Economic Insights – Trends and Challenges	Vol.IX(LXXII) No. 2/2020	69 - 78

OWL Ontology for Environmental Costs Assessment

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Abstract

Environmental protection is a very important worldwide concern, the environmental management problems becoming a priority for companies. Because the managerial accounting does not provide enough and suitable information for environmental management, a new concept has emerged, the environmental management accounting concept. The paper proposes an OWL ontology for environmental costs assessment. In this purpose, the environmental management accounting concept is presented, its advantages are identified, the environmental costs assessment methods are analysed and the OWL ontology for environmental costs assessment is presented.

Keywords: *environmental management accounting; environmental cost; environmental costs assessment methods; OWL language; ontology for environmental costs assessment.*

JEL Classification: *C63; C81; Q56.*

Introduction

Environmental protection is a very important worldwide concern. Its goal is represented by keeping pollution levels down both for the environmental policymakers and for the academic environment members and for the general public (Hill, 2017). Because of this, companies are more and more forced by governmental institutions, non-profit organizations, international organizations, customers, suppliers, public to consider environmental management problems as one of their priorities.

Managerial accounting provides managers the information needed to be used within the organization (Garrison, Noreen & Brewer, 2018). Because the managerial accounting does not provide enough and suitable information regarding the types of environmental costs (Lucarelli, 2003), a new concept has emerged, the environmental management accounting concept.

The paper presents an OWL ontology for environmental costs assessment within an economic organization.

Further, the environmental management accounting concept and its advantages are presented, the methods used to assess the environmental costs are enumerated and the OWL ontology for environmental costs assessment designed with the Protégé ontology editor is described.

Environmental Management Accounting

Environmental managerial accounting is a subject that has emerged relatively recently and has no single, universally accepted definition.

Environmental managerial accounting (EMA) provides a more elaborate approach to managerial accounting, emphasizing, especially, the costs associated to environmental problems and wasted raw materials (Lucarelli, 2003). EMA is that type of managerial accounting oriented to physical information on the flow of energy, water, products and materials, as well as to financial information on environmental costs, environmental revenues and projects that treat environmental protection problems (Jasch, 2006; Jasch, 2009).

It is mentioned that there are several methodologies proposed by the specialized institutions from the EMA domain (International Federation of Accountants, 2005; United Nations Division for Sustainable Development, 2001).

EMA is "the management of environmental and economic performance through the development and implementation of appropriate environment-related accounting systems and practices" (International Federation of Accountants, 2005).

EMA is the process of "identification, collection, estimation, analysis, internal reporting and use of information on the energy, materials and water flows, information related to environmental cost and other monetary information for both conventional and environmental decision-making within an organization" (United Nations Division for Sustainable Development, 2001).

The researchers' interest in this field is illustrated by numerous books and articles from the specialty journals (Bennet, Bouma & Wolters, 2002; Deegan, 2017; Gray, 2002; Matthews, 1997; Stanciu, Joldoș & Stanciu, 2011; Turturea & Turcu, 2013).

Some authors achieve an analysis of the main themes from the domain and describe chronologically the domain development, identifying different development periods (Bennet, Bouma & Wolters, 2002; Matthews, 1997; Stanciu, Joldoș & Stanciu, 2011; Turturea & Turcu, 2013).

Other authors present a critical analysis of the domain articles published in some speciality journals (Gray, 2002; Deegan, 2017).

The implementation of environmental management accounting offers to economic organizations the following advantages (Laforest, 2008; Lucarelli, 2003; Munteanu, 2013; Șendroiu, Roman & Chițu, 2006; Vasile & Man, 2012):

- increase of information quality used in the decision-making process by separate recording of environmental costs that were hidden in the classical accounting systems;
- increase of cost effectiveness, namely the increase of the internal efficiency by clearly identifying and allocating of environmental costs, ensuring the right setting of products prices and, so, improving the price policy;
- facilitating the internal and external reporting process of data regarding the environmental impact of the organization, by identifying the environmental costs;
- increase of organization competitive advantage by using EMA in adequate advertising campaigns;
- improving the image of company by its effort to reduce the environmental costs;
- attracting and motivating the staff because a company that takes into account the environmental impact of its activities is attractive on labour market and ensures a higher morale to its own employees;
- increase of the ability to identify, estimate and reduce the expenditures;
- development of some environmental management systems within the organization that are focused on the environment.

