Contemporary management in extractive industries - multidimensional and practical approach

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Contents

Foreward

Extraction of natural raw materials in current market conditions raises controversies. On the one hand, it is a necessary activity for the proper functioning of modern and traditional branches of industry. On the other hand, both underground and open-pit extraction of natural raw materials are a serious threat to regional ecosystems and communities.

Having the above circumstances in mind, one must constantly look for more effective and efficient management methods in mining industries that will make the continuation and sufficiency of extraction possible together with minimization of environmental burden and problems of mining regions inhabitants associated with the exploitation. These subjects are discussed during periodic international MEET scientific conference (Management – Economics – Ethics – Technics) organized by the Faculty of Organization and Management of the Silesian University of Technology (Poland) and Saint-Petersburg Mining Institute (Russia).

This monograph is composed of three parts where the authors of particular articles – presented during the conference – focus respectively on issues associated with:

- Competitiveness – Part 1: Assessment of competitiveness in mining industries: methods of measurement and strengthening tools,
- Productivity – Part 2: Improvement of productivity in mining industries with the use of organizational and technological methods,
- Sustainability – Part 3: Social and environmental aspects of management in mining industries.

of mining industries, which reflects the constant search for balance between the economic, social and technical aspects of management in these industries. Majority of the articles is based on data and real problems present in national and international mining industries which makes the considerations and results applicable and directly reflected in operational and strategic management decisions.

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- AGH University of Science and Technology, Poland,
- Faculty of Organization and Management, Silesian University of Technology, Poland.

PART I

Assessment of competitivness in extractive industries: methods of measurement and strengthening tools

Chapter 1
COMPARATIVE ANALYSIS OF COMPETITIVE ADVANTAGES OF RUSSIAN FERTILIZER COMPANIES

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Abstract

The Russian fertilizer industry is strategically important and potentially competitive in world markets, while also having good conditions for stable growth in Russia. Intense competition and changes in the structure of world trade forced fertilizer companies to gain and sustain competitive advantages. Therefore, the purpose of the article is to reveal competitive advantages of Russian fertilizer companies and compare them by evaluating their sustainability in order to find out most and less sustainable competitive advantages. In this paper, an analytical model for comparison of competitive advantages of fertilizer companies regarding its sustainability is proposed. This model was used for comparative analysis of competitive advantages of Russian fertilizer companies. Main sources of competitive advantages of Russian fertilizer companies, their components and results of their implementation are presented as one of the results of the research. Sustainable and non-sustainable competitive advantages were revealed. Russian fertilizer companies as well as foreign companies can use the results of the research for revealing more and less sustainable competitive advantages in order to strengthen its positions on the world market.

Key words: fertilizer companies, competitive advantages, sustainability, fertilizer industry, mineral recourses.

1.1. Introduction

The use of fertilizers increased vastly over the twentieth century, and fertilizer use is forecast to continue growing also in the near future (Enger, 2010). Global consumption of fertilizers in the agricultural years (beginning of July - end of June) 2009-2016 is presented in Figure 1. The dynamic growth of consumption of fertilizers is seen in all three segments. The greatest increase is observed for nitrogen fertilizers, which are the most commonly used fertilizer worldwide.

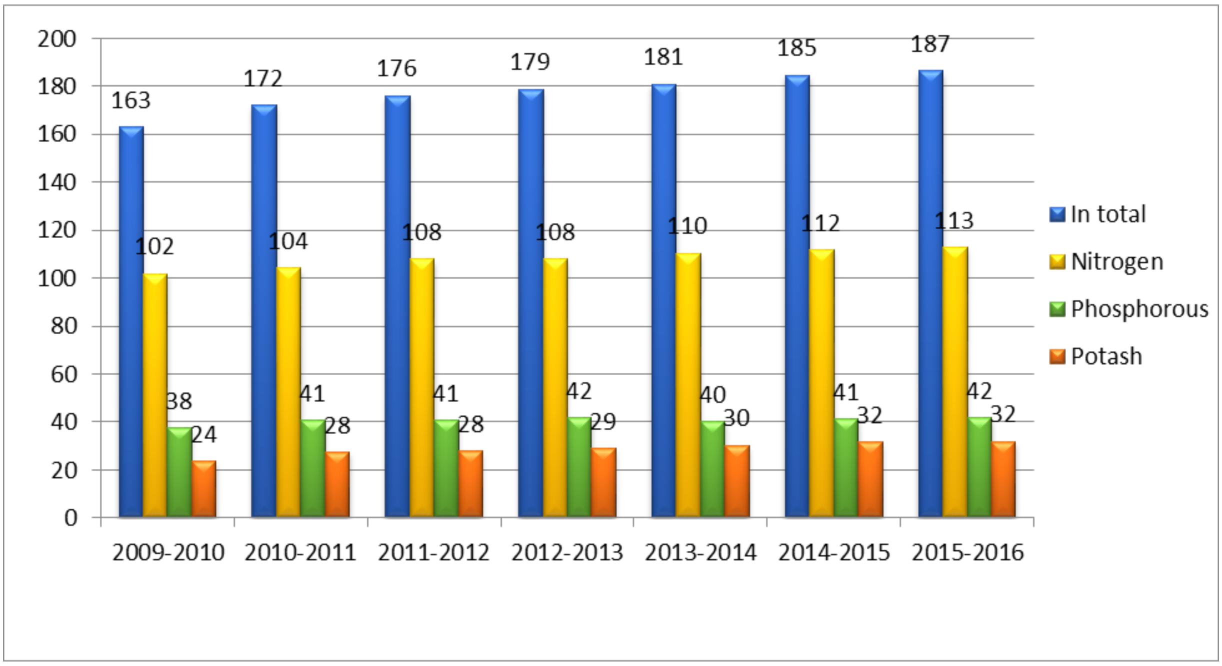

Figure 1. Global consumption of fertilizers (agricultural years) [mln tonnes]

Source: Fertilizer Outlook 2013-2017, Fertilizer Outlook 2015-2019, (Dmitrieva et.al., 2017).

Limited supply caused by resource exhaustibility influence the market situation as well. Thus, attractive industry fundamentals determine steady growth in demand for fertilizers in the long term (Ilinova, Dmitrieva, 2017).

Russia accounts for about 10% of world production of fertilizers.Products of the Russian fertilizer industry (due to the unique natural resources) are characterized by high quality and competitive price as a whole (Dmitrieva, 2016).

Due to the launch of new production facilities (capacity growth) and increased competition, the position of suppliers in the structure of world trade has changed in recent years.

The world market is characterized by very intense competition. According to the International Fertilizer Association, by 2018, it is expected a significant increase of production capacity of nitrogen fertilizers in East Asia (China, Indonesia), Eastern Europe (Russia), North America (USA), Africa (Algeria, Egypt, Nigeria). In the phosphorous segment, Saudi Arabia (+3.5 million tons per year in 2017) and Morocco (+1.8 million tons per year) will provide the main capacity growth. There are other projects (including in the CIS countries – in Kazakhstan and Uzbekistan), but precise data on launch dates and capacities are not yet available. In the potash market the largest project is being implemented in Canada (Jansen, 8 million tons), but now there is no clarity with the timing. Russian companies“ Acron” and “EuroChem” are actively working on the construction of new mines. In 2018, new mines are expected to be commissioned in Canada ("K+S Kali", 2.8 million tons) and Turkmenistan ("Turkmen chemistry", 1.4 million tons). In 2020 it is also expected capacity expansion in Belarus. Important for the market is the announcement of the discovery of potash salt deposits in China.

Increased competition in the world market of mineral fertilizers will complicate the position of Russian companies. In order to maintain leading positions Russian companies need to gain and develop sustainable competitive advantages. Therefore, the purpose of the research is to reveal main competitive advantages of Russian fertilizer companies and to compare them using suggested model in order to find more sustainable.

1.2. Literature studies

Nowadays, there are a lot of theoretical and methodological approaches and research studies devoted to competitive advantages of the companies: their creation, development and maintaining. In traditional approach to strategic management, competitive advantage is described as something that helps a company consistently earn a higher rate of return than its competitors (Porter, 1980; Porter, 1985; Grant, 1995; Schoemaker, 1990). Some authors define competitive advantage as a quality that distinguishes the company from others and keeps it going and growing (Smith and Flanagan, 2006).

Nowadays, companies should not only improve their adaptability and flexibility (Nilson and Rapp, 2005; Wei, et al., 2017, Ponomarenko, 2016, Nevskaya and Marinina, 2017), but also develop the strategy with the main goal to gain and boost competitive advantages(Švárová and Vrchota, 2014; Gyampah and Acquaah, 2008).

However, in times of globalization and intensive business competition it becomes more and more difficult to gain and maintain competitive advantages (Brown and Eisenhardt, 1998; D'Aveni, 1994; Nilsson and Dernroth, 1995; Eisenhardt and Martin, 2000; Hamel, 2000). It is because almost all of them (resources, technologies, information etc.) can be copied and replicated by competitors (Goldsmith, 2013; Singh, 2012).

Previous studies, devoted to mineral fertilizers market, have addressed fertilizer markets and forecasts of fertilizer consumption (Al Rawashdeh, 2011; Al Rawashdeh, 2016; Geman, 2013), development of phosphate and potash resources and reserves (Mew, 2016; Ciceri, 2015; Cooper, 2011). The past research also addressed the evolution of the fertilizer market and its forecasting in the coming decades (Al Rawashdeh, 2014) as well as fertilizer availability in a resource-limited world (Dawson, 2011). In addition, the research has tackled capital investment in fertilizer companies (Geman, 2013), supply behavior of state mining enterprises (Al Rawashdeh, 2008), and efficiency performance of the leading phosphate rock mining companies (Geissler, 2015).

Competitive advantages of fertilizer mining companies could be classified by degree of their sustainability (sustainable and non-sustainable (unsustainable)). The research of sustainability of competitive advantages is a widespread subject of research in academic debates. There are many previous studies devoted to sustainable competitive advantages (Chaharbaghi and Lynch, 1999; Takalaa, 2013; Kotabe, 2014 among many others).

In general, in the theory of sustainable competitive advantages, sustainability is an attribute of advantage that shows whether competitors can copy it or not. There are many definitions of sustainable competitive advantages (Grant, 1995; Chaharbaghi and Lynch, 1999; Barney et al., 1991; Barney et al., 2001; Liu, 2013).

However, there are no research papers focusing specifically on the creation and development of competitive advantages of fertilizer mining companies. Moreover, despite the wide range of scientific works devoted to sustainable competitive advantages, there is no opportunity to measure the sustainability of competitive advantages for fertilizer companies and other companies.

1.3. Methodology

Analyzing and synthesizing previous researches concerning characteristics of sustainability of competitive advantages (Grant, 1995; Chaharbaghi and Lynch, 1999; Barney, 1991) we suggest use three indicators for sustainability of competitive advantages evaluation - possibility of competitive advantages copying (replicability), time for competitive advantages invention/ implementation and resource intensity of competitive advantages implementation (Tab. 1).

Table 1. Indicators for sustainability of competitive advantages evaluation

Indicator	Symbol	Characteristic	Description
Possibility of competitive advantages copying	P	Shows if it is possible to copy competitive advantages and analytical measure of possibility.	It is an evaluation of possibility of company's competitive advantages copying or substitution by competitors. If competitive advantage is easy to copy and there is no possibility to protect intellectual property this determinant take the value 0. If it is impossible to copy competitive advantage the determinant take the value 1.
Time for competitive advantages invention/ implementation	T	Measure of time needed by competitor to achieve competitive advantages and implement it.	It is an evaluation of time needed to achieve competitive advantage. More time needed, closer to 1 is the determinant's value.
Resource intensity of competitive advantages implementation	R	Shows how much resources competitors need for implementing competitive advantage.	It is a measure of amount of resources (financial, human etc.) that competitors need to get competitive advantage and sustain it in turbulent environment More resources needed, closer to 1 is the determinant's value.

Source: own study.

Takalaa (2013) suggest in his research strategy triangle and resource triangle, using that idea in order to evaluate sustainability of competitive advantages by three determinants we suggest to construct the triangle of sustainability of competitive advantages where the sides would be the determinants P, T, R (the example you can see on the Fig. 2).

We have three determinants, which are unidirectional – the bigger value each of them takes - more sustainability the competitive advantage has. So, the bigger the area of a triangle the higher level of sustainability the competitive advantage has. The main idea – is to evaluate level of competitive advantages sustainability using these determinants and reveal more and less sustainable competitive advantage for fertilizers companies in order to create competitive strategy. The implementation of that concept is given in the next paragraph.

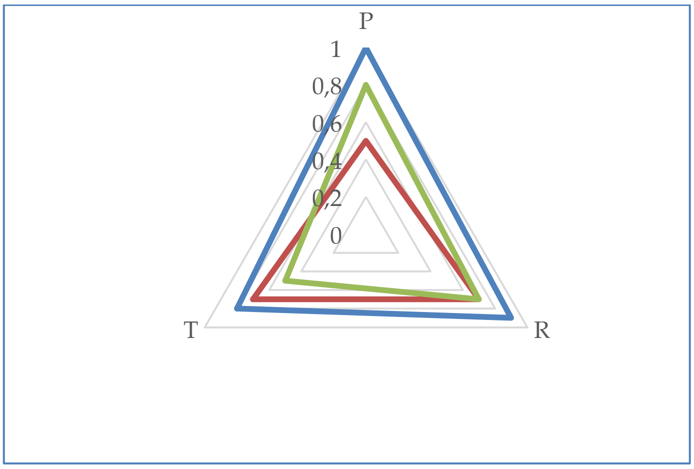

Figure 2. The concept of the triangle of sustainability of competitive advantages (an example)

Source: own study.

1.4. Research results

Intense competition forces fertilizer companies to search for sustainable competitive advantages in order to hold or strengthen their market position. Under such circumstances situation, it is important to understand the sustainability of particular competitive advantages (Ilinova and Dmitrieva, 2017). First, we need to identify main competitive advantages of fertilizer companies. There are many factors contributing to the competitive advantages of producers of mineral fertilizers (Dmitrieva and Ilinova, 2016; Ilinova and Dmitrieva, 2017; Dmitrieva at al., 2017). Using market peculiarities of fertilizer industry (Dmitrieva, 2016) and features of Russian raw material base (Pashkevich et al., 2014) the main sources of competitive advantages, their components and results of their implementation were established (Table 2). After that, we need to compare competitive advantages.

Table 2. Creation of competitive advantages in fertilizer companies

Sources of competitive advantage	Competitive advantages	Result of implementation
Mineral resources	Access to all kinds of mineral resources Mineral raw material independence of the company Access to unique mineral resources	Low production expenses High quality of products
Possibility to create large vertically integrated companies	Vertically integrated business model of the company	Effective planning and management of all the chain of value creation, effect of synergy and low

Sources of competitive advantage	Competitive advantages	Result of implementation
		production expenses
Possibility to transform the production system depending on the demand for mineral fertilizers by types	Flexible business model allowing for a quick change of the production structure	High production and sales efficiency
Possibility to transform the sales system depending on the demand for mineral fertilizers by regions	Flexible sales model allowing for a quick change of delivery regions	High production and sales efficiency
Possibility to develop a logistic system to optimize the costs	Effective logistic system (with own assets)	Low expenses on transport, timely delivery of goods
Possibility to develop company's own distribution system	Own distribution system	Low expenses on distribution, timely delivery of goods, proximity to final buyers, satisfaction of individual inquiries of buyers
Diversification and production of different types of mineral fertilizers	Wide product range	Ability to satisfy demand of a large number of consumers, high profit margin, decreasing risk
Possibility to participate in social and cultural development of the region	Implementation of social and infrastructural programs in the region	Good reputation of the company, involvement of labor, increased level of corporate social responsibility
Fluctuation of currencies	Low cost of production in relation to the world market	Additional profit / increase in sales caused by reduction of prices

Source: own study.

As we have already stated, competitive advantages can be sustainable, conditionally sustainable and non-sustainable (Chaharbaghi and Lynch, 1999; Takalaa, 2013; Kotabe, 2014).

In order to evaluate the sustainability of competitive advantages of fertilizer companies we used the suggested model. For that purpose, competitive advantages listed in Table 2 were characterized using determinants (P, T, R) and the areas of a triangles (S) were calculated.

A group of experts (decision-makers) was involved in the evaluation of sustainability characteristics of competitive advantages. It brought together three specialists in business management, who have considerable experience in forecasting, planning and managing companies in this specific industry, as well as two specialists (senior consultants) in consulting and analytical agencies dealing with such issues. The results of evaluation presented in Table 3.

Table 3. Characteristics of competitive advantages sustainability for fertilizers companies

Competitive advantages											
No.	1	2	3	4	5	6	7	8	9	10	11
P	0,8	0,7	0,7	0,6	0,3	0,4	0,2	0,1	0,4	0,3	0,1
T	0,8	0,9	0,6	0,4	0,7	0,6	0,4	0,3	0,5	0,4	0,2
R	0,8	0,8	0,8	0,5	0,5	0,4	0,2	0,2	0,5	0,4	0,2
S	7,6974	7,7658	5,9618	3,0753	3,2827	2,7035	0,93484	0,5504939	2,6430	1,6410	0,3595

Source: compiled by the authors(1 - Access to all kinds of mineral resources, 2 - Mineral raw independence of the company, 3 - Access to unique mineral resources, 4 - The vertically integrated business model of the company, 5 - The flexible production business model allowing to change structure of production quickly, 6 - The flexible sale business model allowing to change regions of deliveries quickly, 7 - Existence of effective logistic system (with own assets), 8 - Existence of own distribution system, 9 - Wide product range, 10 - Implementation of programs for development of social facilities and infrastructure in the region, 11 - Low cost of production in relation to the world market.)

The triangles of sustainability of competitive advantages were built (Fig. 3). The concept of triangle was used because it helps not only to reveal more and less sustainable competitive advantages but also to present more informative each of it.

As it was mentioned competitive advantages could be sustainable and non-sustainable (Chaharbaghi and Lynch, 1999; Takalaa, 2013; Kotabe, 2014 among many others). Also in high environmental turbulence (Ilinova and Dmitrieva, 2017), some competitive advantages that seems to be sustainable could become non-sustainable (conditionally sustainable). For fertilizers companies possibility of competitive advantages copying (replicability), time for competitive advantages invention/ implementation and resource intensity of competitive advantages implementation have equal significance for evaluation sustainability of competitive advantages. Each of them could take the value from 0 to 1, were 0 determine competitive advantage which is easy to copy without spending a lot of time and resources, and 1 determine competitive advantage that is impossible to copy or it will take a lot of time and resources. So, for these determinants we make convention: if each of determinant take value from 0 to 0.33 competitive advantage determined as non-sustainable, from 0.33 to 0.66 – conditionally sustainable, from 0.66 to 1 – sustainable (three levels of competitive advantages sustainability). Calculating areas of triangles for fertilizer companies, the follows convention could be made:

- $0<F(P, T, R) \leq 1.3098$– the competitive advantage of fertilizer company considered as non-sustainable,

- 1.3098 < F (P, T, R) ≤ 5.2391 – the competitive advantage of fertilizer company considered as conditionally sustainable,
- 5.2391 < F (P, T, R) ≤ 12.0273 the competitive advantage of fertilizer company considered as sustainable.

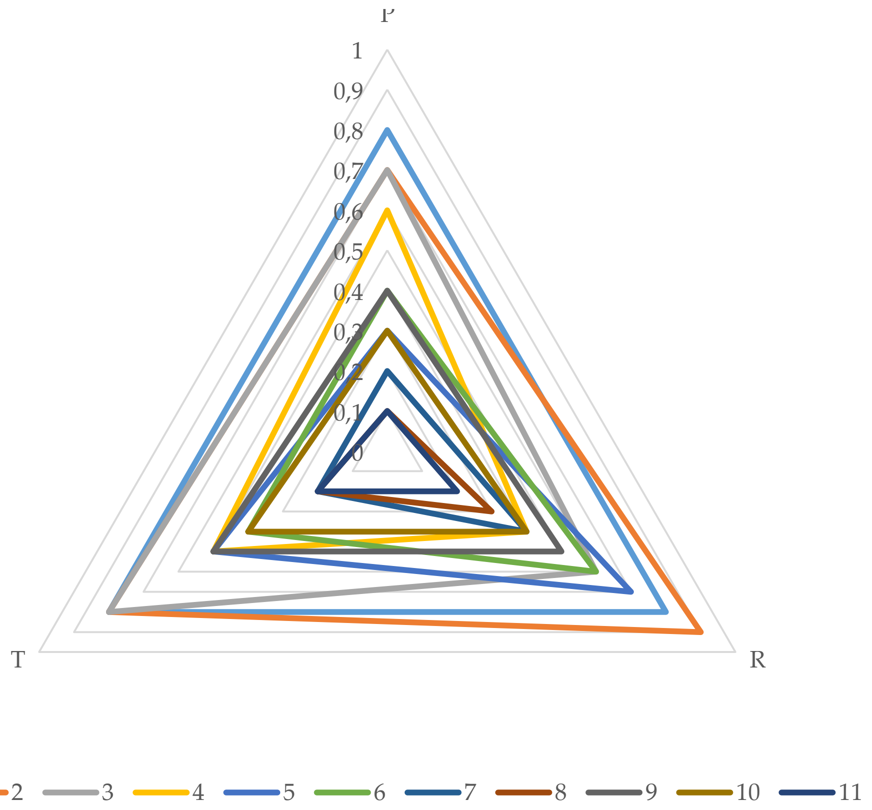

Figure 3. Triangles of sustainability of competitive advantages for fertilizers companies

Source: own study (1 - Access to all kinds of mineral resources, 2 - Mineral raw independence of the company, 3 - Access to unique mineral resources, 4 - The vertically integrated business model of the company, 5 - The flexible production business model allowing to change structure of production quickly, 6 - The flexible sale business model allowing to change regions of deliveries quickly, 7 - Existence of effective logistic system (with own assets), 8 - Existence of own distribution system, 9 - Wide product range, 10 - Implementation of programs for development of social facilities and infrastructure in the region, 11 - Low cost of production in relation to the world market.)

Using this classification the following conclusions could be done about sustainability of competitive advantages of fertilizers companies: 1,2,3 – it is sustainable competitive advantages; 4,5,6,9,10 - conditionally sustainable competitive advantages; 7,8,11 - non-sustainable competitive advantages.

Table 4 presents sustainability of competitive advantages of Russian fertilizers companies with examples of the Russian companies that have these competitive advantages. In addition, table presents possible results of competitive advantages realization for companies.

