to search data sources taking into account not only structural dependences, but also the semantic context.

Business data contain a lot of hidden relationships and dependencies that make their understanding and usage difficult. To interpret the values of financial indicators correctly, many measures and ratios need to be examined that either directly or indirectly influence the final result. Explicit visualization not only makes the interpretation of indicators easier, but it also contributes to finding explanations of current values of indicators.



Legend:

- potential growth, i.e. growth of value of first indicator should be accompanied by increasing values of second indicator (green lines),
- proportional growth, i.e. growth of value of first indicator should be accompanied by proportional increasing value of second indicator (blue line),
- proportional positive/negative change, i.e. growth or decrease of value of first indicator causes proportional respectively increase or decrease of second indicator (red line).

**Fig. 6.** Domain definition of *Revenues from sales* (source: own elaboration).

## 5 Conclusion

The use of a financial ontology seems to be a promising extension for Business Intelligence systems. It not only improves the efficiency of analysis, but also increases the capacity of understanding of financial data. This paper presents the approach to the ontology of the financial knowledge design process. The stages of ontology design were described and illustrated using the Business Intelligence system.

The research on using the presented approach of creating a financial ontology, despite its initial character, is challenging. Many extensions and applications of this work are possible, notably on content understanding, semantic search, interface adaptation. Current work is directed toward the development of smart navigation throughout the very large field of ontological concepts, and the method of financial ontology updating by adding new concepts either through a SME manager or data mining algorithms.

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