Environmental Costs Aassessment Methods

The environmental cost, the most important element of the EMA, is "a universally accepted economic category and represents that part of the uses that compensates the consumption of the capital goods and labour force in the technical, organizational and management conditions to obtain an environmental service" (Grădinaru, Colibaba & Voineagu, 2003).

Environmental costs represent a large part of costs incurred by companies (Rannou & Henri, 2010) and can be significantly reduce or even eliminated as a result of managerial decisions from operational and housekeeping changes to investments in green process technologies and redesign of processes and products (Environmental Protection Agency, 1995).

United States Environmental Protection Agency classifies these costs in two categories: internal costs that have a direct financial impact over company and external costs (*societal costs*) for which company is not responsible and which are costs to individuals, society and environment (Environmental Protection Agency, 1995).

Internal costs include (Environmental Protection Agency, 1995): *conventional costs* (materials costs, labour costs, utilities costs etc.), *potentially hidden costs* (site studies costs, site preparation costs, audit costs, research and development costs, waste management costs etc.), *contingent costs* (penalties, fines, legal expenses, natural resource damages costs) and *image and relationship costs* (corporate image costs, relationship with customers costs, relationship with professional staff costs etc.)

External costs refer to environmental degradation for which company is not legally responsible and to adverse impacts on human beings, their properties and their welfare that cannot be compensated through the legal system (Grădinaru, Colibaba & Voineagu, 2003).

There were debates about including external costs in company's accounting, but more rigorous regulations regarding the environmental liability have led to internalization of some costs that had been considered heretofore external costs (Rannou & Henri, 2010).

The methods used by companies to assess the environmental costs are (Rannou & Henri, 2010; Turturea & Turcu, 2013): life-cycle costing, environmental balance, full-cost accounting method, total-cost accounting method and activity-based costing method (ABC method). These methods are not exclusive, having a set of parameters in common (Rannou & Henri, 2010).

Life-cycle costing that is based on a more global approach of a life-cycle analysis identifies the environmental costs generated by a company during the life-cycle of a product. But this method does not take into account the intangible costs (including the relationship with stakeholders' costs) and the contingent costs that cannot be easily associated with a certain stage in the life-cycle of a product (Rannou & Henri, 2010).

Environmental balance consists in identifying and measuring the input and output flows of a company in terms of energy, water, materials, waste substances and emissions (Rannou & Henri, 2010). This method records only the consumption of natural resources, ignoring the other cots and does not provide a numeric equivalent of this consumption that, however, can be estimated, if it is required (Turturea & Turcu, 2013).

Full-cost accounting method consists in allocating of all costs to a product (materials, labour etc.), including the actual and potential environmental costs (Rannou și Henri, 2010). However, in this method the complex problems regarding the determination of a monetary value of externalities' costs must be solved (Turturea & Turcu, 2013).

Total-cost accounting method that is similar with the full-cost accounting method is carried out to measure the cost of capital investments (Rannou & Henri, 2010).

Activity-based costing method (ABC method) based on which the OWL ontology for environmental costs assessment was built represents one of the last conquests from the cost accounting domain (Bâtcă-Dumitru, Sahlian & Șendroiu, 2019; Ebbeken, Possler & Ristea, 2000).

The concept that this method is based on is that the activities consume resources (for instance: energy) and products (cost objects) consume activities (for instance: teaching activity), while in the traditional accounting systems it is assumed that a product (cost object) directly consumes resources (Emblemsvag & Bras, 2001; Epuran, Băbăiță & Grosu, 1999).