Table 4. Sustainability of competitive advantages of Russian fertilizers companies in high environmental turbulence

Competitive advantages	Sustainability of competitive advantage	Companies
Access to all kinds of mineral resources	Sustainable (S=7,6974) Realization of competitive advantage allows companies produce all kinds of fertilizers and not depend from supplies. It is the most sustainable competitive advantage in fertilizers industry.	None of Russian companies
Mineral raw independence of the company	Sustainable (S=7,7658) Realization of competitive advantage allows companies operate in its own rhythm without dependence from terms and conditions of supplies	PhosAgro, Uralkali, Evrochem
Access to unique mineral resources	Sustainable (S=5,9618) Realization of competitive advantage allows companies produce and supply unique product to market or define conditions in case of providing rivals with this resource. It is almost impossible to copy that competitive advantage	PhosAgro, Uralkali
The vertically integrated business model of the company	Conditionally sustainable (S=3,0753) This competitive advantage is easy to copy and almost all fertilizers companies in Russia already has it because it provide lower costs and independence in operational activity	PhosAgro, Evrochem, Akron, Uralkali
The flexible production business model allowing to change structure of production quickly	Conditionally sustainable (S=3,2827) It is possible to copy that competitive advantage, but it requires resources. At the same time it helps company to satisfy the actual demand of consumers	PhosAgro
The flexible sale business model allowing to change regions of deliveries quickly	Conditionally sustainable (S=2,7035) It is possible to copy but requires resources and time because of remoteness of places of consumption from places of production for fertilizers companies.	PhosAgro, Uralkali
Existence of effective logistic system (with own assets)	Non-sustainable (S=0,9348) It is easy to copy this competitive advantage for rivals and it is not requires many time.	PhosAgro, Uralkali, Evrochem
Existence of own distribution system	Non-sustainable (S=0,5505) It is easy to copy this competitive advantage for rivals and it is not requires many time	Uralkali, PhosAgro

Competitive advantages	Sustainability of competitive advantage	Companies
Wide product range	Conditionally sustainable (S=2,6430) For fertilizers companies product range is restricted by availability of mineral resources, so to have this competitive advantage company need firstly to get access to resources.	PhosAgro, Evrochem, Akron
Implementation of programs for development of social facilities and infrastructure in the region	Conditionally sustainable (S=1,6410) It is possible to copy, but at the same time requires effective management system to use it for companies' benefit.	Akron, PhosAgro, Uralkali, Evrochem, Uralchem
Low cost of production in relation to the world market	Non-sustainable (S=0,3595) This competitive advantage is appears mainly due to the depreciation of the ruble to the dollar. This situation allows companies either to reduce the price for foreign consumers, or to get additional profit. But in high environmental turbulence this competitive advantage could be lost fast.	PhosAgro, Uralkali, Uralchem

Source: own study.

As it seen from the Table 4, Russian fertilizers companies that have sustainable competitive advantages (PhosAgro, Uralkali, Evrochem) have more competitive power than their competitors do. In addition, it was found that company PhosAgro has almost all competitive advantages that allows it get leading positions at the market. Companies Evrochem and Uralchem need to develop sustainable competitive advantages or to find other directions to increase it competitiveness.

1.5. Conclusions

Sector-specific market and industry features and high level of turbulence of its external environment connected with complexity and huge amount of unexpected and unpredictable changes in prices, demand, behavior of competitors, policy regulation, etc. characterize the fertilizer industry.

Russian fertilizer companies enjoy a significant share of the global fertilizer market. However, the competitive advantages of Russian manufacturers, which are largely resource-based, can be partially or completely lost, because the Russian companies keep their competitiveness to a large extent through high quality raw materials, but not through increasing of their production and management efficiency.

Our approach for a discussion on strategic development of fertilizers companies based on necessity to create and develop sustainable competitive advantages, which are steady basis for successful development of the companies. Fertilizers companies have to focus precisely on the competitive advantages, which are the most sustainable. In this way, important issue is to separate sustainable and non-sustainable among a set of advantages. In particular, relevant issue is to formulate conceptual approach and suitable tools allowing identify sustainability of advantage. In this paper, we made an effort to solve this problem.

Our research focuses on investigation of main types of competitive advantages of fertilizers companies and creation of model for assessment of degree of their sustainability, which is necessary in order that all resources and efforts of the company have to be directed to receiving, development and deduction of sustainable difficult copied advantages. Concentration of the company on sustainable competitive advantages allows cementing its stability in highly turbulent external environment.

The results of this paper are the concept of creation of competitive advantages by the fertilizer companies and an analytical model for comparison of competitive advantages of fertilizer companies regarding its sustainability.

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References

Al Rawashdeh, R. (2008). The supply behavior of state mining enterprises: A case study of the Jordanian phosphate industry. *Resources Policy*, 33, 196–202. https://doi.org/10.1016/j.resourpol.2008.04.001

Al Rawashdeh, R., Maxwell, P. (2011). The evolution and prospects of the phosphate industry. *Mineral Economics*, 24, 15 – 27.

Al Rawashdeh, R., Maxwell, P. (2014). Analysing the world potash industry. *Resources Policy*, 41, 143 – 151. https://doi.org/10.1016/j.resourpol.2014.05.004

Al Rawashdeh, R., Xavier-Oliveira, E., Maxwell, P. (2016). The potash market and its future prospects. *Resources Policy*, 47, 154 – 163. https://doi.org/10.1016/j.resourpol.2016.01.011

Barney, J.B. (1991). Firm resources and sustainable competitive advantage. *Journal of Management*, 17, 99-120. DOI: 10.1016/S0742-3322(00)17018-4

Barney, J.B., Wright, M., Ketchen, D.J. (2001). The resource-based view of the firm: ten years after 1991. *Journal of Management*, 27 (6), 625–641. https://doi.org/10.1016/S0149-2063(01)00114-3

Brown, S. L., Eisenhardt, K.M. (1998). Competing on the Edge. Harvard business School Press: Boston, MA.

Chaharbaghi, K., Lynch, R. (1999). Sustainable competitive advantage: towards a dynamic resource-based strategy. *Management Decision* 37/1, 45–50. DOI: 10.1108/00251749910252012

Ciceri, D., Manning, D., Allanore, A. (2015). Historical and technical developments of potassium resources. *Science of the Total Environment*, 502, 590–601. https://doi.org/10.1016/j.scitotenv.2014.09.013

Cooper, J., Lombardi, R., Boardman, D., Carliell-Marquet, C. (2011). The future distribution and production of global phosphate rock reserves. *Resources, Conservation and Re-cycling*, 57, 78–86. https://doi.org/10.1016/j.resconrec.2011.09.009

D'Aveni, R. A. (1994). Hypercompetition: Managing the Dynamics of Strategic Maneuvering. Free Press: New York, NY.

Dawson, C.J., Hilton, J. (2011). Fertilizer availability in a resource-limited world: Production and recycling of nitrogen and phosphorus. *Food Policy*, 36, 14–22. https://doi.org/10.1016/j.foodpol.2010.11.012

Dmitrieva (2016). Recommendations for the strategic analysis process of mining and chemical companies improvement. *Organization and Management. Scientific Paper №91. Silesian University Of Technology Scientific Papers.* №1954. 25-39.

Dmitrieva, D, Ilinova, A, Kraslawski, A. (2017) Strategic Management of the Potash Industry in Russia. *Resources Policy.* 52. 81-89. https://doi.org/10.1016/j.resourpol.2016.11.004

Dmitrieva, D., Ilinova, A. (2016). Application of Strategic Analysis Methods and Tools in Russian Mining and Chemical Complex. *International Journal of Applied Engineering Research,* 11 (8), 5567-5572.

Eisenhardt, K., Martin, J. (2000) "Dynamic capabilities: what are they?", *Strategic Management Journal,* 21,1105-1121.

Enger, E.D. (2010). Environmental Science: A Study of Interrelationships, 12th edition. McGraw-Hill Higher Education, Boston, MA.

Geissler, B., Mew, M.C., Weber, O., Steiner, G. (2015) Efficiency performance of the world's leading corporations in phosphate rock mining. *Resources, Conservation and Recy-cling, 105, 246–258.* https://doi.org/10.1016/j.resconrec.2015.10.008

Geman, H., Vergel Eleuterio, P. (2013). Investing in fertilizer–mining companies in times of food scarcity. *Resources Policy*, 38, 470 – 480. https://doi.org/10.1016/j.resourpol.2013.07.004

Goldsmith D. (2013). Rethinking the company's competitive advantage. Financial Executive, 29, 6, 14-17.

Grant, R. (1995). Contemporary Strategy Analysis, Blackwell, Cambridge, MA.

Gyampah, K.A., Acquaah, M. (2008). Manufacturing strategy, competitive strategy and firm performance: an empirical study in a developing economy environment. *International Journal of Production Economics*, 111 (2), 575–592. https://doi.org/10.1016/j.ijpe.2007.02.030

Hamel, G. (2000). Leading the Revolution. Harvard Business School Press: Boston.

Ilinova, A., Dmitrieva D. (2017). Competitive advantages of mining and chemical companies in high environmental turbulence. *Economic and technological conditions of development in extractive industries.* Proceedings of International Conference on Management – Economics – Ethics – Technology (MEET 2017). 43-54.

Kotabe, M., Murray, J. (2004). Global sourcing strategy and sustainable competitive advantage. *Industrial Marketing Management.* Vol. 33, Issue 1, 7-14 https://doi.org/10.1016/j.indmarman.2003.08.004

Liu, Y. (2013). Sustainable competitive advantage in turbulent business environments. *International Journal of Production Research*, 51:10, 2821-2841. https://doi.org/10.1080/00207543.2012.720392

Mew, M.C. (2016). Phosphate rock costs, prices and resources interaction. *Science of the Total Environment,* 542, 1008–1012. https://doi.org/10.1016/j.scitotenv.2015.08.045

Nevskaya, M.A., Marinina, O.A (2017). Challenges and opportunities of state regulation of the innovation process in the Russian mineral resources sector. Academy of Strategic Management Journal, № 1, V 16. pp. 149 – 159

Nilsson, C-H., Dernroth, J. (1995) The strategic grounding of competitive advantage — The case of Scania. *International Journal of Production Economics*. Vol. 41 (1–3), 281-296. https://doi.org/10.1016/0925-5273(95)00035-6

Nilsson, F., Rapp, B., (2005). Understanding competitive advantage the importance of strategic congruence and integrated control. Berlin: Springer.

Pashkevich N.V., Iseeva L.I., Fedchenko A.A. (2014) Russia in the World Markets Minerals: Reserves, Production and Export. *Journal of Mining Institute.* Vol. 208. 60-64

Porter, M. E. (1980). Competitive Strategy. The Free Press: New York, NY.

Porter, M.E. (1985). Competitive Advantage. The Free Press: New York, NY.

Ponomarenko, T.V. (2016). Korporativnaya social'naya otvetstvennost' ugol'noj otrasli (praktika rossijskih i evropejskih kompanij) / T. V. Ponomarenko, R.Vol'nik, O. A. Marinina. *Zapiski Gornogo instituta*. T. 222, s. 882-891. doi: http://dx.doi.org/10.18454/pmi.2016.6.882.

Schoemaker, P.J.H. (1990). Strategy, complexity and economic rent. Management Science, 36(10), 1178-1192.

Singh, P.K. (2012). Management of Business processes can help an organization achieve competitive advantage. *International Management Review*. Vol. 8, Number 2, 19-26.

Smith, L.J., Flanagan, G.W. (2006). Creating Competitive Advantage: Give Customers a Reason to Choose You Over Your Competitors, 208.

Švárová, M., Vrchota, J. (2014). Influence of Competitive Advantage on Formulation Business Strategy. *Procedia Economics and Finance*, 12, 687 – 694. https://doi.org/10.1016/S2212-5671(14)00394-3.

Takala, J., Liu, Y., Feng, B., Yang, W. (2013). Analytical Evaluation of Sustainable Competitive Advantage. *IFAC Proceedings Volumes.* Vol. 46, Issue 9, Pages 1240-1243 https://doi.org/10.3182/20130619-3-RU-3018.00193

Wei, Z., Song, X., Wang, D. (2017). Manufacturing flexibility, business model design, and firm performance. *International Journal of Production Economics.* Vol. 193, 87-97. https://doi.org/10.1016/j.ijpe.2017.07.004

Chapter 2
GAP-ANALYSIS OF THE RUSSIAN FEDERATION COAL INDUSTRY

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Abstract

Improving competitiveness of mineral resource complex of the Russian Federation is one of the most relevant objectives at the current moment. For its achievement the coal industry of the Russian Federation has to deal with a number of strategic objectives and indicators. The paper considers the main strategic objectives facing the coal industry of the Russian Federation. The paper provides analysis of volumes production dynamics and coal preparation in recent years in Russia. GAP analysis is one of the tools of strategic decision development. By means of its tools it is possible to identify discrepancies between planned and actual activity results. The recommendations of improving methods of providing GAP analysis of the coal industry of the Russian Federation are given. The paper was prepared using data on the Russian coal industry for 2013-2017. Compliance assessment of the planned and actual strategic indicators of the coal industry activity by means of GAP analysis tools is made. The authors have defined specific types of "gaps" for coal industry of the Russian Federation.

Keywords: coal mining; strategic analysis; coal; coal export; GAP-analysis.

2.1. Introduction

The key directions of fuel and energy section development in Russia are the following: reducing power consumption and increasing power efficiency; the accelerated upgrades of fixed assets; improving investment attractiveness; export potential development; formation of the internal competitive environment; steady power supply of industry and citizens. At the moment the key indicator is decreasing power consumption of GDP (Galiyev, 2015).

The Long-term program of the Russian coal industry development till 2030 was approved by the order of the Government of the Russian Federation January 24, 2012 No. 14-r. In this program the volume of coal mining equal to 325 mln. t. has been defined as the minimum volume providing corporate efficiency of the coal industry in 2030. The top limit of coal mining development is 430 mln. t.

However, taking into account changes and challenges of the last years as well as decisions of the Government of the Russian Federation, there was a requirement of making amendments in the Long-term program. Thus, the Ministry of Energy of the Russian Federation adopted the Program of the coal industry development till 2030 in 2014 (further - the Program). The new edition of the Program involves the annual volume of coal mining up to 480 million t. (according to the optimistic scenario) or 410 million t. (according to the pessimistic scenario) by the year of 2030.

Besides, the program of steaming coal preparation development in Russia has been adopted. According to it the volumes of coal preparation will increase to 345 mln. t. by 2030. (the growth by 1,9 times in comparison with the level of 2015) (Peng, 2016).

The obligatory requirements for perspective development of the coal industry are stated in the Program:

- decreasing expenses of coal production and transportation, ensuring competitive advantage of coal export to developing countries which increase volumes of fuel and power resources use;
- the maximum use of improving quality reserves of supplied coal to expand its consumer's use and cut down its transportation cost;
- making easy access of coal companies to the market of the loan capital for financing production modernization and increasing work safety;
- gradual modernization of coal industry which allows to increase efficiency of labour;
- transition from trade of "crude" energy resource in the external and internal markets to trade of hi-tech "power product" which provides increasing productivity coefficient of its final use (on the basis of advanced coal processing) and cutting down transport costs for consumer delivery.

The influence of the main risks causes a number of system problems of the Russian coal industry development (Gribin, 2017; Smotrihin, 2016):

- intensification of dependence on external coal environment caused by increasing export orientation while at the same time reducing capacity of domestic market and maintenance of production level and transport expenses;

- high risks of projects implementation of new fields development in the light of industry dependence on use of foreign mining equipment in the conditions of sanctions and limited access to credit resources;
- continuous reduction of increasing labour productivity reserves with the simultaneous growth of operational expenses owing to pay rise, electricity rate increase as well as prices for materials;
- insufficient development of outsourcing;
- tough requirements for implementing license agreements to provide exploration and production works that cause unprofitable development of a considerable share of coal fields sites.

One of the factors having negative effect on coal mining growth rates is the competition with natural gas. Since thermal power plants of Primorsky Region of Russia started using gas instead of coal in 2017, the volumes of coal mining have decreased by 2,7 times in this region (URL: http://tass.ru/ekonomika/4959230).

Important aspect of ensuring efficiency of any project implementation, including such global as the coal branch of Russia, is monitoring of indicators achievement (efficiency indicators). For this purpose the Program contains more than forty main target indicators. Among them there are such indicators as:

- coal mining in Russia;
- coal mining per capita engaged in coal industry;
- updating of production capacities;
- average number of injury cases causing death;
- delivery volumes to various segments of domestic market
- export deliveries volumes;
- assets profitability of coal enterprises;
- heat equivalent of coal production for power industry;
- a share of prepared steam coal in the total volume of its production;
- a price ratio of gas/coal in domestic market;
- average range of coal production transportation.

The program provides three stages: I (2012-2015); II (2016-2020); III (2021-2030). Control values of target indicators for the end of each stage have been established. Control values of some indicators for 2025 have been already established.

The process of the Program implementation is controlled by the Ministry of Energy of the Russian Federation. The Deputy Minister of Energy A. Yanovsky noted that "... during 2012-2016 the program was implemented successfully regarding to its potential production development. It means growth of mining volume and production of marketable output in general as well per capita engaged in the industry. The export volume will exceed the level of 185 mln. t. in 2017.Thus, together with prices increase of foreign markets it will allow to intensify investment process and provide target achievement to update production capacities" (Yanovsky, 2017).

The research objective is to carry out the analysis of the Russian coal industry achievements in 2017, discrepancies identification between the actual and planned values as well as identifying their reasons.

The research hypothesis is "gaps" existence in achieving target indicators of strategic development of the Russian coal industry.

2.2. Literature studies

The issues connected with competitiveness of coal production, coal-mining enterprise as well as coal industry in general are considered in the different scientific works: (Kozlov, 2017; Ponomarenko et al., 2016; Tarazanov, 2018; Tkacheva, 2015; Plotkin 2017; Yanovsky, 2017; Vasilev, 2017) and the others.

Enterprise strategic decisions tools are various tools, including methods of SWOT analysis and GAP analysis developed within the American management theory (Borovikov, 1999; Mhitaryan, 2006; Markovskiy, 2012).

It should be noted there is no sufficient number of research works devoted to the GAP analysis both Russian and foreign scientists. It concerns not only theoretical consideration of the GAP analysis methods but also its tools development for application in various branches of national and foreign economies. Such scientists as Borovikov A., Markov V., Mkhitaryan S.V., Ruben R. consider the issues of methodology of the strategic analysis including GAP analysis in their research works.

The GAP analysis is a complex research aiming at identification and analysis of discrepancies, gaps between the actual and planned level of enterprise indicators. Carrying out such analysis allows to allocate problem zones (bottlenecks) preventing to reach planned targets and estimate degree of company readiness to achieve target indicators.The GAP analysis can be applied in daily practice to increase overall performance of the separate directions of the company as well as in the process of strategic planning. In the latter case the GAP analysis application is the most effective one as it allows to be realistic about accomplish ability and efficiency of the planned purposes and tasks before they are coordinated, approved and financially supported. Table 1 presents different types of "gaps" arising in any company operation.

Table 1. Types and description of "gaps"

Gap	Description
Market gaps	
Communicational gap	Gap between actually rendered service, the sold goods and communications concerning quality of service or goods.
Gap of quality service assessment	Comparison of expectations with perception of goods and services.
Market gap	Gap between qualitative characteristics of goods (services) and consumers requirements. Discrepancy between the range of goods and structure of demand, discrepancy between company production quality and similar production quality of competitors, a gap between brand essence and consumer perception.
Competitive gap	Gap between the current company advantages and competitors' opportunities, comparison of product and company characteristics of competitors taking into account weight of factors.
Image gap	Gap between company image and production perception by consumers.
Organizational gaps	
Production gap	Gap between production and: • the available reserves: part-time employment of employees, availability of free capacities and production facilities, etc. • potential resources: structure reorganization, personnel training, readjustment of the equipment, efficiency equipment performance, etc.
Gap of involvement	Gap between plans of top management and real results.
Relation gap	Gap between plans and directives of top management and activity of company employees.
Gap of planning	Gap between employees' understanding and attitude to real situation
Strategic gaps	
Gap "strategy - realization"	Gap between strategic plans and results.
Gap of standards	Gap between top management plans and consumers' requirements.

Source: (Borovikov, 1999).

The Gap analysis general scheme is presented in Figure 1.

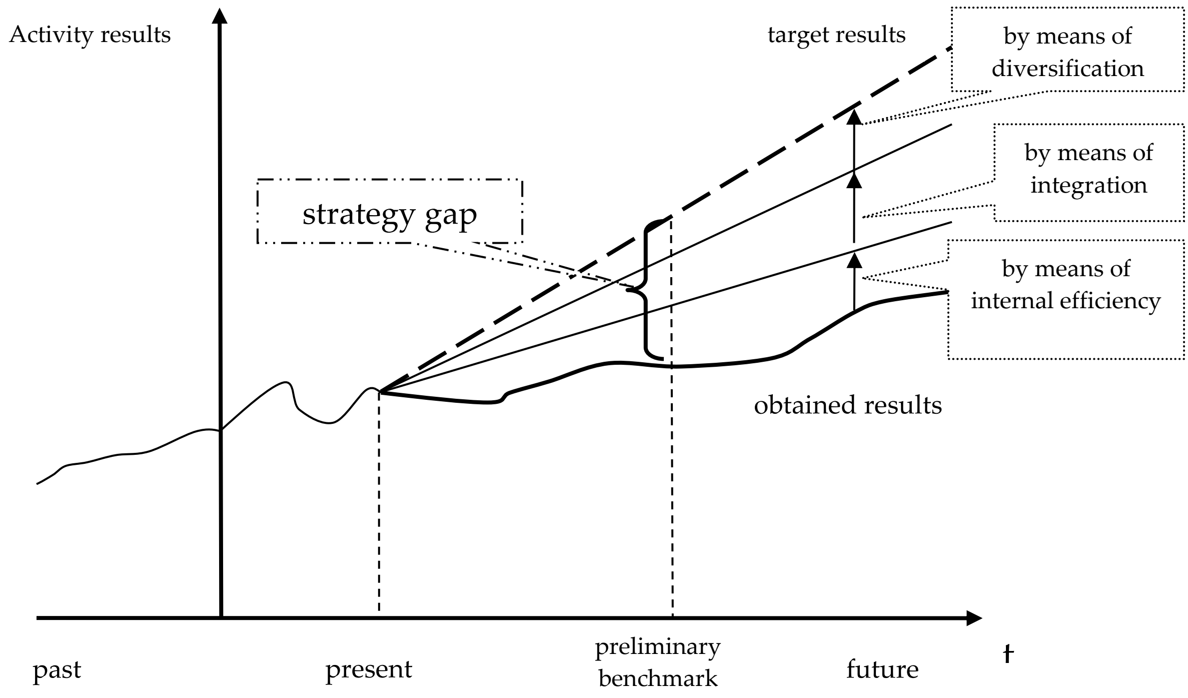

Figure 1. Methodology of carrying out GAP analysis

Source: (Mhitaryan, 2006).

The GAP analysis is recommended to be carried out alongside SWOT analysis. The operating procedures are given in Figure 2.

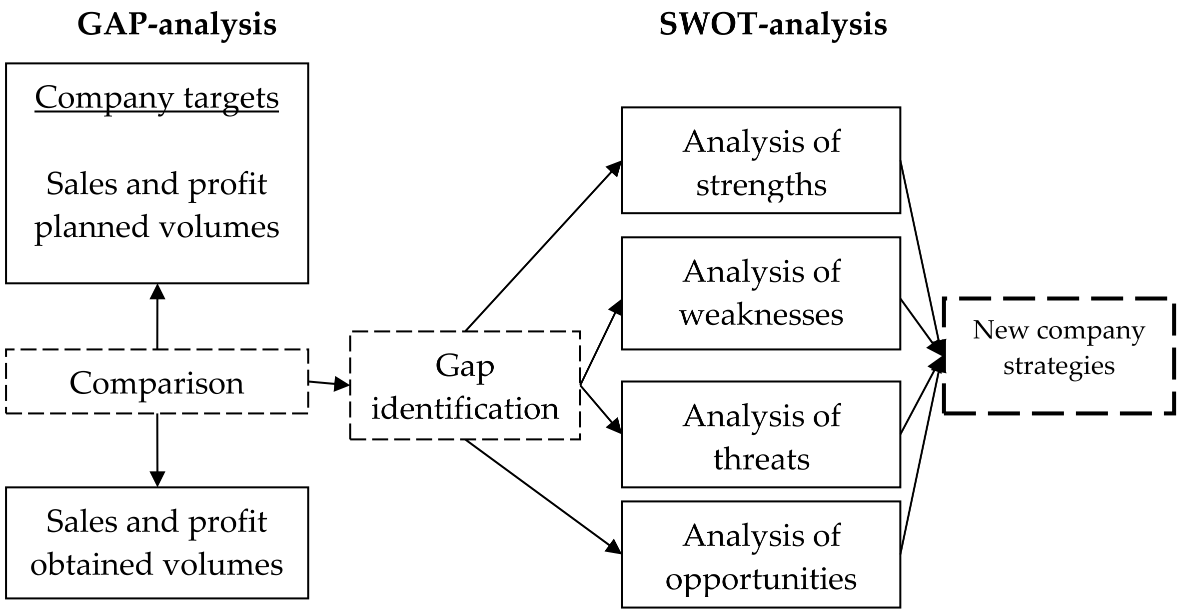

Figure 2. Algorithm of GAP- and SWOT-analysis

Source: (Markovskiy, 2006).

