Paweł **LOREK**

SUSTAINABLE INNOVATION AS AN IMPORTANT FACTOR OF FIRM DEVELOPMENT

Paweł **Lorek,** PhD – *University of Economics in Katowice*

Correspondence address:
1 Maja street 50, Katowice, 40-287, Poland
e-mail: pawel.lorek@ue.katowice.pl

ABSTRACT: The environmental and social aspects are becoming increasingly important for enterprises. A very important matter is also achieving the high level of innovation for gaining competitive advantage. The way to reconcile these aspirations seems to be a development path called sustainable innovation.

The aim of the article is to identify the concept of sustainable innovation in the context of modern enterprises and to propose the method of supporting it using an algorithmic approach.

KEY WORDS: sustainable innovation, sustainable development, graph exploration

Introduction

The concept of sustainable development is becoming increasingly important in many countries' policies. This fact is reflected in legal regulations. These regulations impose specific obligations on public administration and enterprises. In this situation it is necessary to implement the principles of sustainable development in the practice of companies. The attitude of companies towards sustainable development can be various and depends on many factors like: the size of the company, the profile of industry or the country of origin which determines specific management rules. The most common rule seems to be the pursuit of profit, without taking into account environmental and social factors.

The next rule is declaring of taking into account the postulate of sustainable development due to the image benefits. These declarations, however, are rarely being realized. This phenomenon is often observed in case of companies engaged in the exploitation of natural environment (oil companies, forestry, mining and metallurgical industries). Unfortunately, no legal regulations have been established to punish this abuse so far. However, there are companies interested in real, not fake, sustainable development. The main problem of these companies is the issue of taking into account the demands of sustainable development in the offer of manufactured products and rendered services. This often requires an unconventional, creative approach. These reasons lead to the concept of sustainable innovation. This term is subject of interest to an increasing number of researchers, who underline its significance for the implementation of the overall concept of sustainable development.

The need for sustainable innovations

The definition of sustainable innovation might be problematic. As in the case of sustainable development, sustainable innovation should describe the creative process, which takes into account environmental, social and economic criteria. With these assumptions, the sustainable innovation can be defined as follows (Ketata, Sofka, Grimpe, 2014):

- sustainable innovation concerns a product, process, service or method,
- aims to meet market needs,
- reduces the negative impact on the environment,
- takes into account the entire life cycle of developed solution,
- sets up a new standards for current issue.

The key issue for making distinction between sustainable innovation and innovation in general is considering social and environmental factors. In order to develop an innovative solution in the sustainable category, it must have a positive impact on major environmental and social issues. Classic examples of sustainable innovations can be, for example, more efficient waste water treatment or the development of new types of dust reduction filters. Despite the cited examples, sustainable innovation should not be equated only with environmental engineering. Such innovations can be found in the textile, food, furniture and energy sectors (Schaltegger, Wagner, 2011).

Sustainable innovation can be assigned to following categories (Aagaard, Lindgren, 2015):

- improving the functioning of existing products, services and processes with respect for environmental and social factors,
- use of alternative technologies for existing applications,
- applying present knowledge in new market areas,
- development of innovative technologies applicable in new market areas.

The issue of improvement of existing products, services and processes is associated with the emergence of new restrictions on changing market realities. These restrictions may include rising prices of raw materials and energy but also costs associated with greenhouse gas emissions. As an example of this type of innovation, it can be mentioned the information system, which provides assistance in optimizing the consumption of disposable items in enterprises (Seidel et al., 2017). Another form of restrictions are consumers, who pay more attention to environmental and social aspects (Bekmezci, 2015). There are even consumers for who environmental and social aspects are fundamental motivators in decision making (Jastrzębska, 2017). This category includes all innovations which lead to reduce of raw material and energy consumptions. Similar connotations can be found in the category of alternative technologies usage. For companies, the incentives to develop such innovations are generally more oppressive legal forms. As an example, it can be pointed attempt to replace combustion engine with electric engine in cars and buses (Maxwell, 2009). This kind of innovation is forced by more strict pollution emission standards. Applying the present state of knowledge in new market areas is a form of transferring experience from one market segment to other segments. It generally involves the use of existing organizational solutions in a new environment.

The most innovative approach to innovation is the development of new technologies that create a new market sector. As an example, it can be pointed the market for household installations for generating electricity from renewable sources. It is obvious that this case has economic (profits for companies which produce renewable energy sources facilities), environmental (lower

environmental burden of industrial emissions from non-renewable sources) and social benefits (new jobs in renewable energy sources sector, reduction of household expenditures).