The concepts of activity-based costing and process costing are used as synonyms in the domain literature (Ebbeken, Possler & Ristea, 2000).

Activity-based costing method is characterized by the fact that indirect costs are no longer assigned to products through inaccurate and arbitrary quotas, but in accordance with the participation of products to enterprise's activities. The functional ensemble of the enterprise is represented by activities and processes (Bâtcă-Dumitru, Sahlian & Șendroiu, 2019).

Activity is a "set of homogeneous tasks, specific to an achievement process of the value chain and resources consuming" (Emblemsvag & Bras, 2001; Epuran, Băbăiță & Grosu, 1999).

Process is a "chain of activities oriented to obtain an output (result), characterized by: the output of a result, a consumption of resources (evaluated to cost level) and an influence factor of costs (cost driver) (Bâtcă-Dumitru, Sahlian & Șendroiu, 2019).

According to Horvath & Mayer (1989) cited by Ebbeken, Possler & Ristea (2000, pp. 366), the processes are: pre-production processes, support processes and running processes.

Cost driver is the factor that produces a change to cost level, but also the activity unit of measure (Cokins & Căpușneanu, 2010).

When activity-based costing method is used to assess the environmental costs, the problem of allocating those costs to activities and products that generated them has emerged. Experts recommend, firstly, identifying the environmental costs, when this method is used. Thus, companies can use ABC method to allocate environmental costs to activities in the traditional way or by inserting an environmental cost driver (Rannou & Henri, 2010; Turturea & Turcu, 2013).

Building the OWL Ontology for Environmental Costs Assessment

Ontologies are used to collect knowledge from a certain domain of interest. An ontology describes the concepts from the domain and the relationships that are established between those concepts (Horridge, 2011).

Currently, the technologies used to build ontologies have matured enough so that there are many methodologies, tools and languages that can be used in this purpose.

At the time of Internet expansion, a new generation of ontology languages called web-based ontology languages has been created. These languages are continuously developing and are represented by: RDF, RDFS, XOL, SHOE, OIL, DAML+OIL și OWL (Allemang & Hendler, 2011; Buraga, 2004; Buraga, 2006; Corcho, Fernandez-López & Gómez-Perez, 2003; Daconta, Obrst & Smith, 2003; Rebstock, Fengel & Paulheim, 2008; Segaran, Evans & Taylor, 2009; Straccia, 2014; Tănăsescu, 2016a). The relationship between those languages is emphasized in Figure 1.

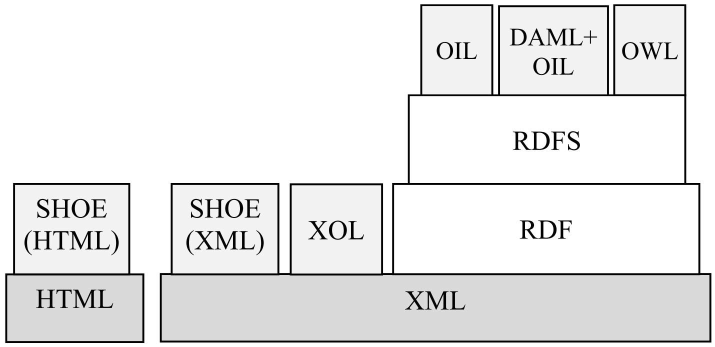

Fig. 1. Web-based ontology languages.

Source: Corcho, Fernandez-López & Gómez-Perez, 2003, pp. 55.

Web Ontology Language (OWL) and its successor OWL 2 are languages for defining and instantiating web-based ontologies (Straccia, 2014). OWL language has been created by the W3C as an extension of RDFS specification for defining classes and properties and for enabling powerful reasoning and inference over relationships (Segaran, Evans & Taylor, 2009).