The paper mainly focuses on the methodology of carrying out the GAP analysis applying to the coal industry of the Russian Federation. The paper main objective is to identify gaps between the planned values of the key coal branch indicators and their actually obtained values.

2.3. Methodology

Having done the literature review devoted to the methodology the GAP analysis it has shown that the GAP analysis includes the main stages:

1. Determination of obtained value.
2. Determination of the most available (target)value.
3. Choice of comparison criterion (criteria).
4. Tools formation for achieving target value.

In our opinion, it is necessary to provide a detailed approach to carry out the GAP analysis. It is possible to offer the following sequence of operations to perform such analysis:

1. Identification of gaps between the actual and planned results:
   1.1.Definition of the key (strategically important) indicators defining strategic competitive advantages.
   1.2.Determination of target value indicators.
   1.3.Determination of the actual values of such indicators.
   1.4.Gap defining between planned and actual values of the specified indicators.
2. Cause identification and gaps elimination between earlier revealed actual and planned results.
   2.1.Assessment of "gap" size and criticality for achieving target value indicators.
   2.2.Identification of the factors having influenced on "gap" emergence.
   2.3.Actions elaboration for gap elimination.

We have carried out the research in the following order:

1. Defining strategic indicators of the coal industry development of the Russian Federation. The indicators mentioned above have been taken into consideration by the Long-term program. The carried out analysis are based on the following key indicators:

- annual volumes of coal mining in Russia;
- coal export volumes;
- the delivery volume for power plants requirement in domestic market;
- return on assets (ROA) of the Russian coal enterprises.

2. Determination of the current values of target strategic indicators. We use the industry statistics data for the period of 5-7 years as well as the results of our researches for determining such values.
3. Gap (no gap) identification on the basis of forecasting by means of the Microsoft Excel tools.

The target indicators data are taken from Appendices No. 3 and No. 9 of the Long-Term Program of the coal industry development till 2030.The actual values of indicators were taken from different scientific publications (Vasilev, 2015; Nevskaya and Marinina, 2017; Yanovsky 2017) and industry reviews (Tarazanov, 2018).

2.4. Research results

Our researches show that coal production volumes must be increased by 1,8% annually in order to obtain the expected value of coal mining (from 352 mln t. in 2013 up to 480 mln t. in 2030). Annual growth of coal production volume is to be 0,9% for achieving results of pessimistic scenario (410 million t.)(Vasilev, 2015).

Figure 3 presents data referring to the planned and actual values of "coal mining" indicator. They allow to conduct the gap analysis of the indicator.

As the carried out research shows, the average growth rate of coal mining for the last 5 years is 1,8%. Coal mining grows at the advancing rates so it is possible to say there is no gap referring to the "coal mining "indicator. The trend shows that in the case of maintaining the existing growth production rates, the target production indicator will exceed 550 mln t. by 2030. Thus, it will exceed target value of 480 million t. by 14,5%. However, it should be noted that the coal mining indicator growth is only 0,33% in 2017. It is caused by problems of gas production increase in Primorsky Region which was mentioned above. Negative impact of such factor as the competition with gas can lead to gap emergence between planned and actual targets of coal mining in the future.

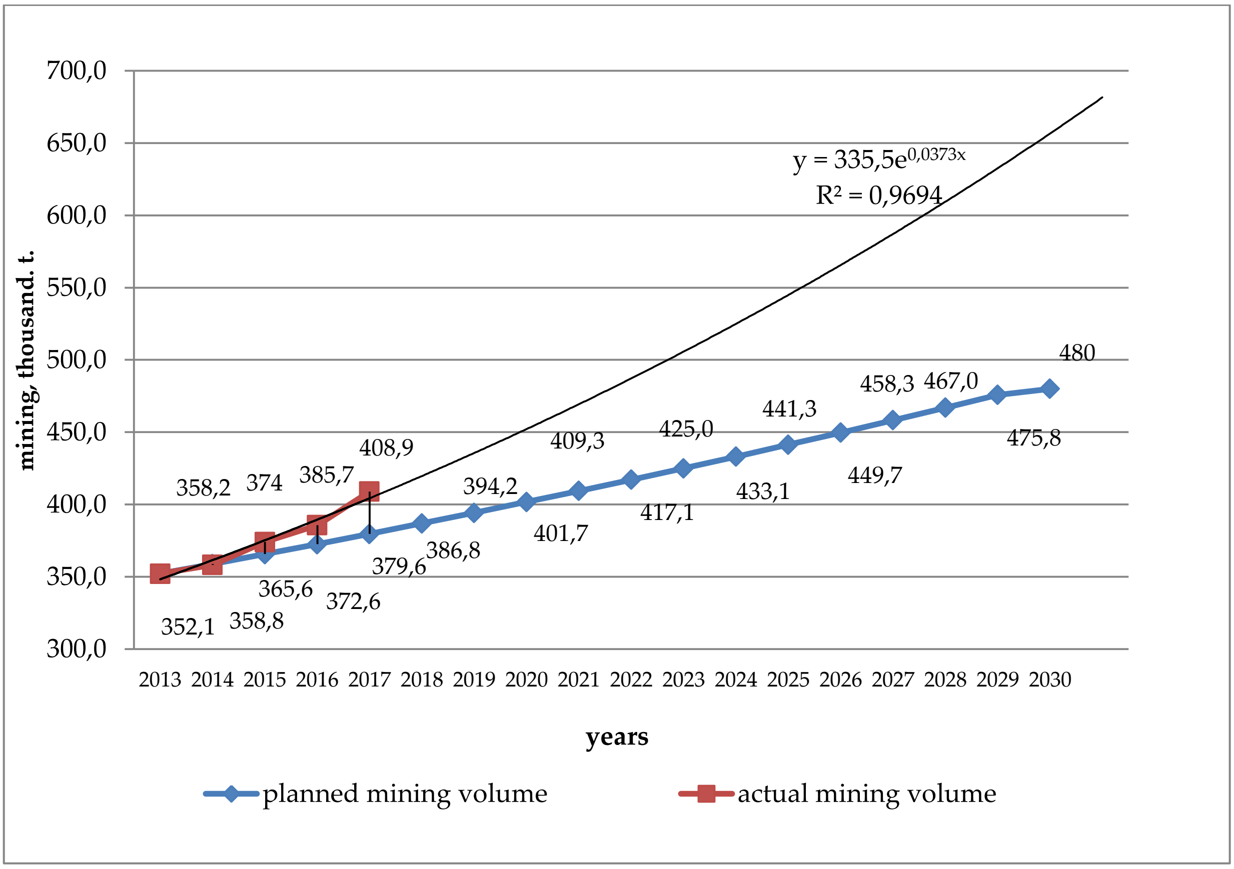

Figure 3. Results of the GAP analysis of the coal mining in Russia

Source: own study.

The results of the analysis of coal export volumes indicator are presented in Figure 4.

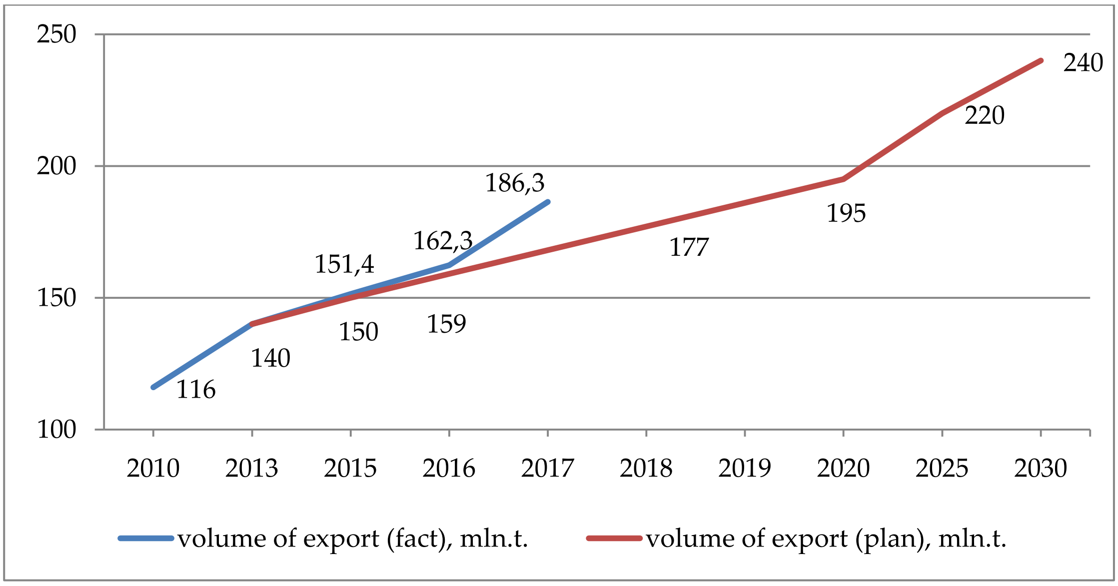

Figure 4. Results of the GAP analysis of coal export volumes in Russia

Source: own study.

The results of the analysis referring to the indicator "the volume of deliveries for needs of power industry" are presented in domestic market at Figure 5.

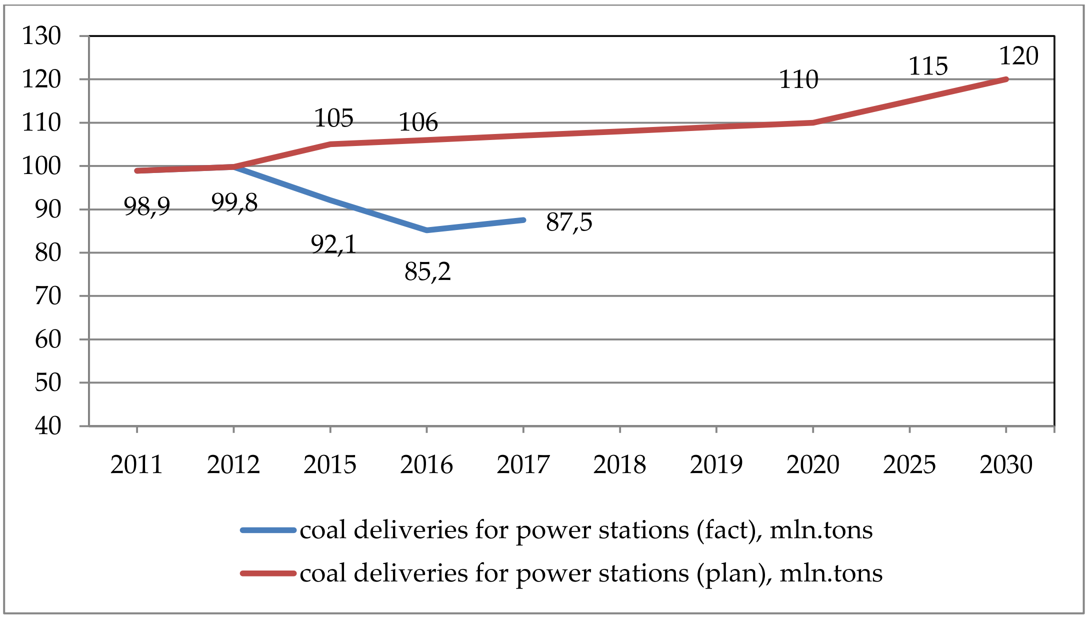

Figure 5. The results of the GAP analysis of coal deliveries volumes for requirements of power plants in Russia

Source: the author's research.

To implement the analysis of profitability of assets indicator we have used the data of annual reports provided by the three largest enterprises of the Russian coal industry (Tab. 2).

Table 2. GAP analysis of profitability of assets of the Russian coal branch

Indicator	Netprofit (losses), mln. rouble	Average assets cost, mln. rouble	ROA, %
JSC "SUEK" 2014 2015 2016	(12466) 200* 303*	84956,5 7582,5* 73815,5*	- 2,6 4,1
JSC "Kuzbassrazrezugol" 2014 2015 2016	(10938,8) 3683,4 2689,6	87310,4 89020,1 92368,6	- 4,1 2,9
HC"SDS-ugol" 2014 2015 2016	(2786,6) (1367,5) (2426,8)	29707,1 26031,6 22274,6	- - -
Target value in accordance with the Program 2015	-	-	-

Indicator	Netprofit (losses), mln. rouble	Average assets cost, mln. rouble	ROA, %
2020			15
2030			20
			25

* $ mln.

Source: it has been calculated using annual accounting reports of the coal companies.

The data presented in Table 2 allow to identify the gap: the target indicator did not reach a half of its value in 2015.

2.5. Conclusions

The final results of carrying out the GAP analysis of the coal industry of the Russian Federation are presented in Table 3.

Table 3. Results of the GAP analysis of the coal enterprise

Strategic target	Gap	Type of the gap	Objective
Annual coal mining volume	Not identified	-	To maintain the current growth rates of coal mining
Coal export volumes	Not identified	-	To increase coal export volumes taking into account external and internal factors
Coal supply volume for power plants requirements in the domestic market	Identified	Strategy-implementation	To put into operation power plants according to the Program (CHP in Sovetskaya Gavan, the Sakhalin GRPP-2, Erkovetsky GRPP, etc.)
ROA	Identified	Strategy-implementation	To increase level of ROA

Source: own study.

Failure to meet the deadline of the planned power plants construction can be one of the gap reasons in supply volume for requirements of power industry. Thus, putting into operation of the first stage of Sakhalin GRPP-2 (120 MW)was planned in 2016. However, it has been postponed till June, 2018.

CHP with power capacity of 120 MW in Sovetskaya Gavan was planned to launch at the end of 2017. Erkovetsky GRPP simultaneously with the CHP construction (which power capacity is 4800 MW)as well as development of coal pit with coal mining up to 25 mln. t. are planned in 2021.

The reason of the ROA gap is insufficient volumes of net profit of the coal enterprises. In HC "SDS-ugol", in particular, it was observed the large percent volume of payment which is comparable with total revenue in 2016. JSC "Kuzbassrazrezugol" had net profit decline while increasing average cost of assets that caused ROA decrease in 2016. Thus, it is possible to confirm the research hypothesis.

Reference

Borovikov, A., Ruben, R. (1999). GAP & SWOT-analysis – universal for usage methods of marketing and management. *Marketing and Advertisement,* 9, 23-34.

Galiev, G.K., Galieva, N.V. (2015). Economic and technological aspects of increase in efficiency of the coal industry. *Coal*, 1, 45-52.

Gribin, Y.G., Popov V.N., Rozhkov, A. A. (2017). System approach to identification of intra production reserves of increase in efficiency of social and economic management of the mountain enterprise. *Coal*, 4, 11-15.

Kozlov, A.V., Teslya, A.B., Chzhan, S. (2017). Principles of assessment and technique of management of the innovative capacity of the enterprises of the coal industry. *Journal of Mining Institute*, 223. doi: http://dx.doi.org/10.18454/PMI. 2017.1.131

Markovskiy, V.A. (2012). Use of a technique of the GAP-analysis for assessment of efficiency of a logistics system of distribution. *Modern Researches of Social Problems (online scientific magazine)*, 2 (10).

Mhitaryan, S.V. (2006). Sectoral marketing. Moscow: Eksmo.

Nevskaya, M.A., Marinina, O.A. (2017). Challenges and opportunities of state regulation of the innovation process in the Russian mineral resources sector. *Academy of Strategic Management Journal*, 1, 149 – 159.

Extraction of coal in Primorye has decreased by 2,7 times because of transfer of combined heat and power plant on gas. URL: http://tass.ru/ekonomika/4959230

Peng, P., Kirtipal, B., Junior, N. (2016). Competitiveness and Cost Sensitivity Study of Underground Coal Gasification Combined Cycle Using Lignite. *Energy Fuels*, 30(3). doi: http://dx.doi.org/10.1021/acs.energyfuels.6b0001

Plotkin, B.K., Haykin, M.M. (2017). Formation and development of the theory of mineral and raw logistics. *Journal of Mining Institute*, 223. doi: http://dx.doi.org//10.18454/PMI. 2017.1.139

Smotrihin, V.P. (2016). Coal-processing industry in Russia. *Globus,* 2 (14).

Tarazanov, I. (2018). Russia's coal industry performance for January - December, 2017.*Coal*, 3. doi: http://dx.doi.org/10.18796//0041-5790-2017-3-36-50

Tkacheva, O., Batashova, A., Zhukova, I., Smakhtina, A., Topchienko, L. (2015). Strategic Management of Coal Mining Industry Efficiency. *Asian Social Science*, 11(20). doi: http://dx.doi.org/10.5539/ass.v11n20p104

Vasilev, Y. (2015). The long-term prospects of development of coal mining in Russia. *Mining Information and Analytical Bulletin (Scientific and Technical Journal)*, 8.

Vasilev, Y., Vasileva, P. (2017). Improving efficiency of coal provision of TPS in the Russian federation. [in:] *17th International multidisciplinary scientific geoconference SGEM 2017. Ecology, economics, education and legislation,* 17(53). doi: http://dx.doi.org/10.5593/sgem2017/53

Yanovsky, A.B. (2017). Main trends and prospects of the coal industry development in Russia. *Coal*, 8. doi: http://dx.doi.org/10.18796//0041-5790-2017-8-10-14

Ponomarenko, T.V., Volnik R., Marinina O.A. (2016). Corporate social responsibility of the coal industry (experience of Russian and European companies.). *Journal of Mining Institute* 222: 882-891. doi: http://dx.doi.org/10.18454 / PMI .2016.6.882

What is GAP-analysis, analysis of gaps. [Electronic resource]. URL: http://marketolog.biz/index.php?pid=125http:// marketolog.biz/index.php?pid=125

Chapter 3

THE COMPETITIVE EDGE OF THE KNOWLEDGE MANAGEMENT SYSTEM IN THE ORGANIZATIONAL CAPITAL OF AN INDUSTRIAL COMPANY

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Abstract

Today, when the economy is knowledge-based and characterized by rapid changes in the external environment, intangible resources can become a key source of competitive advantages and growth in the company's value as they are unique and cannot be copied by competitors or replaced by another asset. However, a lot of companies do no have any system of managing intellectual activity that would encompass R&D management, management of employee innovation activities, as well as formation and development of knowledge management systems. The purpose of the research is to develop an organizational and economic tool for managing intellectual activity in the company's management system. Research methods include a system approach, comparative and regression analyses, as well as concepts of a resource approach, strategic management, competitive advantages, and intellectual capital. We have justified the application of the dynamic approach in the resource theory to the management of the company's intellectual resources due to market volatility, strong competition and the growth in knowledge and science intensity of the industrial complex.

We have developed a conceptual approach to the management of intellectual activity as a set of methods and tools that ensure the effective use of intellectual resources, the formation of strategic assets and the application of employees' intellectual potential, all these factors influencing innovative and technological performance of the company. We have proposed a model of managing the organizational capital of an industrial company. The model has the following characteristics: management of intellectual activity as the main function; a separate new management function, namely knowledge management; clearly formulated objectives in strategic and tactical management; a newly developed structure of strategic assets connected with organizational capital and including technology, skills, competence, and knowledge management systems (KMS).

Key words: innovative activity, intellectual activity, knowledge management, knowledge management system, organizational capital.

3.1. Introduction

Today's industrial companies and their performance largely depend on a number of factors, such as the huge volatility of commodity prices, where changes may amount to 50-70% of the price, globalization of the economy and global competition in many commodity markets, open innovation, knowledge transfer and growth in research intensity. This is the reason why the intellectual factor and intellectual capital become important factors in production, and strategies concerning innovation and intellectual activity act as a major driver and spur for developing business models.

Organizational capital plays an extremely important role in operating and investment activities of companies; however, it so far has not been studied thoroughly enough from the theoretical and methodological points of view. The same holds true for the organizational capital structure, the place of the knowledge management system (KMS) in it and the role of organizational processes in the mechanism of building competitive advantages. As these issues have not been fully researched, it becomes impossible to systematically build competitive advantages of the company based on its intellectual resources and, consequently, obtain intellectual rent.

Foreign experience in the practical use of KMS has been gathered for more than 20 years, with law firms and oil companies being leaders in this sphere. This is why the object of this study is oil companies characterized by complex and interrelated technological processes and some experience in applying KMS.

3.2. Literature review

Intensive research in the fields of knowledge management, the management of intellectual capital and the management of intellectual activity in both industrial companies and national economies has been conducted over the past 20 years (Barney, 1991; Bontis, 1999; Daum, 2005; Edvinsson, 1997; Grant, 1996; Jurczak, 2008; Zeghal and Maaloul, 2010). Intellectual resource management enables companies to find new sources of competitive advantage and increase their profits and efficiency (Petroleum Engineers, 2014; Ponomarenko and Khaertdinova, 2015; Nevskaya and Marinina, 2017; Rumelt, 1994).

Research in the fields of intellectual capital management and knowledge management has given rise to new theoretical concepts (Edvinsson, 1997; Pisano, 1994; Zeghal and

Maaloul, 2010; Stewart, 2007), which are closely interrelated with the dynamic concept in the resource-based theory (Teece and Pisano, 1997). The building and development of intellectual capital is explained quite well by various concepts of the resource approach, which view resources as long-term assets that distinguish one company from another. The dynamic concept proves that when resources interact and are used, they change, develop, and create sustainable competitive advantages as well as value (Sergeev and Ponomarenko, 2011). In order to respond to changes in the external environment, it is necessary to update key competencies, which is ensured by the dynamic capabilities of the company (Teece and Pisano, 1997). They are organizational actions taken when implementing strategies through which the company manages its resource base and creates the potential for value growth (Grant, 1996; Pisano, 1994).

The analysis of scientific literature has shown that at present there are many approaches to understanding the essence of intellectual capital. Intellectual capital of an organization is knowledge, qualification, experience, and motivation of personnel, communication systems (technologies and channels) that create competitive advantages and added value. The core of intellectual activities is innovation which is created as a result of R&D. R&D mean a set of activities that precede the launch of a new product or system into industrial production, including scientific research and production of product prototypes.

Two main approaches to classify organizational capital (Figure 1.):

- structural approach (identification of individual elements of organizational capital);
- process approach (identification of the main processes of the formation and use of knowledge).