Algorithmic approach for sustainable innovations support

The process of developing of innovative solutions often requires the ability to synthesize information from multiple disciplines. This phenomenon is strongly present in the process of developing of sustainable innovations. The necessity of taking into account many of technical, environmental, economic and social factors makes it necessary to combine information from many areas of knowledge. Here, one of the basic barriers appears. In the age of strict specialization, the ability to link accumulated knowledge with other disciplines is becoming increasingly difficult. Another barrier is the increasing number of various documents' types like: technical documentation, scientific articles, reports and legal acts. It is very hard to get familiar with the content of all documentation on a particular issue. Finding common elements between different subjects it is even harder task. The described situation is reason for using algorithmic methods in supporting innovation. Computer support for innovation process aims at overcoming barriers resulting from limitations of human abilities. A various methods have been used for this purpose. The most common are data mining and machine learning (Toivonen, Gross, 2015). This approach is not aimed at eliminating man from the innovation process. Developing innovative solutions still requires human invention and, probably, will require in future. However, without going further into the nature of innovation, support for this process is possible through usage of specialized tools. The scheme of functioning of such tool has been shown on figure 1.

The proposed solution is based on the exploration of a set of documents on specific subjects. The choice of knowledge domain and documentation that consists the description of particular domains, depends mainly on organizational conditions such as the specify of the company using the described solution. The next step is to extract the key terms, which are describing the content of the document. The obvious activity at this step, is to use the keyword list (if it is included in the document) as well as the lexical decomposition of the document's title. In the next step, a list of obtained keywords attached with links to source documents are placed in the repository. The created repository is a data source for links exploration algorithm. Identification of links-relations takes place by searching keywords associated with user's query. In the next steps, the found keywords are organized in the form of an undirected graph. The graph can be defined as finite set of vertices

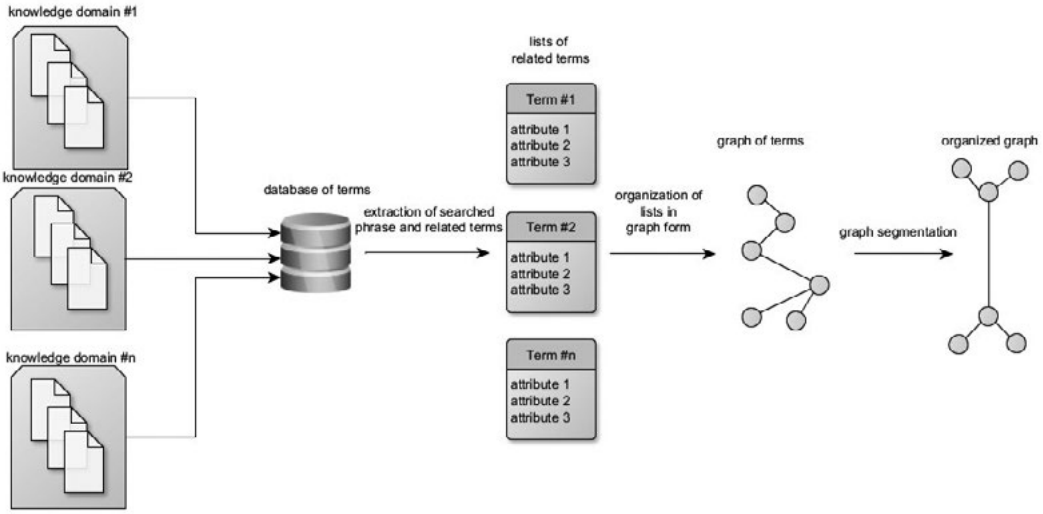

Figure 1. Data extraction and preparation workflow

V and a finite set of edges E containing pairs of elements of the set V (Wilson, 2012). In this case, vertices of the graph are the individual keywords and the edges are links of co-occurrence between keywords in the processed documents. Such data structure has much more potential for visualizing than data stored in tabular form. It is especially well suited for relational data visualization (Wang, Tao, 2016). In order to make it easier to notice the relationships that occur in the analyzed set, it is necessary to organize it, before visualizing the final graph. For this purpose, it can be used (Lee, Sohn, 2016):

- simple algorithms, which place vertices in a coordinate system in a random way,
- circular algorithms, which organize graph vertices in circle form,
- spring layout algorithms, based on the concept of virtual forces repelling and attracting individual vertices,
- multidimensional scaling algorithms, based on the similarity measure of the individual vertex pairs.

The purpose of organizing the graph is to reveal specific structures that show the interaction between the concepts. These structures may have different forms, depending on the strength and nature of the relationship. The most characteristic structures are: bridging concepts, bridging graphs and graph similarity (Kötter, Berthold, 2012). This structures are presented on figure 2.