OWL language provides three ontology specification levels (Buraga, 2006; Smith, Welty & McGuiness, 2004):

- OWL Lite can be used to express classification hierarchies and simple constraints;
- OWL DL provides maximum expressiveness without losing computational completeness and decidability, theoretical bases coming from the description logics;
- OWL Full allows maximum expressiveness and flexibility without take into account the computational completeness problem.

Ontology editing tools (such as: Altova, IsaViz, Kaon2, OilEd, OntoEdit, pOWL, Protégé, SWOOP, WebOnto) can be used to design the OWL ontology. These ontology editors are comparatively analysed in the specialty literature (Buraga, Cojocaru & Nichifor, 2006; Corcho, Fernandez-López & Gómez-Perez, 2003; Kapoor & Sharma, 2010; Tănăsescu, 2016a; Ukype & Mustapha, 2016).

In order to design the OWL ontology, the author has used the Protégé ontology editor (Gennari et al., 2003; Musen, 2015; Tănăsescu, 2016a) that allows both creation of frame-based ontologies (Sachs, 2006; Tănăsescu, Pătrașcu & Oprea, 2009; Tănăsescu, 2013; Tănăsescu, 2016b) and OWL ontologies (Horridge, 2011; Pătrașcu, 2015).

An OWL ontology contains *classes*, *properties* and *individuals* (Horridge, 2011).

Classes represent sets that contain individuals. Classes are concrete representations of domain's concepts. Classes may be organized into a superclass-class hierarchy which is also called taxonomy (Horridge, 2011).

The author has used the top-bottom strategy proposed by Uschold and King (Noy & McGuiness, 2001) at building of the class hierarchy of the OWL ontology for environmental costs assessment. This strategy consists in identifying the general concepts from the domain and, then, in the specialization of them.

Thus, studying the domain literature and discussing with the domain experts, 5 general concepts (classes) have been identified which have been, then, specialized: *Activity*, *Cost*, *CostDriver*, *Process* and *Resource.* These classes have the *owl:Thing* class as superclass and are disjoint classes. The disjoint classes are those classes for which an individual can be an instance of only one of these classes.

After the specialization of the general concepts, a class hierarchy that contains 90 classes has been obtained by deriving the classes (Figure 2).

Process class has been derived in three subclasses that inherit its properties: Pre-*ProductionProcess* class, *SupportProcess* class and *RunningProcess* class (Figure 3).

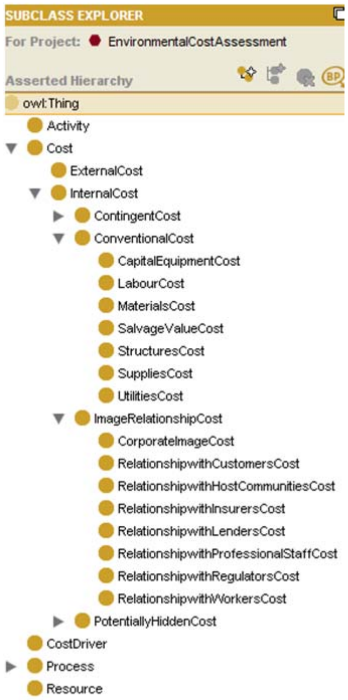

Fig. 2. Ontology class hierarchy.
Source: made by author.

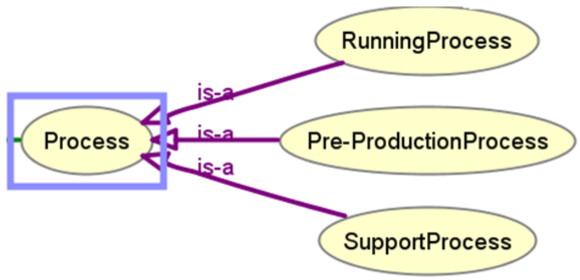

Fig. 3. Process class in OWLViz plugin.
Source: made by author.