Research theoretical grounds and design: dynamic concept in the resource theory (Teece and Pisano, 1997; Grant, 1996); concepts of intellectual capital (Stewart, 2007; Galbraith, 2008; Edvinsson, 1997; Zeghal and Maaloul, 2010); concepts of organizational capital (Armstrong, 2008; Edvinsson, 1997; Stewart, 2007; Martнn-de-Castro and Navas-López, 2006); knowledge management concepts (The Knowledge Management Scenario, 1999, Ponomarenko and Khaertdinova, 2015).

Two main approaches to classify organizational capital

Structural approach

Technologies, innovations, publications, patents, production and business processes, strategy, culture, structures, systems, rules, procedures (*Stewards, 2008; Armstrong, 2008*)

Corporate information systems, databases, hardware and software, organizational structures, copyrights, know-how, licences, trademarks, corporate culture, customer relations (*Orlova, 2008*)

Procedures, technologies, management systems, hardware and software, patents, brands, organizational culture, customer relations (*Milner, 2008*)

A set of concepts of the management and development technologies, databases, patents. R&D costs, *(Shmulev, 2007*)

Process approach

Along with other sorts of capital, the component of intellectual capital that ensures the speed of transformation of the knowledge existing in a company into a sustainable collective source of growth ..., (*Edvinsson,1997*)

The ability of a company to obtain economic benefits from the use of organizational resources (*Garanina, 2010*)

Figure 1. Basic approaches to the classification of organizational capital

Source: own study complied by authors.

Approaches to define the "knowledge management" concept are presented in Table 1.

Table 1. Approaches to define the "knowledge management"

Knowledge management is	Author (source)
„ (…) a new management function which involves "systematic and purposeful formation, updating and application of knowledge to maximize efficiency of a company and profits from knowledge-based assets".	(Milner et al., 2006)
„ (…) systematic processes……; a strategy that transforms all types of intellectual assets into higher productivity, efficiency and new value".	(Gaponenko, 2008)
„(...) structured databases…"	(The Knowledge Management Scenario, 1999)
„ (…) a new business process to manage intellectual assets of an enterprise, which is determined by such parameters as connection with the strategy of an enterprise, organizational culture and discipline …"	(The Knowledge Management Scenario, 1999)
„ (…) activities on the search, use and distribution of knowledge carried out by an organization."	(Oslo Guidelines, 2010)

Source: own study compiled by the authors.

Based on these theoretical aspects and using oil companies as an example, the paper demonstrates the need to develop concepts of organizational capital, determines its structure, identifies the place of KMS in the structure of organizational capital, and makes suggestions for improving the operation of KMS on the basis of the project approach.

3.3. Research methods

Research objective: development of a business mechanism to manage intellectual activities (knowledge) in the management system of a company.

RQ

1. Which direction (dynamic or static) of the resource theory should be applied to the management of intellectual resources of a company?
2. Is there any correlation between innovation activities of companies (R&D costs) and financial performance thereof? Is it possible to quantify this correlation?
3. What is the structure of organizational capital of an industrial company? How does it relate to the management of intellectual activities and knowledge of a company?
4. What are the problems of KMS functioning? What improvements will be achieved by integration of KMS into the management system of organizational capital of an industrial company based upon the project approach methodology?

Research methods: system approach, comparative and regression analysis, concepts of strategic management, resource approach, competitive advantages, intellectual capital.

Assessment of innovative activity in the oil sector by innovative companies in the world.The relationship between R & D expenses and the following indicators was studied: revenue, profitability of sales, innovative intensity. Analysis of the data of the Joint Research Center of the European Commission for 2012-2014, which contains detailed information on the 2500 most innovative active companies in the world. Based on this information, a statistical database was compiled from 51 oil companies, including 34 oil producing companies and 17 oil service companies. The relationship between R & D costs and revenues, R & D costs and profitability of sales of oil companies was explored. The relationship between the parameters considered is described by the regression equation: $y = 189.68x + 42155$.

3.4. Research Results and Discussion

Correlation between R&D costs and revenues (Fig. 2), R&D costs and return on sales of foreign oil companies (Fig. 3).

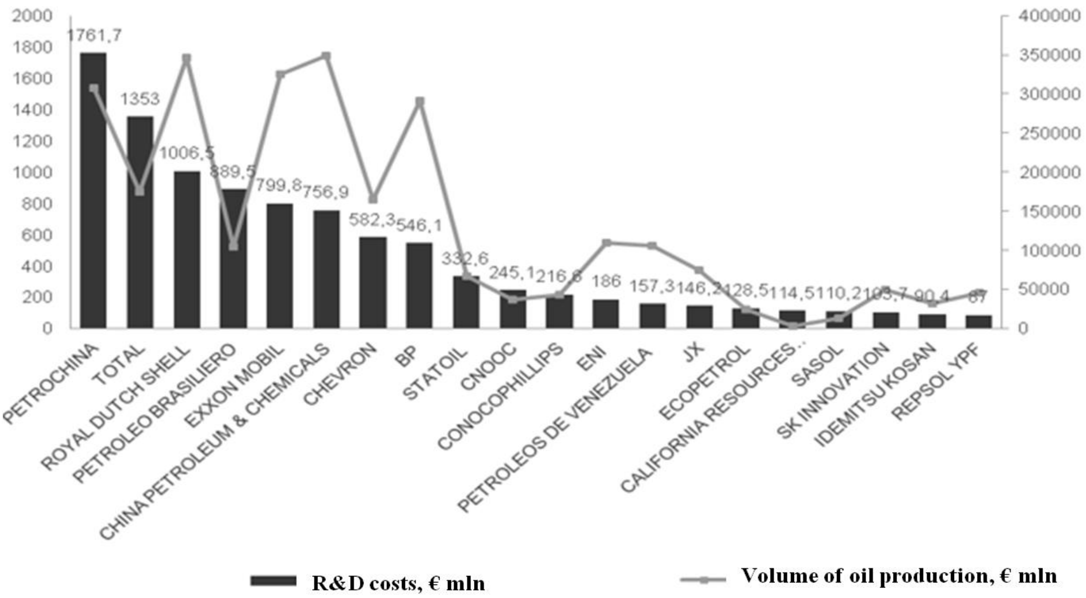

Figure 2. R&D costs and revenues of foreign oil companies, 2014

Source: (R&D Scoreboard, 2015).

Dependence between the considered indicators is described by the following regression equation: y = 189.68x + 42155. Determination factor $R^2 = 0.55229$ (<1), which confirms the average force of correlation between the indicators.

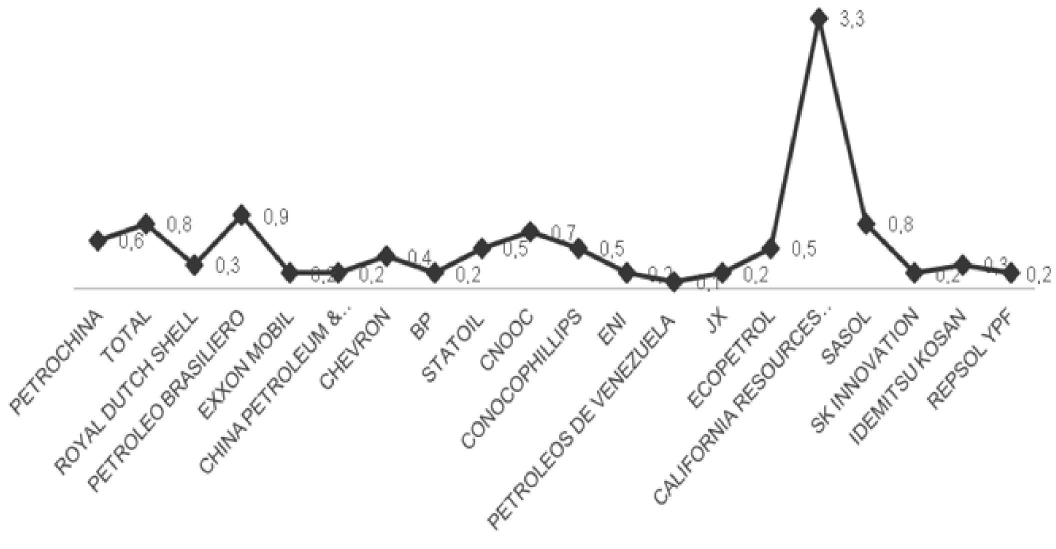

Figure 3. R&D costs and return on sales of foreign oil companies, 2014

Source: (R&D Scoreboard, 2015).

Figure 3 confirms the absence of dependence of return on sales on R&D costs. Dependence is described by the following regression equation: $y = -0.0031x + 9.6361$. Determination factor $R^2 = 0.00556$, which confirms the absence of connection between the indicators.

The level of innovative activities of companies in terms of R&D cost to the volume of products sold (revenue) – innovative intensity (Fig. 4)

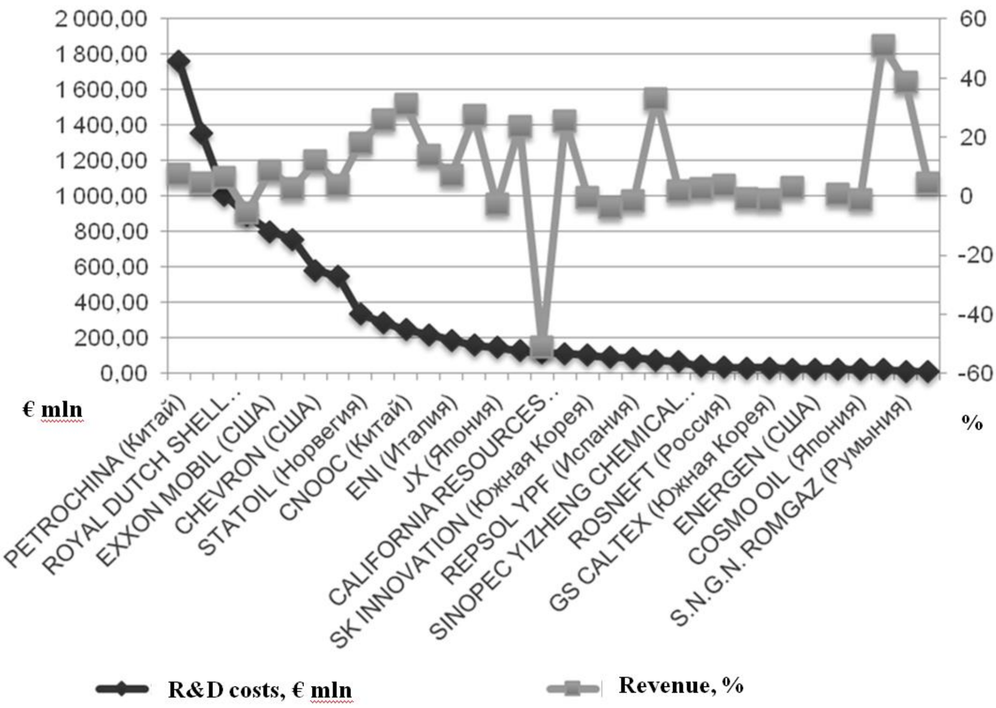

Figure 4. Innovative intensity of foreign oil companies, 2014

Source: (R&D Scoreboard, 2015).

The level of innovation intensity of all companies is approximately the same. The company with the highest indicator of innovation intensity (3.3 €/€) is California Resources Corporation (USA); however, this company ranks only 17th in terms of R&D costs, and its negative return on sales (-40%) confirms the absence of correlation between research and development costs and economic results of a company.

Indicators of innovative activities of Russian oil companies are calculated on the basis of annual reports (Tab. 2). Five largest Russian oil companies have been selected for analysis.

Table 2. Indicators of innovation activities of Russian oil companies, 2014

Ser. No.	Company name	R&D costs, € mln	Sales volume (Revenues), € mln	Volume of oil production, mln tons	R&D costs/ volume of oil production	Innovative intensity, (R&D costs/ sales volume)
1.	Rosneft	460	130447.8	204.9	2.24	0.0035
2.	Lukoil	72.01	127785.6	97.2	0.74	0.0006
3.	Gazprom Neft	44.73	19501.98	52.06	0.86	0.0023
4.	Surgutneftegaz	23.95	13453.45	61.4	0.39	0.0018
5.	Tatneft	20.77	5427.01	26.53	0.78	0.0038

Source: own study.

Innovative intensity of Russian oil companies is at a fairly low level: from 0.0018 ("Surgutneftegas") to 0.0038 ("Tatneft"); while for foreign companies this indicator is 0.2-3.3 (i.e. hundreds of times higher). Rosneft has the largest amount of R&D costs per 1 ton of the oil produced.

PJSC Tatneft headed the ranking of the best European innovative companies in the field of oil and gas production by the number of inventions and was the absolute leader among Russian oil and gas producing companies (Fig. 5).

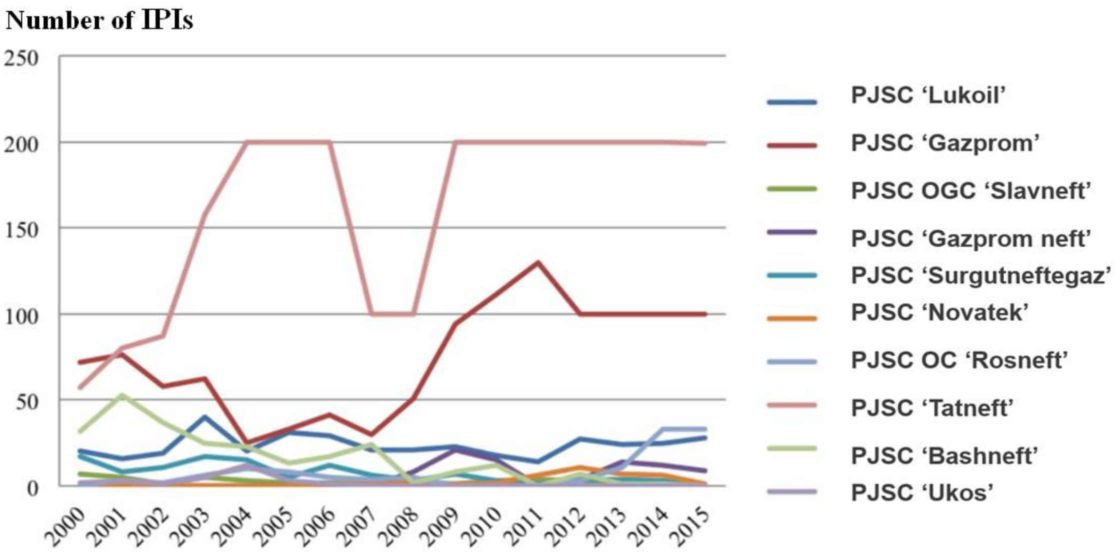

Figure 5. Dynamics of the number of IPIs of the leading oil and gas companies in Russia

Source: own study.

The absence of correlation between profitability of activities and R&D costs confirms the studies (OTM Consulting Report, 2013) that there is no direct correlation between the income of oil companies' shareholders and R&D costs. The analysis has not revealed any unambiguous correlation between the indicators of revenue, return on sales, net profit allocated for dividends, and R&D costs, which confirms complexity of assessing the impact of the level of innovation activities on economic performance of a company (Tab. 3).

Table 3. Leading companies in innovative activities by the number of patents in the oil and gas industry in 2010-2014

Company name	Industrial sector	Country	Number of inventions, unit
North America			
Halliburton Energy Services	Oil related services	USA	210
Schlumberger	Oil related services	USA	50
Baker Hughes	Oil related services	USA	41
ExxonMobil	Oil and gas production	USA	34
UOP LLC	Oil related services	USA	28
Europe			
Tatneft Stock Co	Oil and gas production	Russia	211
Shell Oil Co	Oil and gas production	Netherlands	103
IFP Energy Nouvelles	Oil related services	France	78
BASF SE	Oil related services	Germany	42

Source: (OTM Consulting Report, 2013).

The following shortcomings of patents as indicators of innovation activities have been revealed: many innovations are never patented, while some are covered by many patents at once; a number of patents have no technological or economic value, while the value of others is very high, (Oslo Guidelines: Recommendations for Collection and Analysis of the Data on Innovation, 2005), a large number of patents do not reach the stage of commercial implementation (Pakhomova and Kazmin, 2013). Therefore, the number of patents indirectly characterizes effectiveness of research activities.

Therefore, the conclusion is made that the key factors of successful innovation activity are connected not so much with the investment sphere as with the organizational sphere, as it influences the promotion of innovations in companies.

Main features of organizational capital: Results from intellectual activities; Promotes interaction between intangible resources of a company; Belongs to a company; Is able to bring economic benefits; Is/is not subject to legal protection.

The authors propose a hierarchical type of the structure of organizational capital, which allows considering it separately from other types of intellectual capital.

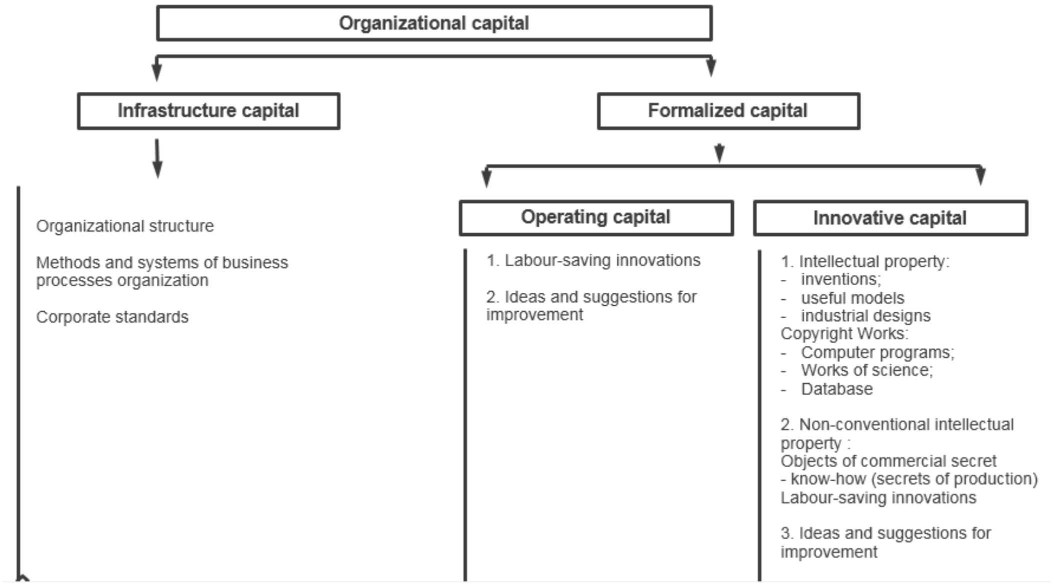

Figure 6. Hierarchical type of the structure of organizational capital

Source: own study.

Main functions of organizational capital:

- organizational support of business processes of a company, aimed at increasing effectiveness of its activities,
- organizational support of intellectual activities (creation of results of intellectual activities),
- support of system interactions between business sectors of a company.

The model of intellectual capital management with the use of KMS, proposed by the authors (Fig. 7).

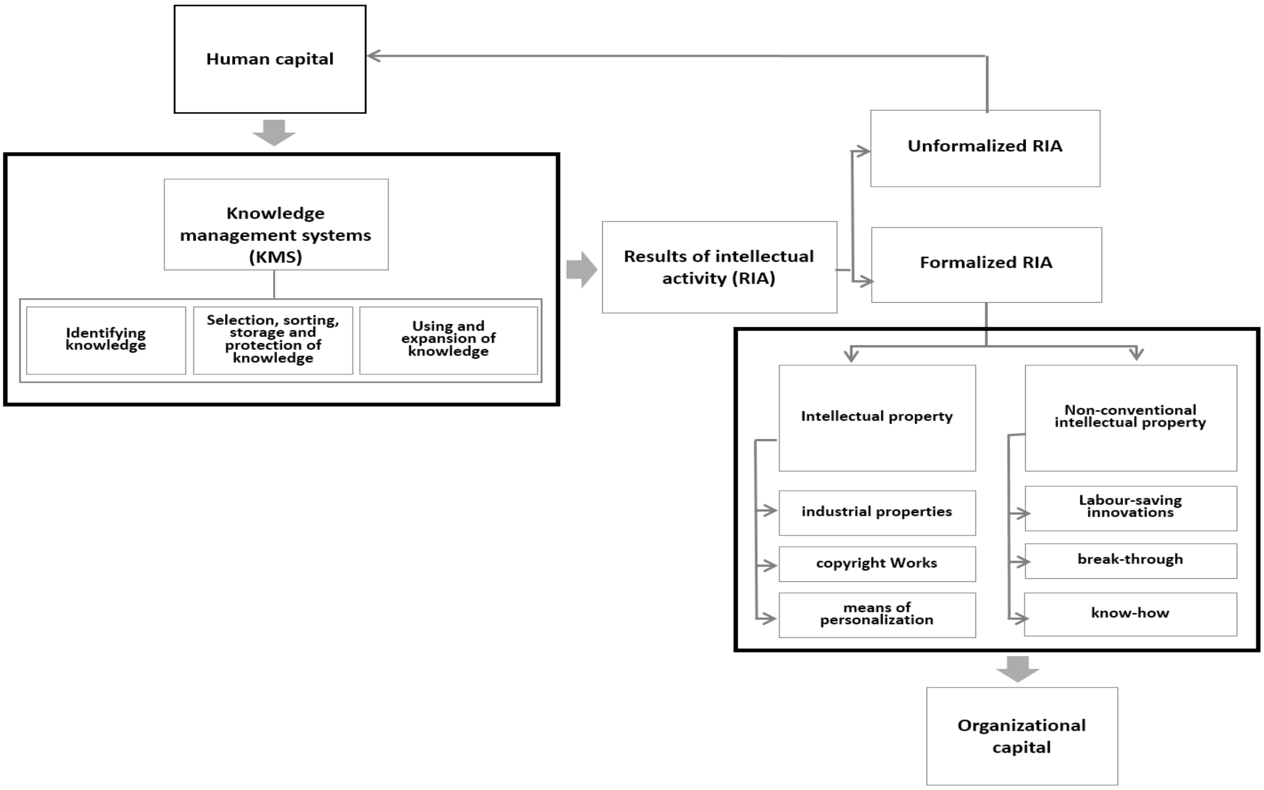

Figure 7. The model of intellectual capital management with the use of KMS

Source: own study.

The result of successful R&D is the results of intellectual activities (IA) – products of scientific and technical activities containing new knowledge or solutions and recorded on any information medium. The studies have shown (OTM Consulting Report, 2015) that a big share of R&D ends unsuccessfully at the stage of commercial implementation for various reasons. IA management system is a set of methods and technologies aimed at implementation of intelligence of employees in order to obtain new knowledge and intellectual resources based thereon. The strategic goal of IA management is to systematically upgrade the technological level of oil companies to maintain leading positions in the global energy sector. The tactical goal of IA management is to intellectually support business processes of a company and to transform knowledge of employees into organizational one.

IA management includes management of innovation activities in the framework of R&D and organization of intellectual activities of employees in operational activities. In the framework of intellectual and innovative activities, processes aimed at improving current activities, as well as research and development, are carried out. The result of these processes is as follows: formal knowledge – the results of intellectual activities (RIA); systems, management methods, corporate standards and regulatory documents. All of the above constitutes organizational capital of a company.

The results of implementation of KMSs in foreign TNCs have confirmed practical importance of knowledge management and included: reduction of transaction costs; shortening of the time required to find the necessary information; improvement of operating activities; information independence of companies, etc.

Using their knowledge and experience (human capital), on the basis of KMS application, employees participate in creation of the results of intellectual activities (RIA) – unformalized (undocumented) and formalized (objects of copyright, patent rights, etc.) ones, transforming individual knowledge into organizational capital of a company. In order to enhance effectiveness of this process, KMSs are applied, including the stages of identification, selection, storage, protection, use and distribution of knowledge (Fig. 8).