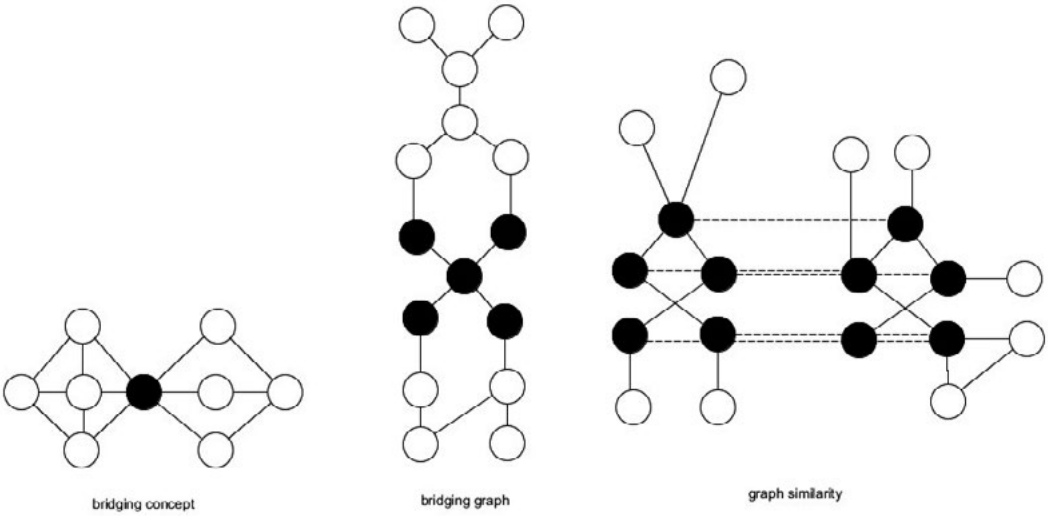

Figure 2. Relations in graph structures
Source: (Kötter, Berthold, 2012).

Bridging concept is a form of relationship that manifest itself through the presence of a node connecting two clusters which represent different ranges of concepts. In this way, it is possible to detect concepts that are seemingly unrelated to each other. The more sophisticated forms of relations are bridging graphs. In this case, the two knowledge domains are linked together by a set of terms. The graph similarity is an indirect form of relation. It manifests itself by the structural similarity of subgraphs in two different domains (Berthold, 2012). The potential relations are not limited to the mentioned types. There are other interesting patterns like: clusters, outliers and other types (Raymond, Belbin, 2006). A list of interesting patterns, indicating the existence of significant relationships between concepts is not limited. Relational patterns can be variable, depending on the subject being analyzed or the publication period. This feature introduces a specific lack of determinism to the described method. Creativity is still inextricably linked with human capabilities.

The described method has been implemented as a Python script. The Python language has been chosen due to good ability for text processing. Moreover, there is a possibility for using a wide range of libraries for graph processing. In this case the NetworkX library has been chosen. The NetworkX is one of the most well developed and tested (Boschetti, Massaron, 2017). As a visualization tool, the Gephi library has been used. The graph layout has

been performed with use of ForceAtlas2 algorithm, which belongs to spring layout algorithms group (Jacomy, Heymann, Venturini, Bastian, 2012). The data source contained 2758 records about scientific articles and 300 records about patents. The example result of simulation has been shown on figure 3. On the graph, a part showing the concepts associated with the term "*energy efficiency*" has been presented.