Cost class has 2 subclasses: *InternalCost* class and *ExternalCost* class. In turn, *InternalCost* class has 4 subclasses: *ConventionalCost* class, *PotentiallyHiddenCost* class, *ContingentCost* class and *ImageRelationshipCost* class (Figure 2). All those 4 subclasses also have subclasses: *ConventionalCost* class has 7 subclasses (Figure 2), *ImageRelationshipCost* class (Figure 2) has 8 classes, *ContingentCost* class (Figure 4) has 9 subclasses and *PotentiallyHiddenCost* class (Figure 5) has 4 subclasses from which 48 subclasses derive.

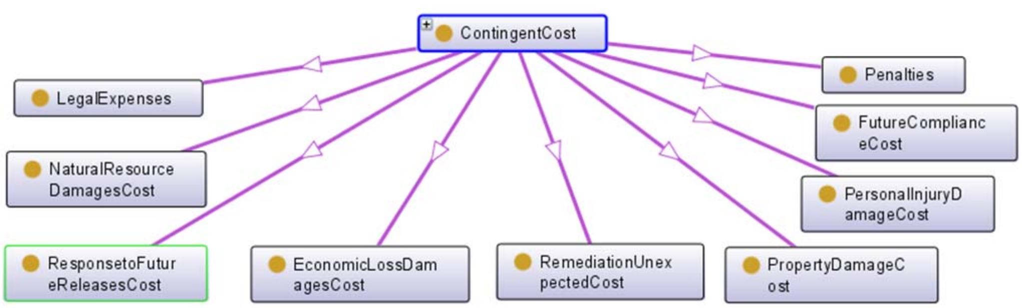

Fig. 4. *ContingentCost* class and its subclasses in OntoGraf plugin from Protégé
Source: made by author.

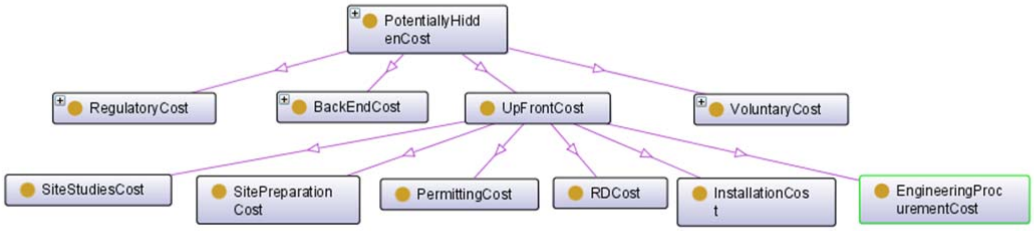

Fig. 5. PotentiallyHiddenCost class, its 4 subclasses and the subclasses of UpFrontCost class in OntoGraf plugin from Protégé

Source: made by author.

OWL properties are binary relationships that can specify facts regarding class members or individuals (Buraga, 2006). There are two owl properties types (Horridge, 2011):

- object properties that represent relationships between two individuals;
- data type properties that model a relationship between individuals and data type values or literals having XML Schema data types.

An OWL property is characterized by the fact that it can be: functional, symmetric, inverse of other property, transitive, inverse functional, asymmetric, reflexive and irreflexive. Properties can, also, include sub-properties (Buraga, 2006).

Two of those 90 classes of the ontology are, further, presented: *Activity* class and *InternalCost* class.

Activity class (Figure 6) is a subclass of the *owl:Thing* system class and contains 9 properties:

- 1 integer functional property (*activityCode*);
- 2 string functional properties (*activityDescription* and *activityName*);
- 2 dateTime functional properties (*endDate* and *startDate*);
- 3 object properties: *belongs* (stores a single individual from *Process* class), *hasAllocated* (contains multiple individuals of *Cost* class) and *hasCostDriver* (stores a single individual from *CostDriver* class).