Figure 8. Knowledge management systems – development of the project approach

Source: own study.

KMSs provide: ability of personnel to independently obtain knowledge, quickly find the necessary information, share experience. Problems of KMS functioning: low level of involvement of a management team; complexity or absence of methods for assessing effectiveness of KMS; inconsistency of strategic and tactical levels of management; a conflict between inertial business models and innovative management concepts. Main KMS tools: network groups of experts, centers of competences, communities of practitioners, crowd sourcing, corporate social networks.

3.5. Conclusions

Application of dynamic direction of the resource theory to the management of intellectual resources of a company is justified in connection with volatility of markets, strong competition and growth of knowledge capacity and research intensity of the industrial complex. On the basis of the regression models of correlation between financial indicators and R&D costs, it is concluded that there is no correlation between the indicators. The structure of organizational capital is proposed. The problems of functioning of the existing KMSs are revealed, including low level of involvement of a management team, complexity or absence of methods for assessing effectiveness of KMS, inconsistency of strategic and tactical levels of management, a conflict between inertial intellectual models and innovative management concepts. Modernization of KMS based upon the project approach methodology and integration of KMS into the management system of organizational capital of an industrial company will facilitate efficiency.

References

Armstrong, M., (2008). The practice of human resources management. St. Petersburg.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management* 17 (1), 99 – 120.

Bontis, N. (1999). Managing organizational knowledge by diagnosing intellectual capital: framing and advancing the state of the field. *International Journal of Technology Management*, 18 (5–8), 433 – 462.

Daum, J. H. (2005). Intangible Assets-Based Enterprise Management – A Practical Approach. [in:] PMA IC Symposium, 15 December 2005, Stern School of Business, New York University: NYC/USA http://www.juergendaum.com/news/01_15_2006.htm

Edvinsson, L. (1997). Intellectual capital. Realizing Your Company’s True Value. [in:] Edvinsson, L., Malone, M. (Eds.), Harper Business: N.Y.

Galbraith, J.K. (2008). New industrial society: elected. Anthology of economic thought. Eksmo: Moscow.

Gaponenko, A.L., (2008). TM Knowledge management. Eksmo: Moscow.

Garanina, T.A. (2010). Intangible assets and intellectual capital: a role in creating the company's value. *Bulletin of St. Petersburg University*, 8 (2), 78-105.

Global Industry Analysis, Inc. Global Strategic Business Report (2012). Knowledge Management Market Report. http://www.strategyr.com/

Grant, R. (1996). Towards a knowledge-based theory of the firm. *Strategic Management Journal*, 17, 109 – 122. doi: http://dx.doi.org/10.1002/smj.4250171110

Jurczak, J. (2008). Intellectual Capital Measurement Methods. *Economics and Organization of Enterprise*, 1(1), 37—45. doi: http://dx.doi.org/10.2478/v10061-008-0005-y

Martin-de-Castro, G., Navas-López, J.E., López-Sáez, P., Alama-Salazar, E. (2006). Organizational capital as competitive advantage of the firm. *Journal of Intellectual Capital*, 7 (3), 324—337. doi: http://dx.doi.org/10.1108/14691930610681438

Milner, B.Z., (2008). Innovative development: Economics, intellectual resources, knowledge management. Moscow: INFRA-M.

Milner, B.Z., Rumyantseva, Z. P, Smirnova, V. G, Blinnikova, A.V. (2006). Knowledge management in corporations. M. Case.

Nevskaya, M.A., Marinina, O.A (2017). Challenges and opportunities of state regulation of the innovation process in the Russian mineral resources sector. *Academy of Strategic Management Journal*, 1(16), 149 – 159.

Orlova, T. (2008). Intellectual capital: the concept, essence, types. *Problems of Theory and Practice of Management*, 4, 109-119.

Oslo Guidelines: Recommendations for Collection and Analysis of the Data on Innovation, 2005 Third edition. Joint publication of OECD and Eurostat. http://ec.europa.eu/eurostat/ramon/statmanuals/files/9205111E.pdf

OTM Consulting Report, 2013, https://www.otmconsulting.com

OTM Consulting Report, 2015, https://www.otmconsulting.com

Pakhomova, N.V., Kazmin, A.A, (2013). Correlation of Market Structure and Innovative Activities of Firms: New Results with Regard for Technological Possibilities of Industries. *Problems of the Modern Economy*, 4 (48).

Petroleum Engineers, 2014, https://www.petroleumengineers.ru.

Pisano, G. (1994). Knowledge, integration, and the locus of learning: an empirical analysis of process development. *Strategic Management Journal*, 15, Special Issue: Competitive Organizational Behavior, 85-100. doi: http://dx.doi.org/10.1002/smj.4250150907

Ponomarenko, T.V., Khaertdinova, D.Z. (2015). Corporate systems of the knowledge management in the practices of integrated companies. *Mediterranean Journal of Social Sciences*, 6 (3).

R&D Scoreboard 2015: World - 2500 companies ranked by R&D. Industrial Research and Innovation, http:// http://iri.jrc.ec.europa.eu/home.

Rumelt, R. (1994). Toward a strategic theory of the firm. In: Lamb R. Competitive Strategic Management. Prentice-Hall: Englewood Cliffs: NJ, 556–570.

Sergeev, I.B, Ponomarenko, T.V. (2011). Development of strategic competitive advantages of mining companies: institutional and theoretical aspect. *Problems of Modern Economy*, 2.

Shmulev, G.A., (2007). Methods for evaluating intellectual capital. *Bulletin of BSTU*, 4.

Stewart, T.A., (2007). Intellectual capital. A new source of wealth organizations. Generation. 368p.

Teece, D. J., Pisano, G. P., Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18 (7), 509–533.

The Knowledge Management Scenario (1999). Trends and Directions for 1998-2003. Gartner Group, http://www.gartnergroup.org

Zeghal, D., Maaloul, A. (2010). Analysing value added as an indicator of intellectual capital and its consequences on company performance. *Journal of Intellectual Capital*, 11 (1), 39–60. doi: http://dx.doi.org/10.1108/14691931011013325

Chapter 4

DEVELOPMENT OF A METHODOLOGY FOR ASSESSING THE EFFECTIVENESS OF ARCTIC LNG PROJECTS BASED ON THE SPECIFICS OF THEIR IMPLEMENTATION

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Abstract

The development of the hydrocarbon resources of the Arctic zone is today one of the priority directions of Russia's economic development. The implementation of large-scale projects based on the raw material potential of the Arctic is of great importance in ensuring national energy security, increasing exports of fossil fuels and diversifying its directions, as well as contributing to the acceleration of the socio-economic development of the region. The high concentration of large gas fields in the coastal area and the favorable geographic location concerning the main gas consumers offer wide-ranging opportunities for the implementation of Arctic LNG projects. The purpose of this study is to clarify the approach to assessing the effectiveness of Arctic LNG projects, taking into account their strategic nature and industry characteristics. In research process such tasks as strategic analysis of the prospects for the development of the LNG industry in the Arctic zone of the Russian Federation, identification features of Arctic LNG projects, and justification of their assessment principles were accomplished. It was used methods of generalization, systematization, comparative and strategic analysis.

Keywords: LNG, liquefied natural gas, arctic LNG projects, Russian Arctic Zone.

4.1. Introduction

The Arctic zone of the Russian Federation is a promising region, the resource base of which can bring significant economic benefit to subsoil users and the state. Among the main provisions of the "Strategy for the development of the Arctic zone of the Russian Federation and ensuring national security for the period until 2020" is the integrated use of the Arctic mineral and raw materials potential, which emphasizes the priority of this direction in the development of the region. The need for the development of the raw material base of the Arctic is mainly determined by the need to ensure Russia's current and future needs for fuel and energy resources, including export resources that affect the country's positions on the global market.

The Russian economy is currently heavily dependent on the oil and gas sector, which forms the bulk of tax revenues to the state budget and accounts for about 20-25% of GDP (Fadeev, Cherepovitsyn and Larichkin, 2011; Carayannis, Cherepovitsyn and Ilinova, 2017; Marinina, 2017). Depletion of resources in traditional oil and gas production centers actualizes the complex development of the Arctic hydrocarbon potential, which, in view of the massive reserves, is rightfully considered the resource base of the 21st century (Sakhuja and Narula, 2016). The Arctic zone of the Russian Federation, which accounts for the bulk of the Arctic, concentrates most of the large hydrocarbon fields discovered in Russia (Glomsrod, 2008). The initial recoverable resources of the Arctic region are estimated at a value of the order of 258 billion tons of fuel equivalent, 81% of which is natural gas (State Report, 2016). The priority task is the development of the Arctic shelf, whose huge potential in the future can become the main raw material base not only for Russia but the world market as a whole (Ilinova and Dmitrieva, 2016). According to current estimates, 2/3 of the world's Arctic hydrocarbon resources are concentrated on the Russian shelf (Henderson, 2014).

The gas complex occupies the first place in the structure of the economy of the Arctic zone, but the development of some promising deposits, located mainly on the shelf or in the coastal area, is impeded by the distance from the system of main gas pipelines. The solution of this problem can be the maritime transportation of natural gas, which requires the conversion of natural gas into a liquefied state (Ulvestad and Overland, 2012).

The technology of cooling natural gas to -162 ° C (-260 ° F) and reducing its volume by almost 600 times served as the basis for the formation of the fastest growing energy sector (Dejan Ristic, 2008). According to estimates, since 2000, global demand for LNG has increased by 7.6% per year, which is almost three times faster than the dynamics of demand for natural gas (E&Y, 2013). The main advantage of using LNG technologies in comparison with pipeline transport of natural gas is mobility and supply flexibility, which allows satisfying the energy needs of the countries remote from the main production centers, and allows natural gas producers to expand their sales directions (Bridge and Bradshaw, 2017; Hewitt and Ryan, 2015). As of 2015, 30% of the world's gas trade consists of LNG supplies, and, according to current forecasts, by 2035, they will account for 50% of the gas market (CDUTEC, 2016).

Russia's position on the global LNG market is currently weak, its share in 2016 accounted for about 4% of world trade in LNG (GIIGNL, 2017). Russia's interest in developing new gas markets under modern conditions is quite logical, but this needs to build new large-scale LNG assets. Thus, the implementation of LNG projects in the Arctic zone will allow not only to develop the fields remote from the main gas pipelines but also contribute to the implementation of a diversified export policy in the world hydrocarbon markets.

4.2. Literature studies

At present, the problems of developing the resource potential of the Arctic zone of the Russian Federation are of great interest not only in the scientific community but also in society as a whole.

The development of the mineral resource base of the Arctic region at the state level is carried out by developing and adopting various regulatory and legal documents. Among such documents that determine the significance of hydrocarbon potential in the development of the Russian Arctic, it should be noted the "Strategy for the Development of the Arctic Zone of the Russian Federation and National Security for the Period to 2020", the state program "Social and Economic Development of the Arctic Zone of the Russian Federation for the Period to 2020", as well as the Energy Strategy for the period up to 2035. These documents singled out the main directions for the integrated development of the resource base, identified the most promising projects, determined the need for an active increase in the production capacity of LNG, which indicates a state interest in the development of this sector.

Problems and prospects for the implementation of Arctic raw material projects are often the objects of research in the world scientific community. This subject is devoted to the work of such authors as Cherepovitsyn A.E. (Cherepovitsyn, 2015), Konoplyanik A.A. (Konoplyanik et. al., 2016), Keil K. (Keil, 2012), Gautier D.L. (Gautier, 2009), Conley H. (Conley, 2013). In their studies, the authors substantiated the strategic nature of the raw material potential of the Arctic region, and suggested the main ways to increase the efficiency of Arctic projects, taking into account their specificity.

LNG production is an essential direction for the development of remote and hard-to-reach deposits, as noted by such authors as Braginsky O.B. (Braginskiy, 2006), Dejan Ristic (Dejan Ristic, 2008), S. Andrew McIntosh (McIntosh et. al., 2008). The features of the LNG market and the prospects of modern LNG projects were considered in the works of the author Henderson J. (Henderson and Moe, 2016), as well as companies such as Deloitte (Deloitte, 2016), E&Y (E&Y, 2013), PWC (PWC, 2014).

Despite the relevance of the problem of developing LNG production, the world scientific literature pays little attention to methodological approaches to managing Arctic raw material projects, including LNG projects. The research analysis on this problem revealed that most of the modern scientific papers are of an analytical nature, while the authors often use traditional instruments of investment analysis. However, taking into account this specificity of Arctic LNG projects, such as the need to balance the interests of various stakeholders, a specific approach to analysis is necessary for qualitative assessment of projects, which makes it possible to assess the feasibility of implementing such projects regarding externalities.

4.3. Methodology

The LNG market is dynamic; a regular market and technological changes characterize it. These include issues related to pricing, changes in the structure of supply and demand, innovative development of the LNG sector and the possibility of using uneconomic gas resources (Mulcahy, 2015). Sector-specific issues determine the uniqueness of LNG projects. We have identified the following features of such projects:

The complex value chain of the LNG product. Depending on the chosen business model, the stages of value chain may include exploration and development of the field, gas production and preparation, liquefaction, storage, transportation, regasification of LNG. In this way, the LNG sector accumulates many industry tasks.

1. LNG projects have a multiplier effect on the development of related industries, such as gas processing, shipbuilding, engineering, metallurgy, and others.
2. The implementation of LNG projects often requires the development of international cooperation, which is due to the high capital intensity and high-technology capacity, as well as the need to reduce market risks.
3. The need to maintain high competitiveness in the global LNG market requires constant technological development, which emphasizes the high importance of the innovative potential of the LNG sector.
4. Unfavorable environmental impact on the environment in the areas of construction and operation of assets. Applied technologies should guarantee complete safety of work.

5. LNG-projects have a significant effect both on the achievement of the company's commercial and strategic goals, and on accelerating the socio-economic development of the region in which the project is being implemented. This aspect necessitates the use of a specific assessment toolkit that allows assessing the external and internal effects of the project.

In previous researches of the authors, it was proved that the prospects of development of the production potential of LNG in Russia are realistic even in the current low price situation (Evseeva and Cherepovitsyn, 2017). The successful experience of the first Arctic Russian LNG project Yamal LNG showed that the high competitiveness of Arctic LNG in the world market is mainly due to the low cost of natural gas production, as well as the successful geographic location of the project concerning key consumers. In addition, in the LNG industry, the temperature regime in the production region is important, which affects the productivity of trains and the amount of energy used. These aspects actualize the construction of new LNG plants on the resource base of the Arctic region. Other strategic reasons are presented in Figure 1.

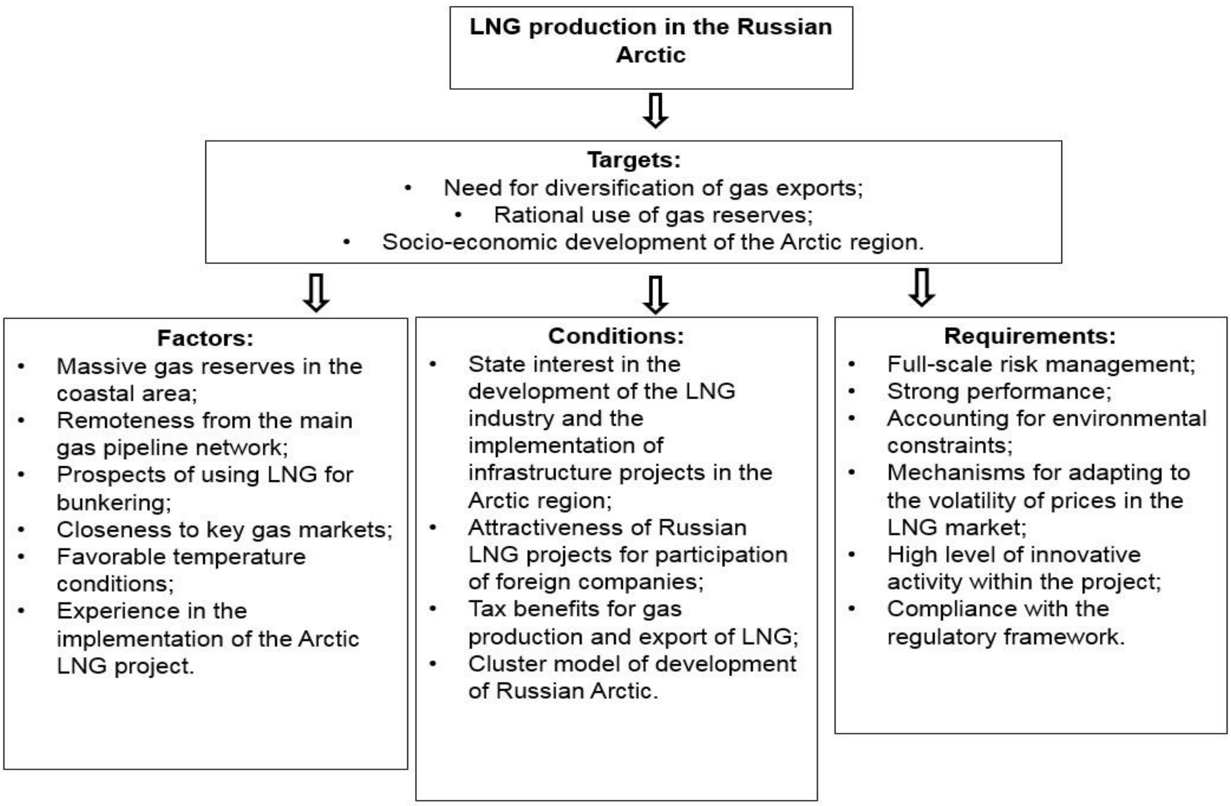

Figure 1. Strategic basis of Arctic LNG production development

Source: own study.

Investment activity in the Arctic zone is characterized by increased risks, due to the features of the legal regulation of subsoil use and the complex natural and climatic conditions of work. An absence of the necessary infrastructure, the need to develop or acquire advanced technologies, commitments to meet stringent environmental requirements significantly increase the capital intensity of Arctic projects, which has a negative impact on the investment climate in the region. In the conditions of limited financial resources, the definition of the directions of investment is one of the most difficult strategic tasks.

The modern Russian practice of making investment decisions is based, as a rule, on indicators NPV, PI, IRR, DPP, which form the basis of commercial efficiency of projects. However, in our opinion, this approach is not rational for strategically significant projects, which include LNG projects.

Arctic LNG projects need synchronization of all project stages with the principles of sustainable development of the region in the long term. At the same time, it should be noted that sufficient contribution of large projects to the development of the infrastructure framework of the region, because most of the Arctic projects are greenfield and currently being implemented on the territory that was not previously developed. On this basis, there are a sufficient number of external effects associated with the development of fundamentally new technologies for successful work in the difficult conditions of the Arctic, increasing the investment attractiveness of the region for the implementation of new projects and the wider development of Arctic territories.

Thus, in addition to internal (commercial) indicators for assessing Arctic LNG projects, which reflect the final results through the modeling and calculation of cash flows, it is necessary to take into account additional indicators that assess the externalities of such projects. We propose to take into account the macroeconomic, social, geopolitical, innovative and environmental effects when assessing the effectiveness of the project as a whole (Tab. 1).

Table 1. Types of effects and typical indicators of assessment that may occur in the implementation of Arctic LNG projects

Types of effects	Indicators
Macroeconomic effect	Cash inflows in the federal and regional budgets through the implementation of projects, the creation of regional infrastructure, the gasification of Russian regions, the share of Russian equipment and technologies in the assets of the project, increase the GDP, the level of welfare, aggregate consumption.
Social effect	Improving the quality of life of the local population, preserving the traditional way of life of indigenous ethnic groups, reducing the flow of migrants from the settlements of the Arctic zone, increasing the number of workplaces in the regions of project implementation.
Geopolitical effect	Increasing of gas production in the Arctic region, strengthening of country's positions in the world energy markets by increasing exports, entering new markets, contributing to the achievement of target indicators of sectoral, state and regional strategies, strengthening international cooperation.
Innovative effect	Increasing the technical and technological levels of development of companies implementing the project, as well as domestic products of related industries, the creation of fundamentally new technologies and technical means for conducting work in the Arctic, the development of the technological potential of the Russian LNG industry, the activation of researches, targeted training.
Ecological effect	Improvement of energy efficiency and resource saving indicators, indicators of the state of the environment in the area of project implementation and operation of facilities and compliance with their permissible standards (noise level, wastewater discharges, greenhouse gas emissions etc.) number of accidents and emergencies and their consequences.

Source: own study.

4.4. Research results

The implementation of Arctic LNG projects is a difficult task. A high cost and an increased level of risk characterize such projects, which are affected not only by the characteristics of the industry but also by the region in which the main works on the construction and operation of the plants are conducted. A dynamic LNG market with its high competition and price volatility introduces additional uncertainty in the decision to create new LNG assets. In the conditions of limited financial and technological resources, the participation of foreign companies and the state in the implementation of such projects becomes particularly important. Therefore, for example, the state support of the Yamal

LNG project in the form of granting tax benefits and state participation in financing infrastructure facilities ensured positive indicators of investment efficiency (Sigra group, 2014). Novatek's cooperation with such large foreign companies as Total, CNPC, SRF, which are shareholders of the project, allowed not only to successfully implement the project goals, but also to give a start for the further development of international partnership in the Arctic region.

The need to take into account the heterogeneity of interests and expectations on the part of each project participant allowed achieving significant external results of the project: (Tab. 2).

Table 2. The main externalities of the Yamal LNG project

Types of effect	GENERAL CHARACTERISTIC OF EFFECT FOR YAMAL LNG
Macroeconomic	Discounted tax revenues in the amount of more than 356 billion rubles*, an increase in GDP due to the implementation of investments in the amount of more than $ 27 billion and project commodity output of more than $ 176 billion*, indirect effects for the related industries, the creation of transport, social and energy infrastructure in the region, increase of investment attractiveness of the region for new projects in general.
Geopolitical	Development of an earlier uneconomic field, extraction and monetization of more than 615 billion cubic meters of Arctic natural gas, an increase in the share of the world LNG market by 5%* after the introduction of all trains, access to the US, Spanish and Indian gas market, expansion of the European gas market share, development of international cooperation.
Social	Minimal impact on the way of life of indigenous peoples, the establishment of health and education institutions in the region, the employment of local people, the creation of more than 32,000 jobs at the current stage.
Ecological	Negative impact on the environment does not exceed the permissible standards due to the introduction of advanced technological solutions in the production sector of the project, the use of resource-saving technologies, effective treatment facilities, as well as the recycling of resources.
Innovative	Creation of fundamentally new technologies for drilling and gas production in the Arctic region, taking into account all environmental requirements, development of its own gas liquefaction technology, targeted training of personnel for the project, accumulating experience in implementing Arctic LNG projects and raw material projects in general.

*Calculations of authors from data from open sources.

Source: own study.

Yamal LNG is a pilot project in the development of Arctic LNG production in Russia. Its main results in the future will affect the requirements for new Arctic LNG projects.

Currently, two more Arctic projects are planned for implementation - Pechora LNG and Arctic LNG-2, and according to those data that are already published, it can be assumed that these projects will also not bring significant commercial effects to its participants. However, experience of Yamal LNG project implementation showed, that even with low commercial efficiency indicators, such projects are feasible for implementation due to a sufficient number of external effects. Therefore, when planning Arctic LNG projects, it is essential to count not only internal economic indicators but also to predict external results that affect both the development of the region and the country as a whole.