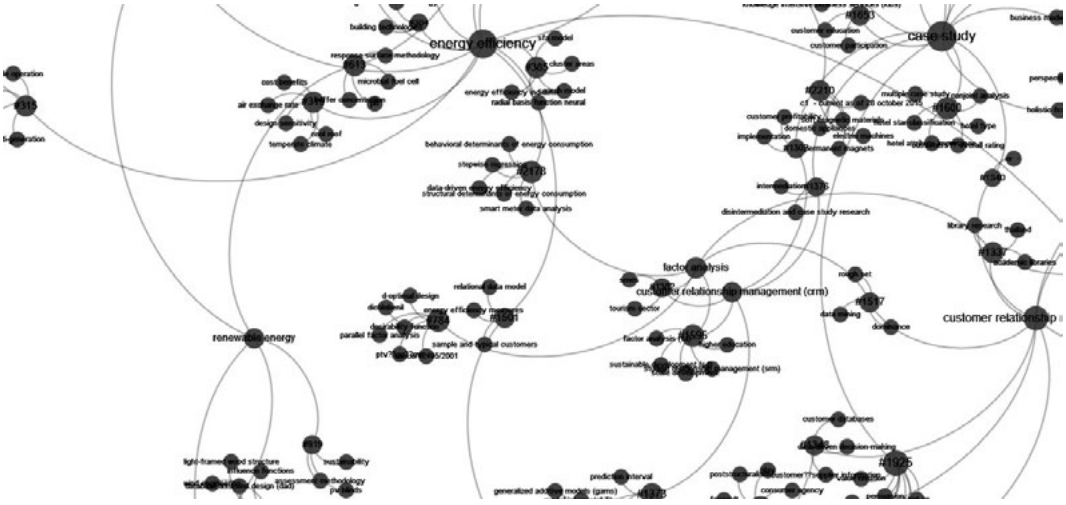

Figure 3. Graph organization result

In the presented graph, it can be noticed the presence of vertices representing documents (vertices marked by "#"), and what keywords are assigned to each of these documents. It can be also noticed which term links certain publications (these are: "*energy efficiency*", "*renewable energy*", "*factor analysis*").

Despite the promising, initial results, the presented approach has many limitations. The limitations of described method are following:

- the clarity of the result is strongly dependent on the selection of source documents,
- the need to process a large number of different documents formats,
- difficulties related to text extraction due to the language of processed publications (e.g. processing Polish and English documents),
- high processing complexity during analyzing large numbers of documents,
- possibility of complications at the level of lexical processing (e.g. due to the presence of synonyms),

- problems with processing of poorly structured documents,
- possibility of overlooking important information by inexperienced users.

Conclusions

There is no doubt that are growing challenges for the companies. Future expectations of consumers will surely include pro-environmental and pro-social elements. In this situation, gaining competitive advantage will depend on the ability of the company to develop product and service innovations with taking into account environmental and social requirements.

In the innovation policy, companies must take into account following considerations:

- growing number of documents' types, necessitates the possessing of knowledge management capabilities,
- development of sustainable innovations will require the ability to synthesize different areas of knowledge,
- computer supporting may be helpful in developing sustainable innovations.

The concept of sustainability innovation described in this article is probably one of the possible approaches. Developing alternative methods and assessing their effectiveness is a promising subject for future research.

Literature

Aagaard A., Lindgren P. (2015), *The Opportunities and Challenges of Persuasive Technology in Creating Sustainable Innovation*, "Wireless Personal Communications" No. 81, p. 1511-1529

Bekmezci M. (2015), *Companies' profitable way of fulfilling duties towards humanity and environment by sustainable innovation, "*Procedia-Social and Behavioral Sciences*"* No. 181, p. 228-240

Berthold M. (2012), *Towards Bisociative Knowledge Discovery*, in: G.J. Williams, S.J. Simoff (eds), *Data Mining*, Lecture Notes in Computer Science No. 3755, Berlin-Heidelberg

Boschetti A., Massaron L. (2017), *Python. Podstawy nauki o danych*, Gliwice

Jacomy M. et al. (2012), *ForceAtlas2, A Continuous Graph Layout Algorithm for Handy Network Visualization*, medialab.sciences-po.fr/publications/Jacomy_Heymann_Venturini_ForceAtlas2.pdf [02-10-2017]

Jastrzębska E. (2017), *The responsible consumer as an answer to new sustainable development challenges*, "Ekonomia i Środowisko" No. 60, p. 198-206

Ketata I., Sofka W., Grimpe Ch. (2014), *The role of internal capabilities and firm's environment for sustainable innovation: evidence for Germany*, "R&D Management" No. 45, p. 60-70

Kötter T., Berthold M. (2012), *From Information Networks to Bisociative Information Networks*, in: M. Berthold (ed.), *Bisociative Knowledge Discovery*, Lecture Notes in Computer Science No. 7250, p. 33-50

Lee H., Sohn I. (2016), *Big Data w przemyśle*, Warszawa

Maxwell I. (2009), *Managing Sustainable Innovation. The Driver for Global Growth*, New York

Raymond B., Belbin L. (2006), *Visualisation and Exploration of Scientific Data Using Graphs*, in: G.J. Williams, S.J. Simoff (eds.) *Data Mining*, Lecture Notes in Computer Science No. 3755, Berlin-Heidelberg

Schaltegger S., Wagner M. (2010), *Sustainable Entrepreneurship and Sustainability Innovation: Categories and Interactions*, "Business Strategy and the Environment" No. 20, p. 222-237

Seidel S. et al. (2017), *Design principles for sensemaking support systems in environmental sustainability transformations*, "European Journal of Information Systems", https://doi.org/10.1057/s41303-017-0039-0.

Toivonen H., Gross O. (2015), *Data mining and machine learning in computational creativity*, Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery No. 5, p. 265-275

Wang Ch., Tao J. (2016), *Graphs in Scientific Visualization: A Survey*, "Computer Graphics Forum" No. 36, p. 263-287