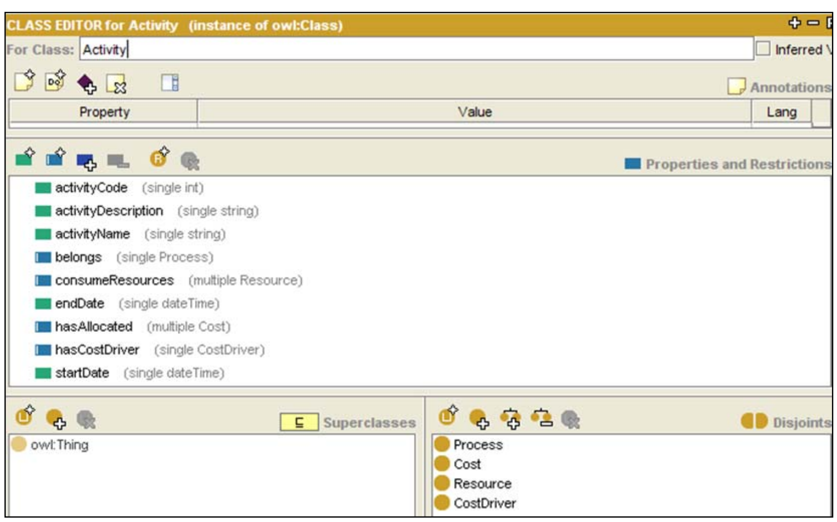

Fig. 6. Activity class properties.

Source: made by author.

Two of those properties (*belongs* and *hasAllocated)* have inverse properties: *contains* (property of *Process* class) and *isAllocated* (functional property of *Cost* class).

InternalCost class (Figure 7) is a subclass of *Cost* class and has 4 subclasses. The class has 6 inherited properties from the *Cost* class, *costType* property being overridden. These properties are: *costCode* (integer functional property), *costDate* (date functional property), *costName* (string functional property), *costValue* (float functional property), *isAllocated* (functional object property) and *costType* (functional property that is overridden and takes only the value *internal*).

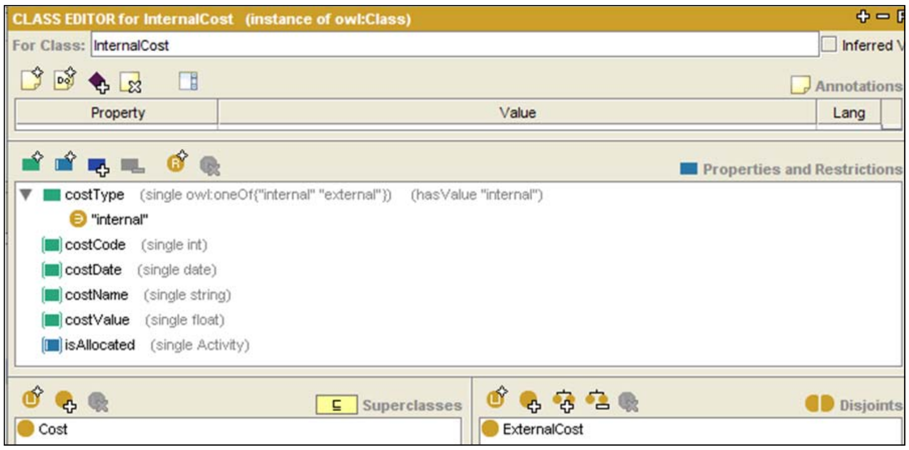

Fig. 7. InternalCost class properties.

Source: made by author.

Conclusions

This paper enumerates the environmental managerial accounting advantages and analyses the main methods used to assess the environmental costs. Also, an ontology for environmental costs assessment build using the activity-based costing method is proposed.

The advantages of *EnvironmentalCostAssessment* ontology are:

- can be adapted and developed by other knowledge engineers;
- can be an intelligent tool for training those who are less competent in the domain;
- can be imported in any application for environmental costs record;
- can be used by any organization that wants to identify and reduce the environmental costs;
- allows the analysis of knowledge from the environmental managerial accounting domain.

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