4.5. Conclusions

Based on the results of the study, the following conclusions were drawn:

1. The LNG industry is of great importance in the fuel and energy sector of Russia, its development will enable the development of remote natural gas fields and strengthen the country's position in the global hydrocarbon raw materials market through the diversification of gas supplies;
2. The Arctic region, in view of the promising resource base in the coastal zone, favorable temperature conditions, favorable geographic location relative to key importers, is strategically important for the development of the Russian LNG industry through the implementation of new LNG projects;
3. Sectoral and regional specifics determine the uniqueness of Arctic LNG projects, which are characterized by high capital intensity and increased risks, a large number of participants (including foreign ones) due to the complex value chain of the LNG product, sufficient contribution to the social and economic development of the region and country as a whole;
4. The peculiarities of Arctic LNG projects stipulate the impossibility of their implementation with the orientation towards achieving only commercial results. Therefore, it is necessary to assess the potential externalities when assessing the effectiveness of projects as a whole;
5. Using the example of the Yamal LNG project analysis, the feasibility of implementing similar projects was proved in view of significant macroeconomic, geopolitical, social, environmental and innovative effects.

References

Braginsky, O.B. (2006). Liquefied natural gas: a new factor of the world energy market. Moscow: The Russian Academy of Sciences.

Bridge, G., Bradshaw, M. (2017). Making a Global Gas Market: Territoriality and Production Networks in Liquefied Natural Gas. *Journal Economic Geography*, 93 (2), 215-223. doi:http://dx.doi.org/10.1080/00130095.2017.1283212

Carayannis, E., Cherepovitsyn, A., Ilinova, A. (2017). Sustainable Development of the Russian Arctic zone energy shelf: the Role of the Quintuple Innovation Helix Model. *Journal of the Knowledge Economy*, 8 (2), 456-470. doi: http://dx.doi.org/10.1007/s13132-017-0478-9

CDUTEC (2016). New gas chemical and LNG projects in Russia. http://www.cdu.ru/catalog/mintop/infograf/082015/ (12.01.2018).

Cherepovitsyn, A.E. (2015). Social and economic potential of large-scale projects of oil-gas shelf development: risks and expectations of interested parties. *Notes of the Mining Institute*, 215, 140-149.

Conley, H. et. al. (2013). Arctic economics in the 21st century. The benefits and costs of cold. Report of the CSIS Europe Program.

Deloitte (2016). Building an industry: Can the United States sustainably export LNG at competitive prices? https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-er-lng-update-part-three.pdf (24.02.2018).

E&Y (2013). The world market of LNG New demand + new supply = new prices? http://www.ey.com/Publication/vwLUAssets/Global-Oil-and-Gas-LNG-RU/%24FILE/Global-Oil-and-Gas-LNG-RU.pdf (01.02.2018).

Evseeva, O.O., Cherepovitsyn, A.E. (2017). Comparative effectiveness analysis of Russian and foreign liquefied natural gas projects. *Economic and Technological Conditions of Development in Extractive Industries*, 73-83.

Fadeev, A.M., Cherepovitsyn, A.E., Larichkin, F.D. (2011). Foreign experience of hydrocarbon resources development at the Arctic continental shelf. *Economical and Social Changes: Facts, Trends, Forecast*, 13 (1), 79-89.

Gautier, D. L., et al. (2009). Assessment of undiscovered oil and gas in the Arctic. *Science*, 324 (5931), 1175–1179.

GIIGNL (2016). The LNG Industry. http://www.giignl.org/ (01.02.2018).

Glomsrod, S. (2008). The Economy of the North 2008. Statistics Norway: Oslo.

Henderson, J. (2014). International partnership in Russia: conclusions from the oil and gas industry. Palgrave Macmillan: London.

Henderson, J., Moe, A. (2016). Gazprom's LNG offensive: a demonstration of monopoly strength or impetus for Russian gas sector reform? *Post-Communist Economies*, 28 (3), doi: https://doi.org/10.1080/14631377.2016.1203206

Hewitt, T., Ryan, C. (2015). What's Different about Floating LNG? A Legal and Commercial Perspective. *Journal of Energy & Natural Resources Law*, 28 (4). doi: https://doi.org/10.1080/02646811.2010.11435252

Ilinova, A., Dmitrieva, D. (2016). Sustainable development of the Arctic zone of the Russian Federation: ecological aspect. *Biosciences Biotechnology Research Asia*, 13(4), 2101 – 2106.

Keil, K. (2012). Opening oil and gas development in the Arctic: a conflict and risk assessment. *Tvergastein Interdisciplinary Journal of the Environment*, 2, 36–43.

Konoplyanik, A.A., Buzovsky, V.V., Popova, Y.A., Troshina, N.V. (2016). Opportunities and ways of the Arctic shelf. *Oil of Russia*, 1-2, 12-17.

Marinina, O.A., Nevskaya, M.A. (2017). Specific nature of labour management in the oil and gas sector in the Russian Far North. *International Journal of Applied Business and Economic Research*, 15 (8), 177-185. doi: https://www.researchgate.net/publication/317745811

McIntosh, S. A., Noble, P.G., Rockwell, J., Ramlakhan, C.D. (2008). Moving natural gas across oceans. *Oilfield Review*, 50-63.

Mulcahy, C. (2015) The changing face of disputes in the liquefied natural gas market. *Journal of Energy & Natural Resources Law*, 33 (3). doi: https://doi.org/10.1080/02646811.2015.1043819

PWC (2014). The progression of an LNG project. https://www.pwc.com/gx/en/mining/publications/assets/pwc-lng-progression-canada.pdf (23.02.2018).

Ristic, D. (2008). Liquified Natural Gas—Overview of Prospectives. *Journal Strategic Planning for Energy and the Environment*, 27 (4), 66 - 75. doi: https://doi.org/10.1080/10485230809509413

Sakhuja, V., Narula, K. (2016). Asia in the Arctic. Narratives, Perspectives and Policies. Singapore: Springer.

Sigra Group. (2014) Government Support to Upstream Oil & Gas in Russia. How Subsidies Influence the Yamal LNG and Prirazlomnoe Projects. http://www.iisd.org/gsi/sites/default/files/ffs_awc_russia_yamalprirazlomnoe_en.pdf (01.03.2018).

State report (2016). The state and environmental protection of the Russian Federation in 2015. Ministry of Nature: Moscow.

Strategy of developing the Arctic zone of the Russian Federation and national security system for the period till 2020. http://government.ru/info/18360/ (08.02.2018).

Ulvestad, M., Overland, I. (2012). Natural gas and CO_2 price variation: Impact on the relative cost-efficiency of LNG and pipelines. *International Journal of Environmental Studies*, 69 (3). doi: http://dx.doi.org/10.1080/00207233.2012.677581

Chapter 5

SOURCES OF VALUE CREATION OF A MINING ENTERPRISE

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Abstract

The publication summarizes the current scientific considerations in the area of sources of value creation of a mining enterprise, as well as results of own research directed to the identification of such sources that are important for implementation and use of processes management concept in an enterprise. The own research covered the literature study and focus group interviews that made it possible to verify the obtained results with reference to the reality of hard coal mining.

Keywords: hard coal mining, value creation, processes management.

5.1.Introduction

The modern market of hard coal is a source of difficult challenges for Polish mining enterprises. Currently, among basic conditions for their proper functioning and development, one can distinguish – apart from the ability of quick adjustment to the technical and technological changes – the ability of management focused on value creation.

Value creation of a mining enterprises is currently considered to be their basic and strategic long-term objective (Sierpińska, 2007; Wodarski, 2009; Bluszcz et al., 2013). This objective can be achieved by identifying the key sources that determine this value. In literature, much attention is paid to these sources, both in general and with reference to the specific nature of Polish enterprises. This paper summarizes the selected research results on sources of value creation of a mining enterprise, as well as the results of own research that refer to these determinants that are of special importance in the context of process approach to the management of a mining enterprise. A premise for the research in such a context was the need of management of Polish mining enterprises that is interested in implementing the concept of process management to improve the efficiency and effectiveness of their business. Identification of sources of value creation is of importance in the aspect of including them in the developed processes management system model in a mining enterprise. This model will constitute a representation of the procedures that will ensure efficiency and effectiveness of processes implemented in a mining enterprise to create value, and – as a consequence – its proper functioning and development in the modern economic conditions.

5.2.Methodology

The research described in this paper aimed to present the previous results of considerations on sources of value creation of a mining enterprise and to indicate such sources that are of importance when it comes to implementation and application of processes management concept. To do so, the research was divided into three stages during which the set methods were used (Table 1).

Table 1. Methods and the result of their use in particular research stages

Research stages	I.	II.	III.
Methods used	Literature study; Summary	Literature study; Summary	Focus group interviews; Summary
Results of methods usage	Presentation of research results in the scope of sources of value creation of a mining enterprise	Determining the sources of value creation that are of importance in the context of implementation and application of processes management concept	Defining the sources of value creation of a mining enterprise that are of crucial importance in the context of implementation and application of processes management concept
	Indication of cognition gap		

Source: own study.

During the I stage of research, the analysis of literature was carried out which discussed the issue of value creation of a mining enterprises. It made it possible to summarize the scope of the research that was carried out so far as well as their results – the sources of value creation of a mining enterprise. On this basis a cognition gap was identified that referred to sources of value creation of a mining enterprise that are of importance in the context of processes management concept.

During the II stage of research, to fill in the cognitive gap, a literature study on processes management was carried out. The authors' considerations were focused mostly on determinants of effectiveness and efficiency of processes that influence the value creation in a long perspective. The results of these considerations made it possible to determine the sources of value creation that are of importance in the context of implementation and application of processes management concept.

During the III stage of the research, to verify the defined sources of value, the focus groups interviews were engaged that were a quality method for collecting information during the discussion carried out by moderators (the authors of this paper). The summary of the results obtained by way of these focus groups interviews made it possible to indicate sources of value creation of a mining enterprise that are of crucial importance in the context of processes management concept.

5.3.Results

I stage of research.

In the publications concerning the value creation of enterprises, much attention is paid to its sources (among others Rappaport, 1999; Walters, 1999; Black et al. 2000; Michalski, 2001; Szczepanowski, 2007; Gołębiewski and Szczepankowski, 2007; Domodaran, 2010). The focus was in particular on these publications which took into account the specific nature of mining enterprises (among others Sierpińska, 2007; Karbownik and Jonek-Kowalska, 2011; Kowal, 2012; Kowal and Kowal 2014; Jonek-Kowalska, 2017). On the basis of analysis of these publications, the authors decided to present the results found in three of them.

In the first publication (Sierpińska, 2007), considerations were presented within seven basic sources of value of a mining enterprise, distinguished due to the specific nature of hard coal mining industry.

The first and most important source of value creation were the mining and geological conditions, as well as the technique and technology of extraction. With reference to mining and geological conditions and their influence on value creation, the significance of such factors as proper seam identification, as well as adequate design of its management which depends, among others, on defined tectonic faults, seam thickness, localization of the resources, natural hazards or the necessity to protect the surface, was emphasized. In turn, with reference to technique and technology of extraction, from among the factors that shape the value, the modernization of extraction or technical equipment, management of extraction front as well as the management of design and optimization of mining process or extraction focus were distinguished.

The second important source of value creation was the estimated period of extraction that depends on the owned and documented industrial resources (their size and quality) as well as on the intensity of extraction.

The third source of value creation are the sales structure and coal distribution channel. It was noted that a key factor is management of coal sale that covers the indication of a proper level and structure of sales, determined by its probable share in professional and industrial power engineering, utility and municipal power plants, other industrial recipients, coke plants and others as well as share of sales for export. The importance of seasonal nature of sales was also emphasized. The coal distribution channels as well as it seasonal nature influence the level of inventory and short-term liabilities. Their high level may lead to usage of financing sources that increase the capital acquisition cost.

The coal prices were indicated as the fourth source of value creation of a mining enterprise. It was emphasized that the prices of coal are among the most important external value creation factors. Their level is set by trends on global mineral materials markets, which result from the level of coal demand and supply having defined quality parameters.

The fifth source of value creation of a mining enterprise is the cost of coal extraction that depends on the following:

- presence of natural hazards and the necessity to ensure safe working conditions,
- necessity to reconstruct extraction front,
- mining works in seams that are more difficult in terms of resources location,
- carrying out necessary timely technical maintenance and repair work to prevent downtime and ensure the safety of use of machinery and equipment,
- increase of prices of foreign services, for example drilling and mining,
- increase of remuneration, strongly correlated with the social conditions that complicate the decision-making.

The sixth source were the ecological conditions that result in significant expenditure on environmental protection which results from the generation of mining waste, discharging waste to the environment (including saline waters), emission of pollutants to air or noise caused by machinery and equipment.

The seventh source was the cost of capital that finances the business of mining enterprises. It was noticed that this cost is higher in this industry as compared with other sectors, which is due to the high risk of the business and associated uncertainty.

The second publication (Kowal, 2012) presents the results of literature study and the focus groups in the scope of sources of value creation of a mining enterprise. These sources were classified into seven key functional areas that take into account the nature and essence of mining business.

The first area that is considered the source of value creation are marketing and sales. In this area the following determinants of value creation were distinguished: direct agreements with domestic and foreign contractors, the knowledge about the sales market, investments into market research – knowing the customers' needs, coal assortments, certainty of supplies, the directions of coal sales, level of inventory, diversification of contractors' portfolio, number of long-term agreements, relation between the quality of seam coal and commercial coal, the flexibility of price policy, competitive advantage in Europe, focus on a customer, the selection of the most effective segments of domestic and foreign market, development of distribution network, deliveries flexibility – market segmentation, market downturn, creation of new recipients – promotion, quality management system, investments into the image, customer service quality policy, investments in coal bulk breaking.

The second source of value creation of a mining enterprise is the production (technology) of coal. The following determinants of value creation were identified: investments in new extraction fields, investments in identification and documentation of resources, investments in unified coal mine, maintaining the extraction ability, investments in Coal Processing Plant, investments in technologies of output enrichment, modernization of technical equipment of the front, extension of present extraction levels, movement of current equipment, investments in quality control systems (quality parameters of coal), investments in implementation of innovative solutions in terms of environmental protection, minimization of mining exploitation effects on the environment, economic use of waste, waste management strategy, economic use of methane.

The next, third area defined being a source of value creation were human resources. The following value creation determinants were distinguished: personal strategy, employment structure, payroll policy, qualified personnel, internal movement of employees and between plants, policy of relations with trade unions, additional employees benefits, ability to change, trainings system, cooperation with schools/universities, investments in vocational training, managerial abilities, work organization, development of incentive system, social policy, development of employee training system, development of occupational health and safety, investments in decreasing the risk of natural hazards, cooperation with research and development units within OHS, investments in providing the employees with personal protective equipment, investments in devices for rooms and technological processes hygiene.

The fourth area being a source of value creation of a mining enterprise are its assets. In this area the following factors were determined: usage of the owned land and buildings, plans concerning the use of fixed assets, planning and implementation of renovations, organization of sales process, control of plans implementations within sales, investments in property protection.

The financial resources were named the fifth area of value creation of a mining enterprise. The following value creating determinants were listed: acquiring financial resources for the business, current management of available financial resources, control of usage of financing means, using reliefs and exemptions, investments in the purchase of stock/shares in other entities, investing available resources into long-term deposits, system of account and measurement of costs, system of debt collection.

The next, sixth area defined as a source of value creation were organizational resources. The following factors were indicated: organizational structure, organization of management work, tasks and competences of organizational units, entities organizational structure, tasks, competences and liabilities organization for entities, organization of strategic, tactical and operational management, management control, legal services, image creation, external contacts.

The information resources were named the seventh and the last area of value creation of a mining enterprise. Among them, we can distinguish the following value creating determinants: investments in computer systems, rules for information and documents flow, rules for using IT means, collection and processing of data for the purpose of management, systems of external communication, systems for information sourcing from the environment.

The author of the third publication (Jonek-Kowalska, 2017) named five basic value sources with a reference to hard coal, production process and lifecycle of mining enterprises. As a result of the considerations she indicated that the basic source are the owned and potential geological resources, being the basis for the mining enterprise functioning. The second came the collection of material and non-material resources. Material resources were defined as having high intensity of capital expenditures and are characterized by significant risk due to the product homogeneity and the lack of possibility to use product or geographical diversification. In turn, among non-material resources she pointed out to the importance of extraction technology that determines not only extraction costs but also significantly influences the harmfulness of production for the environment and society. In this scope the role of the so-called clean coal technologies in the areas of extraction, mechanical processing, usage of coal in power engineering, possibility of transforming (for example into liquid fuels) and waste management was emphasized by the author. What she also pointed to was that the technology of extraction is important in the context of the possibility of usage of off-balance sheet and non-industrial resources. I. Jonek-Kowalska as the third most important factor of value creation indicated the combination and development of held material and non-material resources, especially in the process of remedial restructuring associated with the decreasing role of coal in the energy balance. She defined the three mentioned sources as crucial in the aspect of influence on the operational carriers of value. The subsequent two she classified as strongly influencing the strategic carriers. In the first place she paid attention to the possibility (and quite often the necessity) of establishing economic relations by the mining enterprises in the form of energy concerns or global mining concerns that guarantee that such entities will survive and develop. Next, she pointed out to the implementation of sustainable development and corporate social responsibility concepts arguing that if these elements are omitted this has disastrous effect on the image of mining enterprises and thus their value.

It must be noted, however, that the results of the research presented in the discussed publications (Sierpińska eds., 2007; Kowal, 2012; Jonek-Kowalska, 2017) fall into the category of research focused on value based management emphasizing its links with resource based view as well as the ideas of sustainable development and corporate social responsibility. These research results did not indicate sufficiently the sources of value creation that are of importance in the aspect of process approach and associated concept of processes management, even though its main goal is the creation of enterprise’s value.

Due to the lack of direct link between the presented results of research on sources of value creation of a mining enterprise with the concept of processes management, it was stated that in the available academic sources there is a cognition gap in that aspect. Yet, the identification of these sources is of importance to implement this concept of management which according to many scientists is one of the dominant trends of modern economic theory and practice, and which according to management of mining enterprises is the adequate direction of changes that should take place in the hard coal industry.

II stage of research.

- It was assumed that the basis to fill in the said cognitive gap will be a literature study. So far, there is a lack of literature on processes management in the hard coal mining industry and scarce publications in this scope present only selected issues concerning the classification or modeling of processes or methods and tools that support processes management. Therefore, an analysis of literature on the processes management in the enterprise was made (among others Czekaj, 2009; Skrzypek, and Hofman, 2010; Nowosielski, 2011; Maciejczak, 2011; Grajewski, 2009, 2012; Bitkowska et al., 2011; Bitkowska, 2013). On this basis it was stated that the heart of this concept is creation of enterprise value by ensuring effectiveness and efficiency of processes implemented by such an enterprise:
- within the structure defined by stages of identification and classification, modeling, measurement or results assessment as well as improvement and development of course of processes,
- in the interrelated organizational and social areas, areas of knowledge, economic and financial and IT areas.

Taking this into account, it was assumed that the sources of value creation of a mining enterprise in the concept of processes management must be search for in determinants of effectiveness and efficiency of processes in the scope of the abovementioned structure and areas. And so, on the basis of literature study it was assumed that there are 40 determinants of effectiveness and efficiency of enterprise processes (Tab. 2).

Table 2. Determinants of effectiveness and efficiency of processes in the scope of the structure of processes management and areas of organization and social, knowledge, economics and finance, IT

Determinants of effectiveness and efficiency of processes	
STRUCTURE OF PROCESSES MANAGEMENT	
1)	linking the processes with strategy and basic strategic objective (value creation),
2)	identification and classification of processes in the context of value creation,
3)	modeling the course of processes that ensures their maximum effectiveness and efficiency,
4)	organization and control of the manner of carrying activities within the processes as compared with their assumed course,
5)	defining measures/indicators of processes results and norms/standards referring to their level,
6)	making measurements, reporting and assessing processes implementation results on the basis of assumed measures/indicators and norms/standards,
7)	improvement and development of the course of processes on the basis of their implementation results assessment,

8)	using methods or tools that support the measurement, reporting and assessment of processes results, as well as their improvement and development.
	AREA OF ORGANIZATION AND SOCIAL
9)	organizational structure focused on processes,
10)	presence of process awareness among employees,
11)	focus on teamwork,
12)	determining process managers (or other relevant positions) as well as process teams,
13)	integration of HR management with processes management,
14)	organizational culture that fosters processes management,
15)	open attitude to the changes proposed by the employees, focus on the improvement and development of the course of processes,
16)	team assessment – responsibility for the results of the processes shall be borne by process managers and process teams.
	AREA OF KNOWLEDGE
17)	the knowledge of the employees in the scope of processes management concept – training on particular stages of process management structure and its dimensions,
18)	presence of relevant communication network for the use of employees' knowledge on particular processes and sharing this knowledge in process teams,
19)	record keeping of knowledge on processes and their results,
20)	access of employees to knowledge on processes, for example documentation that covers objectives, maps, processes measurement indicators,
21)	motivating employees to share knowledge and experience,
22)	possibility of making changes and improvements in the processes by the employees,
23)	providing the employees with relevant knowledge on particular processes in due time,
24)	presence of knowledge management system for the purpose of processes management.
	AREA OF ECONOMICS AND FINANCE
25)	knowledge of modern accounts that make it possible to manage the costs of processes,
26)	calculating, reporting and monitoring costs of processes,
27)	availability of financial and accounting background for the purpose of calculating, reporting and monitoring costs of processes,
28)	using modern methods that can support calculating, reporting and monitoring costs of processes,
29)	planning activities and resources for the purpose of optimization of costs of processes,
30)	costs of processes and indicators based on these costs – as a basis for the assessment of process effectiveness,
31)	providing employees with information on costs of processes,
32)	taking into account the costs of processes in the incentive system.
	AREA OF IT
33)	access to highly qualified experts (IT specialists),
34)	development and implementation of IT system dedicated for processes management,
35)	employees' training on the proper usage of IT system dedicated for processes management,
36)	trainings for employees on the use of IT tools to map the course, measurement, reporting, results assessment, as well as analysis and improvement of processes,
37)	use of IT tools to map the processes course,
38)	use of IT tools to measure, report and assess the results of processes implementation,
39)	use of IT tools to analyze and develop the processes,
40)	development and implementation of a software that ensures process integration of IT systems with the customers' systems.

Source: own study.

It must be noted, that the listed determinants of effectiveness and efficiency of processes are indirectly linked with the sources of value creation of a mining enterprise defined in literature. And so, with reference to the first of the presented publications (Sierpińska eds., 2007), one can notice their indirect link with – for example – production process management, optimization of mining work, management of coal sale or costs of coal extraction. With reference to the second publication (Kowal, 2012), one can indicate an indirect link with determinants in each of the identified sources of value creation. For example in the area of marketing and sales it is the knowledge of sales market, in the area of production – investments into implementation of innovative solutions, in the area of HR – development of incentive system, in the area of tangible assets – organization of sales process, in the area of financial resources – account and costs measurement system, in the area of organizational processes – organizational structure, and in the area of IT resources – rules for the use of IT resources. Similarly, in the case of the third publication (Jonek-Kowalska, 2017), one can notice an indirect link between sources of value creation and defined determinants, for example this applies to extraction technology or production costs.

III stage of research.

To verify the defined sources – determinants of value creation in the context of processes management with regard to the specific nature of the mining enterprise, two focus groups interviews were engaged. They composed of 10 representatives of management of two Silesian mining enterprises who are interested in the issues related to processes management and using this concept in mining practice. The focus groups were about discussion and knowledge sharing between the participants in the scope of the 40 presented determinants. It was assumed that each focus group participant can share their opinion on determinants, as well as make an assessment of their influence on the creation of value of a mining enterprise.

During the focus groups it was unanimously stated that the specific determinants are of average, significant or very significant influence on the effectiveness and efficiency of processes and consequently on the value creation of a mining enterprise. Moreover, during the discussion several determinants were emphasized that according to many of the representatives of management are important in the aspect of the usage of processes management concept and influence on the creation of value of mining enterprise (Fig. 1). In particular, it applies to the following determinants:

90% of answers “Very significant influence”, 10% of answers “Significant influence”:

13) integration of HR management with processes management – during the discussion it was noted that the key to success is a presence of incentive program associated with the processes results,

6) making measurements, reporting and assessing processes implementation results on the basis of assumed measures/indicators and norms/standards – during the discussion it was emphasized that this is the basis of effectiveness and efficiency of processes,

5) defining measures/indicators of processes results and norms/standards referring to their level – during the discussion, the present problems were indicated; it was also noted that such measures and norms exists with reference to several processes,

1) linking the processes with strategy and basic strategic objective (value creation) – during the discussion, emphasis was put on the meaning of strategic goal cascading into objectives of processes, teams and their members,

80% of answers “Very significant influence”, 20% of answers “Significant influence”:

34) development and implementation of IT system dedicated for processes management – during the discussion problems in this area were identified that are linked with access to highly-qualified specialists,

20) access of employees to knowledge on processes, for example documentation that covers objectives, maps, processes measurement indicators – during the discussion the problems the solutions for which are time consuming as there is currently no such documentation were identified,

18) presence of relevant communication network for the use of employees’ knowledge on particular processes and sharing this knowledge in process teams,

12) determining process managers (or other relevant positions) as well as process teams – during the discussion it was noted that the establishment of a relevant department for processes management, appointing its leader and team members is important in the context of establishing affiliation and group responsibility and team work,

70% of answers “Very significant influence”, 30% of answers “Significant influence”:

33) access to highly qualified experts (IT specialists) – during the discussion it was classified as important but sourcing such specialists is characterized by high intensity of capital expenditures which is important in the context of current economic and financial situation of mining enterprises,

27) availability of financial and accounting background for the purpose of calculating, reporting and monitoring costs of processes – during the discussion, attention was paid that the SZYK 2 IT system used in mining industry can support processes management in this scope but is not used for that purpose,

26) calculating, reporting and monitoring costs of processes – during the discussion the modern opportunities in this scope were identified as well as their meaning for processes effectiveness.

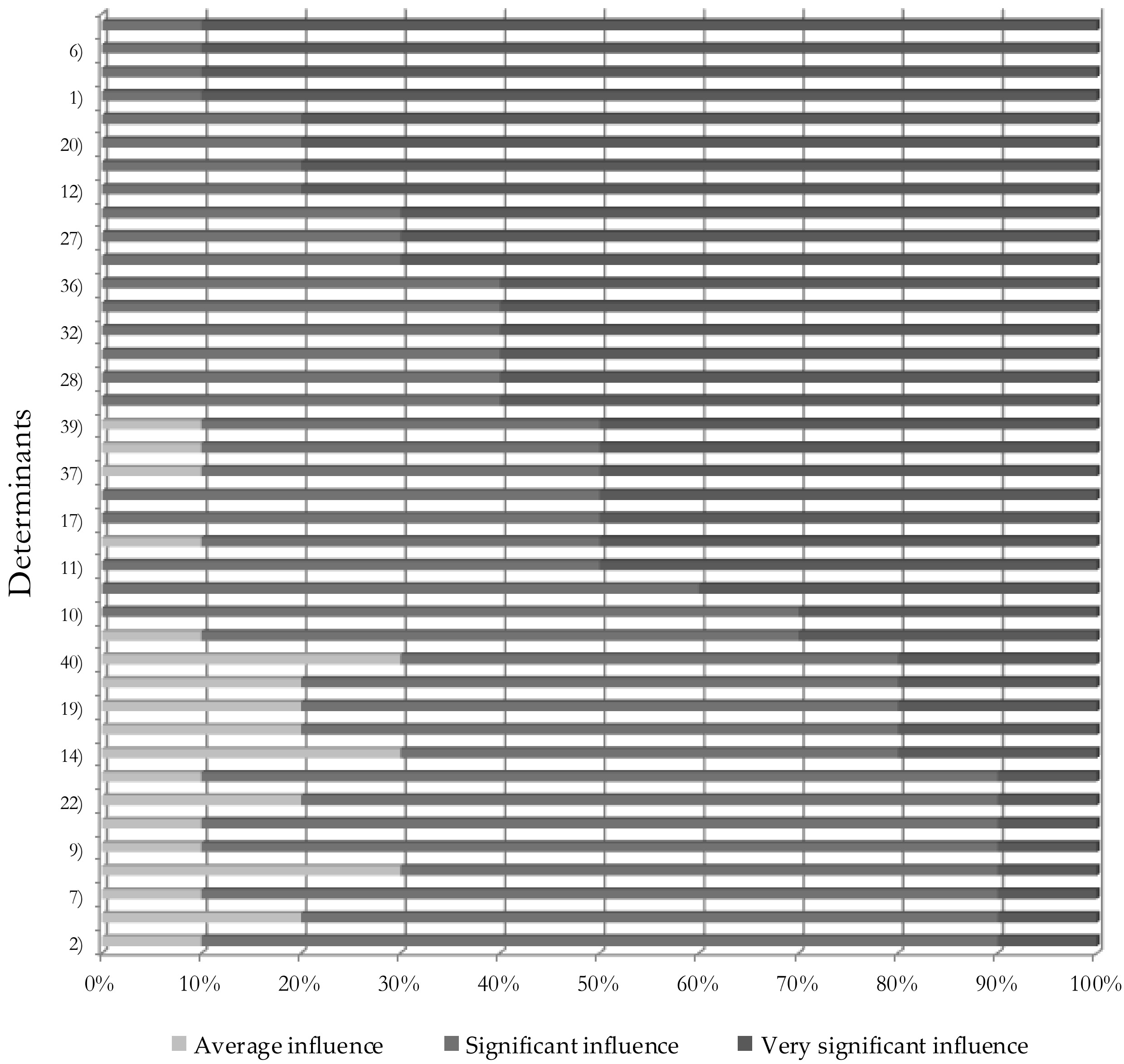

Figure 1. Results of assessment of influence significance of defined determinants on value creation of a mining enterprise (numbers of determinants as in the text)

Source: own study.

5.4.Conclusions

Determining the sources of value creation of mining enterprises is of significance in the aspect of implementation of modern management concepts that are focused on proper functioning and development in the current economic conditions. Currently, among such concepts the processes management can be distinguished. According to management of mining enterprises, implementation of this concept is a proper direction of changes that should take place in the hard coal mining industry. The research results presented in this publication on the sources of value creation were aimed to identify those of importance in the aspect of implementation the concept of processes management in mining enterprises. These results are general but taking them into consideration in the processes management system model being developed will make it possible to focus on determinants of effectiveness and efficiency of processes, and in turn will result in the value creation of a mining enterprise. Further considerations and research results in this scope will be subject of other publications.

References

Bitkowska, A. (2013). Zarządzanie procesowe we współczesnych organizacjach. Difin: Warszawa.

Bitkowska, A., Kolterman, K., Wójcik, G., Wójcik, K. (2011). Zarządzanie procesami w przedsiębiorstwie. Aspekty teoretyczno – praktyczne. Difin: Warszawa.

Black, A., Wright, P., Bachman, J. (2000). W poszukiwaniu wartości dla akcjonariuszy. Dom Wydawniczy ABC: Warszawa.

Bluszcz, A., Kijewska, A., Sojda, A. (2013). Analiza efektywności zarządzania wartością przedsiębiorstwa górniczego. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 786, 87-96.

Czekaj, J. (Eds.) (2009). Zarządzanie procesami biznesowymi. Aspekt metodyczny. Wydawnictwo Uniwersytetu Ekonomicznego: Kraków.

Domodaran, A., (2010). Value Creation and Enhancement: Back to the Future. http://www.stern.nyu.edu.

Gołębiewski, G., Szczepankowski P. (2007). Analiza wartości przedsiębiorstwa. Difin: Warszawa.

Grajewski, P. (2009). Uwarunkowania implementacji procesów do organizacji. In Nowosielski, S. (Eds.), Podejście procesowe w organizacjach, Wydawnictwo Uniwersytetu Ekonomicznego: Wrocław, 381-395.

Grajewski, P. (2012). Procesowe zarządzanie organizacją. PWE: Warszawa.

Jonek – Kowalska, I. (2017). Prowartościowe kształtowanie parametrów produkcji górniczej w warunkach ryzyka branżowego i rynkowego. Wydawnictwo Politechniki Śląskiej: Gliwice.

Karbownik, A., Jonek-Kowalska, I. (2011). Udział kosztów wytwarzania w kształtowaniu wartości przedsiębiorstw górniczych. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 685, 431-442.

Kowal, B., Kowal D. (2014). Czynniki kształtujące wartość przedsiębiorstwa górniczego węgla kamiennego. *Przegląd Górniczy*, 9, 44 -47.

Kowal, D. (2012). Determinanty kształtujące wartość przedsiębiorstwa górniczego. *Zarządzanie Przedsiębiorstwem*, 1, 19-28.

Maciejczak, M. (2011). Zarządzanie procesami biznesowymi w teorii i praktyce. Wydawnictwo PJWSTK: Warszawa.

Michalski, M. (2001). Zarządzanie przez wartość: firma z perspektywy interesów właścicielskich. WIG – Press: Warszawa.

Nowosielski, S. (Eds.) (2011). Podejście procesowe w organizacjach. Wydawnictwo Uniwersytetu Ekonomicznego: Wrocław.

Rappaport, A. (1999). Wartość dla akcjonariuszy. Poradnik menedżera i inwestora. WIG-Press: Warszawa.

Sierpińska , M. (Eds.) (2007). Wykorzystanie nowoczesnych koncepcji wspomagania decyzji dla poprawy efektywności zarządzania zakładem górniczym i spółką węglową. Patria: Kraków.

Skrzypek, E., Hofman, M. (2010). Zarządzanie procesami w przedsiębiorstwie. Oficyna Wolters Kluwer business. Warszawa.

Szczepanowski, P. (2007). Wycena i zarządzanie wartością przedsiębiorstwa. Wydawnictwo Naukowe PWN: Warszawa.

Walters, D. (1999). The Implications of Shareholder Value Planning and Management for Logistics Decision Making. *International Journal of Physical Distribution & Logistics Management*, 29 (4), 240-258.

Wodarski, K. (2009). Zarządzanie ryzykiem w procesie planowania strategicznego w górnictwie węgla kamiennego. Wydawnictwo Politechniki Śląskiej: Gliwice.

Chapter 6

REMEDIAL RESTRUCTURING AS A WAY TO EXTEND THE FINAL STAGE OF AN ENTERPRISE BASED ON THE EXAMPLE OF POLISH HARD COAL MINING

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Abstract

The major objective of this article is to analyse and assess the use of remedial restructuring as a way to extend the final stage of an enterprise based on the example of Polish hard coal mining. To achieve the objective formulated in this way, the first part of the article presents the reasons and symptoms of crisis in Polish hard coal mining in the context of the lifecycle of two mining companies, excavating power coal, i.e.: Kompania Węglowa SA and Katowicki Holding Węglowy SA. Next, the scope of the remedial restructuring in years 2015–2016 was characterised. For the studies, the reference works' studies, market condition analysis in the Polish hard coal mining and the profitability assessment, including its all determinants, were used.

Keywords: remedial restructuring, mining company, company lifecycle, crisis management, Polish hard coal mining.

6.1. Introduction

The company lifecycle has four basic stages, i.e. foundation, development, maturity and final stage, with the companies attempting to extend particular stages characterised by satisfactory development pace, i.e. development and maturity, using any ways possible. In the final stage, the company terminates its activity and inevitably heads for liquidation. It experiences a crisis caused by internal or external factors, or by their mutual coupling. At this stage, the company may strive to extend the lifecycle, but due to the state of collapse it is in, this task is difficult and usually fails (Nawrocki and Jonek-Kowalska, 2016). A standard way of exiting the crisis and extending the final stage or maturity is the remedial restructuring.

The remedial restructuring can be carried out within the existing company resources by means of:

- improved management;

- improved work organization;
- cost reduction;
- increased motivation;
- human resources improvement;
- improved quality of products and processes.

It is also possible to "make the company leaner" in order to reduce expenditure and, consequently, improve efficiency faster than if the resources were unchanged, though in a more radical and controversial way. In such a situation, the following measures are adopted:

- elimination of inefficient production chain links;
- sales of some assets;
- shutdown of certain facilities;
- dismissals;
- product line limitations.

Since the 1990s, the Polish hard coal mining has been struggling with the problem of temporary and long-term economic ineffectiveness of particular mines and, consequently, the entire mining companies. It has also been subject to remedial restructuring to extend the lifecycle of the companies themselves and the whole sector. The major premise justifying that process is to maintain the energy security of Poland for which hard coal has still been a key power resource (Karbownik and Turek, 2011). Nonetheless, an important priority for the remedial restructuring in the mining sector is also the job retention in the Upper Silesian Coal Basin (Dubiński and Turek, 2009; Gumiński, 2014).

Given the above circumstances, the major objective of this article is to analyse and assess the use of remedial restructuring as a way to extend the final stage of an enterprise based on the example of Polish hard coal mining. To achieve the objective formulated in this way, the first part of the article presents the reasons and symptoms of crisis in Polish hard coal mining in the context of the lifecycle of two mining companies, excavating power coal, i.e. Kompania Węglowa SA and Katowicki Holding Węglowy SA (Korski et al., 2016). Next, the scope of the remedial restructuring in years 2015–2016 was characterised. For the studies, the reference works' studies, market condition analysis in the Polish hard coal mining and the profitability assessment, including its all determinants, were used (Hąbek and Wolniak, 2016; Manowska et al., 2017).

6.2. Methodology

To assess the operations of two studied mining companies and to identify their current development stage in the research section of the article, the total return on assets (1) and return on sales were used.

$$ROA = \frac{FR}{A} \tag{1}$$

where:

FR — net financial result;

A — total assets.

$$ROS = \frac{FR}{RV} \tag{2}$$

where:

FR — net financial result;

RV — sales revenue.

What is more, chain indexes of dynamics were used for crisis symptom analysis for production costs and sales revenue (3).

$$I = \frac{i_t}{i_{t-1}} \tag{3}$$

where:

i_t — value of the variable in time t,

i_{t-1} — value of the variable in time $t-1$.

For the studies, the data derived from the financial statements of the analysed companies for years 2003–2016 and the materials of the Ministry of Economy, concerning mean hard coal selling prices and production costs in the Polish hard coal mining were used.

6.2.Symptoms and causes of crisis in the Polish hard coal mining

As already mentioned, the analysis of the mining company lifecycle was applied for two mining companies excavating power coal in the Upper Silesian Coal Basin (USCB). First of them is Katowicki Holding Węglowy SA (KHW SA) founded in 1993 by consolidating independent mines operating in USCB those days. Initially, KHW SA comprised 11 of them. The second coal mine analysed is Kompania Węglowa SA established in 2003 by way of merging 5 coal companies. Initially, it comprised 23 mines.

A typical symptom of crisis in a company is the deteriorated net financial result which, in a longer perspective, results in liquidity loss and limited own capital inflow. A long-term profitability loss exerts an adverse impact also on the abilities to obtain own and third-party external capital. Cumulation of all the above symptoms leads to the company bankruptcy and the termination of the final stage with its liquidation. Given the above, Figures 1 and 2 show the return on assets and on sales respectively in the analysed mining companies.

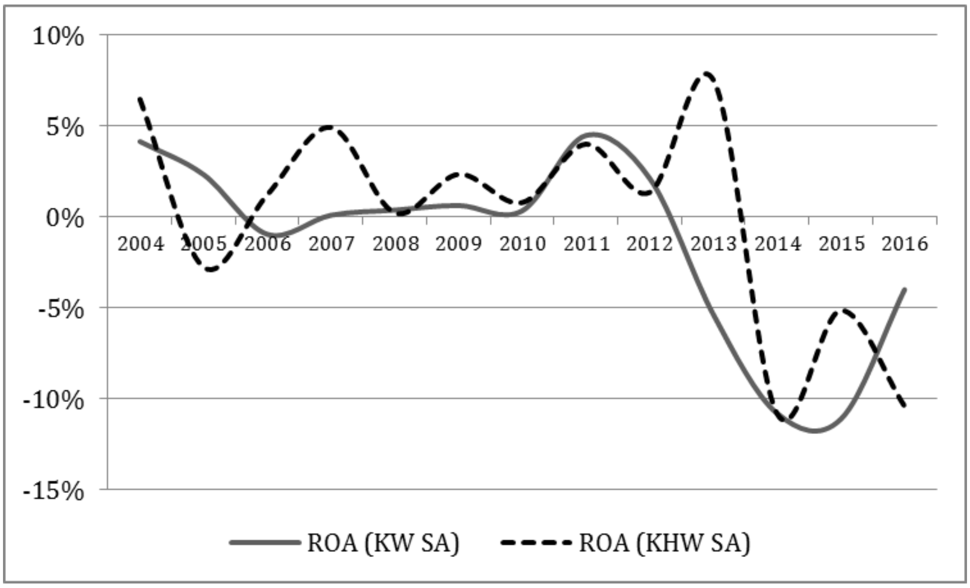

Figure 1. Total return on assets in Kompania Węglowa SA (KW SA) and Katowicki Holding Węglowy (KHW SA) in years 2004–2016 [in %]

Source: own compilation based on the financial statements.

A characteristic feature of the return on assets for both companies, in the entire analysed period, is its high changeability, caused by significant financial market fluctuations which indicates high risk associated with the operations of those mining companies.

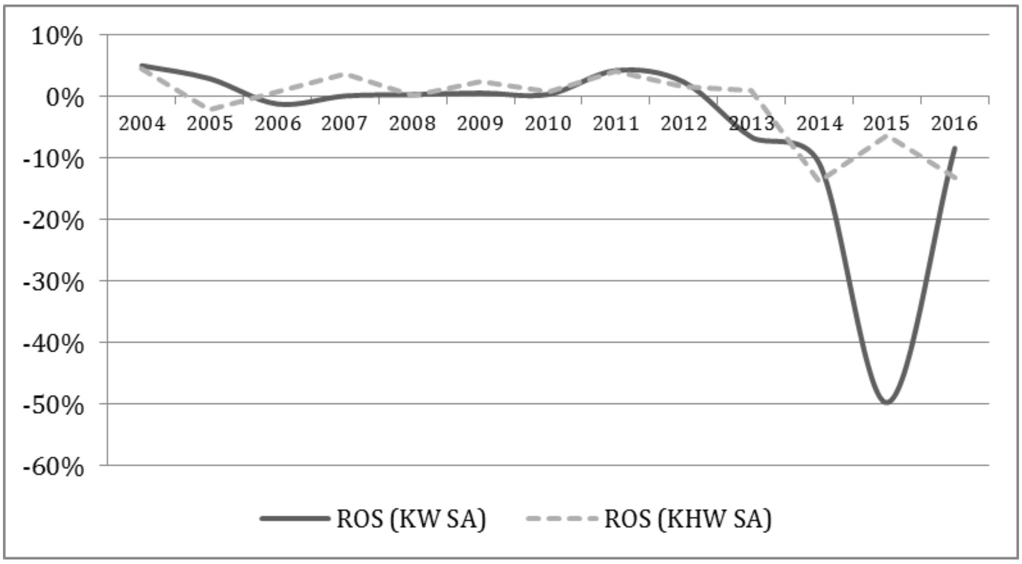

Figure 2. Return on sales in Kompania Węglowa SA (KW SA) and Katowicki Holding Węglowy (KHW SA) in years 2004–2016 [in %]

Source: own compilation based on the financial statements.

The best period in terms of ROA and ROS achieved were the years 2007–2012. At that time, the analysed indexes are positive. Their highest values are recorded in 2011. Since 2012, a sudden fall of financial results in both analysed mining companies has been recorded (Turek and Michalak, 2011).

The dynamics of revenue and own costs in both companies is presented synthetically in Table 1 and 2.

Table 1. Chain indexes of dynamics for sales revenue and the mining production costs in Kompania Węglowa SA in years 2005–2016

Specification	Years					
	2005	**2006**	**2007**	**2008**	**2009**	**2010**
chain index for revenue	0.977	0.960	0.986	1.285	1.000	0.976
chain index for costs	0.996	0.993	1.000	1.158	1.005	0.993
Specification	**Years**					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
chain index for revenue	1.211	0.882	0.967	0.872	0.180	2.287
chain index for costs	1.131	0.910	1.428	0.887	0.167	2.100

Source: own study.

Table 2. Chain indexes of dynamics for sales revenue and the mining production costs in Katowicki Holding Węglowy SA in years 2005–2016

Specification	Years					
	2005	2006	2007	2008	2009	2010
chain index for revenue	0.972	1.117	0.958	1.012	1.159	0.968
chain index for costs	1.005	1.139	1.010	1.048	1.080	1.046
Specification	**Years**					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
chain index for revenue	1.059	0.957	1.001	0.929	0.949	0.856
chain index for costs	1.030	0.971	0.982	1.050	0.942	0.878

Source: own study.

Sales revenue in Kompania Węglowa SA grew on a year-to-year basis solely in 2008 and 2011[*]. In Katowicki Holding Węglowy SA, the growth periods are slightly more numerous and they cover the following years: 2006, 2008, 2009, 2011 and 2013. The increase in the sales revenue in 2008–2013 in both companies results primarily from the increased hard coal price in that period (Fig. 5).

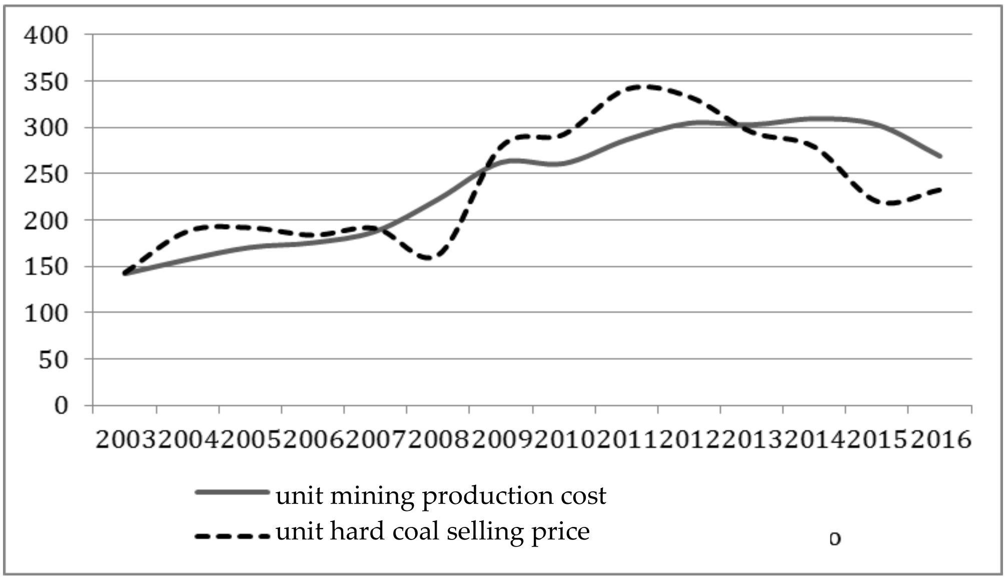

Figure 5. The unit selling price and unit mining production cost in years 2003–2016 [in PLN/t]

Source: own compilation on the basis of data from the Ministry of Economy.

[*] Years 2015–2016 are when Kompania Węglowa SA was liquidated. High dynamics index in 2016 results from practical termination of operations by the company in 2015. The value of sales revenue in 2016 refers to Polska Grupa Górnicza.

According to Figure 5, it can be seen explicitly that in years 2008–2012 the coal price exceeded the unit mining production cost, thanks to which the analysed companies were able to achieve good financial results and positive economic efficiency.

For the unit production costs, it is possible to notice high fluctuations of their level and a more numerous group of growth periods. In Kompania Węglowa SA the unit production cost grows in 2008, 2009, 2011 and 2013. For Katowicki Holding Węglowy SA, the costs grow continuously from 2005 to 2011, and also in 2013. This results from two key circumstances. The first of them is the increase in the remuneration level (Bąk and Michalak, 2018), being more than 50% of the total costs in the Polish hard coal mining, in relation to the pressure from trade unions and the requirements of mining teams. The other is a very high overhead cost level, reaching 80% which, given decreasing output, exerts an adverse influence on the unit mining production cost (Vaněk et al., 2017).

The slump of hard coal prices in 2013, in connection with the growing unit costs, contributes to the end of the boom in the Polish coal mining. The efficiency fall is so serious that the losses absorb equity which is negative in both companies in 2013–2014, and its absolute value grows. Consequently, both companies lose their liquidity and are on the verge of bankruptcy (Wolniak and Skotnicka-Zasadzień, 2012).

6.3. Course of remedial restructuring in 2016–2017

In connection with the bankruptcy of two largest mining companies and, consequently, the possible loss of energy security by Poland, a decision was made to carry out deep restructuring of both companies. The first stage was the audit in all mines belonging to KW SA and KHW SA. Its objective was to take stock of all assets and record the results of each of them to separate the efficient and inefficient plants. What is more, a decision was made to sell some non-productive assets to obtain some funds to complement the capitals. Also, buyers were found for some mines operating within the mine structures, which were transferred to Węglokoks SA or Tauron Wydobycie, depending on the excavated coal type (power or coke coal).

The second restructuring stage was the liquidation of mines which were inefficient due to excessive unit production costs, deposit recovery or high level of natural hazards. Such plants were transferred to Spółka Restrukturyzacji Kopalń SA which manages the assets and personnel of the liquidated mines by 2018 or 2012. The funds for the liquidation are obtained from the state budget, according to the European regulation, assuming governmental donations for mining plants solely when they are liquidated. The workers from the liquidated mines were offered a chance to use the severance pays and social protection or opt for an early retirement. Some of them were employed in the operating mines.

The third stage of remedial restructuring was the creation of a new mining company from the mines left in Kompania Węglowa SA and Katowicki Holding Węglowy SA, called Polska Grupa Górnicza (PGG). The structure of that company contains solely mines having a long-term operating perspective and likely to achieve positive economic efficiency, meaning the ones which excavate good quality coal for a low unit cost. The said consolidation was to enable PGG to operate in market economy conditions, without any financial support from the state, in accordance with the applicable European Union restrictions, assuming complete competitive advantage of the hard coal mining (Bijańska and Wodarski, 2017).

Moreover, to assure a market for the existing hard coal companies, Polska Grupa Górnicza was merged with the power sector and is supervised by 2 power companies. This was the fourth, and last, currently, remedial restructuring stage in Polish coal mining in years 2016–2017. It is worth adding here, that in 2017 the newly-created group managed to improve profitability significantly, although it has not been positive yet.

6.4. Conclusions

This article presents remedial restructuring as a way to extend the final stage in the Polish hard coal mining sector. In 2013–2014, due to the decrease of hard coal prices on the global and Polish market and the increase in unit production costs in Polish mining companies, the sector witnessed the most serious crisis in history. As a result of that crisis, 2 largest mining companies faced bankruptcy. To prevent their liquidation and energy security loss of Poland, it was decided to carry out a deep restructuring of the sector, covering 4 following stages: audit of the existing mines and mining companies, liquidation of inefficient mines, amalgamation of the remaining companies in Polska Grupa Górnicza, and consolidation of the newly-created company with the power sector.

The introduced changes made it possible to extend the final stage of the studied companies. In 2017, the efficiency of the newly-created group grew thanks to removing any mines with insufficient resources, excessive production costs and excessive natural hazard level. However, to ensure further effective operations of the Group, it is necessary to ensure cost-related discipline, consistent human resources management and effective dialogue with the community.

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References

Bąk, P., Michalak, A., (2018). The problem of managers' remuneration in state-owned enterprises in the context of corporate governance. *Gospodarka Surowcami Mineralnym = Mineral Resources Policy*, 34(1), 155-174.

Bijańska, J., Wodarski, K., (2017). Defining a strategy of coal enterprises in crisis situation. [in:] 4th BE-ci. International Conference on Business & Economics 2017, 05-07 June, 2017, Bekirogullari, Z., Minas, M.Y., Thambusamy, R. X. (Eds.), Future Academy: Brno, 91-105 doi: 10.15405/epms.2017.06.10

Dubiński, J., Turek, M. (2009). Wybrane aspekty zmian restrukturyzacyjnych w polskim górnictwie węgla kamiennego (w latach 1990-2008). *Prace Naukowe GIG, Górnictwo*, 2, 5-19.

Gumiński, A. (2014). Wyzwania dla zarządzania zasobami ludzkimi w polskim górnictwie węgla kamiennego. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie*, 69, 53-62.

Hąbek P., Wolniak, R. (2016). Factors influencing the development of CSR reporting practices: experts' versus preparers' points of view. *Engineering Economy*, 26(5), 560-570.

Karbownik, A., Turek, M. (2011). Zmiany w górnictwie węgla kamiennego - geneza, przebieg, efekty. *Przegląd Górniczy*, 67(7/8), 11-18.

Korski, J., Tobór–Osadnik, K., Wyganowska M., (2016). Reasons of problems of the polish hard coal mining in connection with restructuring changes in the period 1988–2014. *Resources Policy*, 48, 25-31.

Manowska, A., Tobór Osadnik, K., Wyganowska, M. (2017). Economic and social aspects of restructuring Polish coal mining: Focusing on Poland and the EU. *Resources Policy*, 52, 192 - 200.

Nawrocki, T., Jonek-Kowalska, I., (2016). Assessing operational risk in coal mining enterprises - internal, industrial and international perspective. *Resources Policy*, 48, 50-67.

Turek, M., Michalak, A. (2011). New performance funding models as the way of finance management improvement in mining enterprises. *Equilibrium*, 6(2), 77-90.

Vaněk, M., Bora, P., Maruszewska, E. M., Kašparková, A. (2017). Benchmarking of mining companies extracting hard coal in the Upper Silesian Coal Basin. *Resources Policy*, 53, 378-383.

Wolniak, R., Skotnicka-Zasadzień, B. (2012). The concept of study of Servqual method's gaps. *Quality and Quantity*, 4(46), 1239-1247.

PART II

Improvement of productivity in extractive industries with the use of organizational and technological methods

Chapter 7

CONSOLIDATION IN THE HARD COAL MINING SECTOR: CASE STUDY

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Abstract

This paper intends to present the major organisational changes which were carried out in the hard coal mining sector in Poland between 1990 and 2018. The authors of the paper indicate that in compliance with the changes in market rules and progressing globalisation processes, the organisational change in the form of consolidation has become a fixed part of the mining sector. In the course of the years, mergers of mines were each time aimed at improving profitability and offered a chance for preserving the highest number of operating mines. The authors, indicating the historical background related to the changes in the entire sector, drew special attention to Polska Grupa Górnicza, established recently. The premises contained in the paper and pertaining to the consolidation carried out in the case of PGG, which united the resources of Kompania Węglowa S.A. and Katowicki Holding Węglowy S.A., offer a chance of improvement for the operation of the mining sector in Poland.

Keywords: consolidation, mining companies, organisational changes.

7.1.Introduction

Consolidation, restructuring and globalisation of companies are terms which have been accompanying the Polish mining sector since the system changes initiated in the 1990s. Since 1990 numerous changes in the organisation of companies and modes of conducting mining work or determining the production volume have been carried out in the hard coal mining sector in Poland. The hard coal mining sector still necessitates reforms, but changes are being made in it, including consolidation, organisational restructuring, organisation of employment and changes in the production volume. This article contains a historical outline of changes that took place in the organisation of coal companies in Poland between 1990 and 2018. Furthermore, emphasising the processes of globalisation and the necessary consolidation of companies operating as part of a single industry branch, it presents current changes that occur in the State Treasury companies, until recently Katowicki Holding Węglowy S.A. (KHW S.A.) and Kompania Węglowa S.A.(KW S.A.) and at the present moment Polska Grupa Górnicza S.A. (PGG S.A.).

7.2. Organisational restructuring: consolidation activities and globalisation

In relation to numerous organisational changes which took place in Poland between 1990 and 2018, it has to be emphasised that the mining industry is subjected to numerous reorganisation activities (*Informacja o funkcjonowaniu górnictwa węgla kamiennego*, 2017; *Program dla sektora górnictwa węgla kamiennego w Polsce …*, 2018). For the society, the most significant process is mine merging. These activities have the nature of consolidation and are the result of commonplace globalisation. The two terms have a very significant meaning in the light of changes that occur in the mining sector. The premises for consolidation and motivators of globalisation constitute the direction and the basis of changes which not only have to be defined, but also implemented. The first type of consolidation which should be mentioned in the case of mining companies is a tight consolidation. Such consolidation refers to uniting resources on a broad scale. The uniting companies merge a significant portion or all of their resources. Merging of resources is simultaneously related to joint fulfilment of objectives and focused on long-term cooperation of the consolidated entities (Jonek-Kowalska and Turek, 2010). Furthermore, the uniting of entities in the form of consolidation may be viewed on two levels: horizontal and vertical and their combinations. Vertical integration is characterised by cooperation of companies as part of implementation of various stages of economic activities. In the case of this type of consolidation, it is possible to indicate production and distribution or supply and production. The core of consolidation is the stage of the production chain. The second type of consolidation, namely horizontal consolidation, refers to the consolidation of the same stage of operation of companies. In this manner, the companies narrow down their cooperation to a specific area. The combination of horizontal and vertical consolidation offers greater possibilities of uniting elements from both areas, resulting in the merger of both complementary and substitute resources (Turek, 2017). It is also necessary to mention consolidation in the aspect of merging mining companies with energy companies, i.e. merger of supplier and buyer into one economic entity.

Globalisation is an impulse for consolidation activities and background of operation of every economic entity. Globalisation is a set of processes of multi-dimensional nature; it integrates entities on an international scale with respect to social and economic aspects (Jonek-Kowalska, 2018). It is influenced by a number of factors; in the economic area, it is strongly related to the scientific and technical evolution (Bąk et al., 2016). Along with technological progress, a global economy tied with specific industry markets is being formed (Cynarski, 2003). Globalisation determines changes in company management. The process of changes in company management methods is made on several levels (Gierszewska and Wawrzyniak, 2001):

- structural (virtualisation);
- labour systems (creation of flexible systems);
- competence (new knowledge creation);
- organisational technology and procedures (e-business introduction);
- values (emphasis on corporate social responsibility).

The basis for development of global economy in the era of globalisation are smart, self-learning, self-regulating, virtual and agile companies, as well as network companies relying on technological, functional, organic and geographical relations (Hejduk, 2006). Development of companies in the present-day conditions is primarily directed at increase of entrepreneurship, innovation and competitiveness. The possibility of development of companies which react to changes occurring in the environment relies on the progress of science advancing in the world of economy, based on knowledge and techniques that enable knowledge management. Intellectual capital has primary importance for modern companies; it encompasses highly-qualified employees who possess knowledge and skills to use it for designing modern production organisation systems and service provision systems as well as modes and techniques of management that allow for complying with constantly growing customer needs.

7.3. Analysis of organisational changes implemented in the hard coal mining sector in Poland between 1993 and 2016

The process of merging companies, privatisation, reduction of employment and restrictions imposed on production volume constitute numerous activities implemented in the hard coal sector in Poland since the beginning of the 1990s. The carried out organisational change that refers to the Polish companies from the mining sector is the consolidation of the sector, along with liquidation of unprofitable mines. Sector consolidation took place both in the horizontal and the vertical dimension on account of mergers of independent mines into plants with two mining areas and combining various coal companies, as well as expanding such combinations onto product recipients - consolidation with energy companies.

The entire period of organisational changes forming a part of repair restructuring resulted in consolidation of the so-called "mining areas." The original purpose of consolidation of mines was the necessity of covering losses of less efficient companies by companies that fared much better. In line with the principle "the stronger pushes the weaker", attempts were made at levelling debt in the state-owned hard coal mining sector.

The mining sector, characterised by unprofessional management and, at the present moment, also weighed down by numerous restrictions on the part of EU member states, has been restructured for a number of years via organisational changes. Mines were forced to change the mode of operation from command economy to free-market economy. In contrast to the beginning of the 1990s, the operation of coal companies no longer focuses on producing the largest quantity of coal, but on targeted production, which may be sold as quickly as possible at the highest price.

When analysing the very beginning of system changes in Poland between 1990 and 1997, the first organisational changes were made as part of the mining sector restructuring programme (Szlązak, 2004a; Szlązak 2004b). These changes were aimed at making the mines independent; they were separated from the structure of Wspólnota Węgla Kamiennego (Hard Coal Community) and received full autonomy (Magda, 2000). The objective of undertaken activities was separation of mines which had the capacity of efficient operation in the free-market economy and those that did not have such capacity. Activities forming a part of such organisational change included liquidation of unprofitable mines on account of excessive employment and significant non-production property. In March 1993, the Economic Committee of the Council of Ministers adopted the "Restructuring Programme of Hard Coal Mining Sector in Poland: Implementation of Stage I Within the Framework of the State's Financial Possibilities" prepared by the Ministry of Industry and Trade, on the basis of which a new organisational structure of the hard coal mining sector was formed (Podobińska-Staniec, 2017). As a result of these transformations, the following companies were established:

- Nadwiślańska Coal Company,
- Bytomska Coal Company,

- Rybnicka Coal Company,
- Gliwicka Coal Company,
- Rudzka Coal Company,
- Katowicki Holding,
- Jastrzębska Coal Company.

The next organisational change in the Polish mining sector was initiated on 1 April 1993, when JSW S.A. officially started to operate as one-person state treasury company. It consisted of the following mines: "Borynia", "Zofiówka", 'Jastrzębie", "Moszczenica", "Pniówek" in Jastrzębie Zdrój and "Krupiński" in Suszec and "Morcinek" in Kaczyce. The company also included: Municipal Management Company in Jastrzębie Zdrój, Mine De-Methanisation Plant in Jastrzębie Zdrój, "Moszczenica" Co-generation Plant in Jastrzębie Zdrój and "Zofiówka" Co-generation Plant in Jastrzębie Zdrój. On 1 July, Katowicki Holding Węglowy S.A. was also established, encompassing 11 mines. Overall, 61 mines were consolidated into coal companies around the country. Out of the remaining ones, which remained outside the structure of coal companies, seven were liquidated (Wałbrzych, Victoria, Thorez, Saturn, Żory, Nowa Ruda, Sosnowiec), and three still formed independent mines; these were Bogdanka S.A. Hard Coal Mine, Jan Kanty S.A. Hard Coal Mine, Porąbka-Klimontów S.A. Hard Coal Mine (Szlązak, 2004a; Szlązak 2004b).

The first stage of the restructuring programme of the Polish mining sector was continued as part the second stage, between 1994 and 1995. The aim of the programme was to improve profitability by increasing the labour efficiency, implementing tasks to mitigate the social effects of restructuring and pro-environmental investments. The common elements between the present-day transformation and the one pursued during the discussed second stage include conclusion of long-term agreements with strategic recipients, modernisation of technical equipment, introduction of financial incentive schemes for employees and increase in the role of the quality of offered coal.

The subsequent stage of organisational changes took place between 2002 and 2006. In January 2007, 33 mines operated in Poland, grouped into the following mining entities (Fornalczyk et al., 2008):

- Kompania Węglowa S. A.: 17 mines (4 mining centres were established);

- Katowicka Grupa Kapitałowa, which included Katowicki Holding Węglowy S. A., encompassing 5 mines and one limited liability mine where 100% shares were owned by KHW S.A.;
- Jastrzębska Spółka Węglowa S. A.: 5 mines;
- Południowy Koncern Węglowy S.A. - one mine with two mining areas (50.45% shares held by KW S.A., 49.55% of shares held by PKE S.A.), "Budryk" S.A. Hard Coal Mine;
- Lubelski Węgiel "Bogdanka" S. A. (90% of shares held by the State Treasury);
- Siltech Sp. z o.o. (100% of shares held by a private owner).

When analysing subsequent changes in the Polish hard coal mining sector, it is necessary to take the privatisation processes into account. LW Bogdanka S.A. made its' début on the stock exchange in June 2009 and Jastrzębska Spółka Węglowa S.A., in July 2011; in the same year, this company also completed its process of consolidation into a coal and coke group. The year 2013 was also an important moment of transformations: TAURON Wydobycie S.A. purchased 47.5% shares of Południowy Koncern Węglowy S.A. from Kompania Węglowa, becoming its' sole owner. Organisational changes also took place in companies responsible for the conducted restructuring process. In April 2009, Spółka Restrukturyzacji Kopalń S. A. took over Bytomska Spółka Restrukturyzacji Kopalń Sp. z o.o., and in 2014 purchased 100% shares in Kazimierz-Juliusz Sp. z o.o. Hard Coal Mine from Katowicki Holding Węglowy S. A. Knurów-Szczygłowice Coal Mine was separated from the structure of Kompania Węglowa S.A. and joined JSW S.A. in August 2014. In October 2015, LW Bogdanka became a part of Grupa Enea S.A., which has been holding 66% of Bogdanka's shares as of 26.10.2015. The group created in this manner became a modern fuel and energy concern (Podobińska-Staniec, 2017).

The core of transformations of the Polish coal mining sector in the area of consolidation took place on account of premises which have always remained the same, namely merging less profitable mines with efficient mines. The core of such activity is to be searched for both in the development and improvement of profitability of mining companies. It cannot be forgotten that apart from positive aspects, consolidation processes have been related to the processes of mine liquidation, significant reduction of extraction and a clear cutback in employment.

7.4.Establishment of PGG as the continuation of mining sector consolidation in Poland

The operation programme of hard coal sector in Poland between 2007 and 2016 assumed more changes in the organisation of the sector and further transformations. A significant change occurred in one of the largest coal companies in Poland, Kompania Węglowa S.A. (KW S.A.). In 2011, the company's management board decided to liquidate the middle organisational level (extraction centres) as of 1 January 2012, thereby increasing the scope of independence of the mines. As part of further activities between April and May 2015, KW S.A. handed over free of charge three mines (Makoszowy, Brzeszcze and Centrum) to Spółka Restrukturyzacji Kopalń S.A. (SRK S.A.). Subsequently, in May the same year (2015), Bobrek and Piekary mines were sold from KW S.A. to Węglokoks Kraj Sp. z o.o. In April 2016, KW S.A. also handed-over to SRK S.A. the mining area of Rydułtowy-Anna Mine. The end of the organisational transformations of Kompania Węglowa S.A. on 29 April 2016 was marked by sale to the newly-established Polska Grupa Górnicza Sp. z o.o. of 11 mines and 4 plants, including (www.pgg.pl):

- Bielszowice Hard Coal Mine;
- Pokój Hard Coal Mine;
- Halemba-Wirek Hard Coal Mine;
- Bolesław Śmiały Hard Coal Mine;
- Piast Hard Coal Mine;
- Ziemowit Hard Coal Mine;
- Sośnica Hard Coal Mine;
- Chwałowice Hard Coal Mine;
- Marcel Hard Coal Mine;
- Jankowice Hard Coal Mine;
- Rydułtowy Hard Coal Mine,
- Co-generation plants,
- Mining Investment Work Company;
- IT and Telecommunications Company;
- Repair and Production Company.

The second important entity that belonged to the State Treasury on the hard coal market in Poland was Katowicki Holding Węglowy S.A. which, in June 2015, pursuant to the provisions on the functioning of the hard coal mining sector of 07.09.2007, handed over free of charge to SRK S.A. the Mysłowice mining area separated from Mysłowice Hard Coal Mine - Wesoła and Boże Dary mining area separated from Murcki-Staszic Hard Coal Mine. The year 2015 was permanently marked in the history of the Polish mining on account of establishment of Polska Grupa Górnicza Sp. z o.o. (PGG) on 1 January 2015. The Group was established pursuant to the agreement of the governmental side, the International Protest and Strike Committee, company trade unions operating in Kompania Węglowa S.A. and Zakłady Spółki Restrukturyzacji Kopalń S.A., Kompania Węglowa S.A. and Węglokoks S.A. On 29 April, 2016, PGG purchased Kompania Węglowa S.A. The organisational structure of the newly-established group as of 1 July 2016 consisted of three complex mines:

- Ruda Hard Coal Mine (mines Bielszowice, Halemba-Wirek and Pokój);
- ROW Hard Coal Mine (mines Chwalowice, Jankowice, Marcel and Rydułtowy);
- Piast-Ziemowit Hard Coal Mine (mines Piast and Ziemowit);
- and two independent mines: Bolesław Śmiały Hard Coal Mine and Sośnica Hard Coal Mine.

The shareholding structure of PGG as of 31.12.2016 was [pds]: 1 share out of 5,000,500 shares, i.e. 0.00002%, held by the State Treasury, the remaining shares held by: Węglokoks S.A., Fundusz Inwestycyjny Polskich Przedsiębiorstw, Fundusz Inwestycyjny Zamkniętych Aktywów Niepublicznych, Towarzystwo Finansowe Silesia Sp. z o. o., PGE Górnictwo
i Energetyka Konwencjonalna S.A., Energa Kogeneracja Sp. z o.o. and PGNiG Termika S.A.

The formation of Polska Grupa Górnicza was continued by execution of an agreement on 31.3.2017, pursuant to which as of 1 April 2017, PGG Sp. z o.o. took over the mines and the employees of Katowicki Holding Węglowy S.A. Thus, the holding became another mining area of PGG Sp. z o.o. The purpose of the merger was to improve the potential of the largest European coal company and to offer assistance with respect to the difficult situation of the Holding, where the debt exceeded PLN 2.5 million (www.pgg.pl). As a result of the merger, approx. 12,500 employees were transferred to PGG from KHW (http://gornictwo.wnp.pl). The management board of PGG noted the possibility of making use of the synergy effect from combining the potentials of incorporated companies in the form of:

- more efficient use of the production property - possibility of allocating machines and devices among mines and mining areas, depending on the needs;
- possibility of allocating employees among mining areas - full use of the mine long-walls;
- optimisation of the technological process of enriching and sorting coal in mines;
- creation of a better and fuller offer that allows for reaching new recipients;
- reduction in administrative costs (www.pgg.pl).

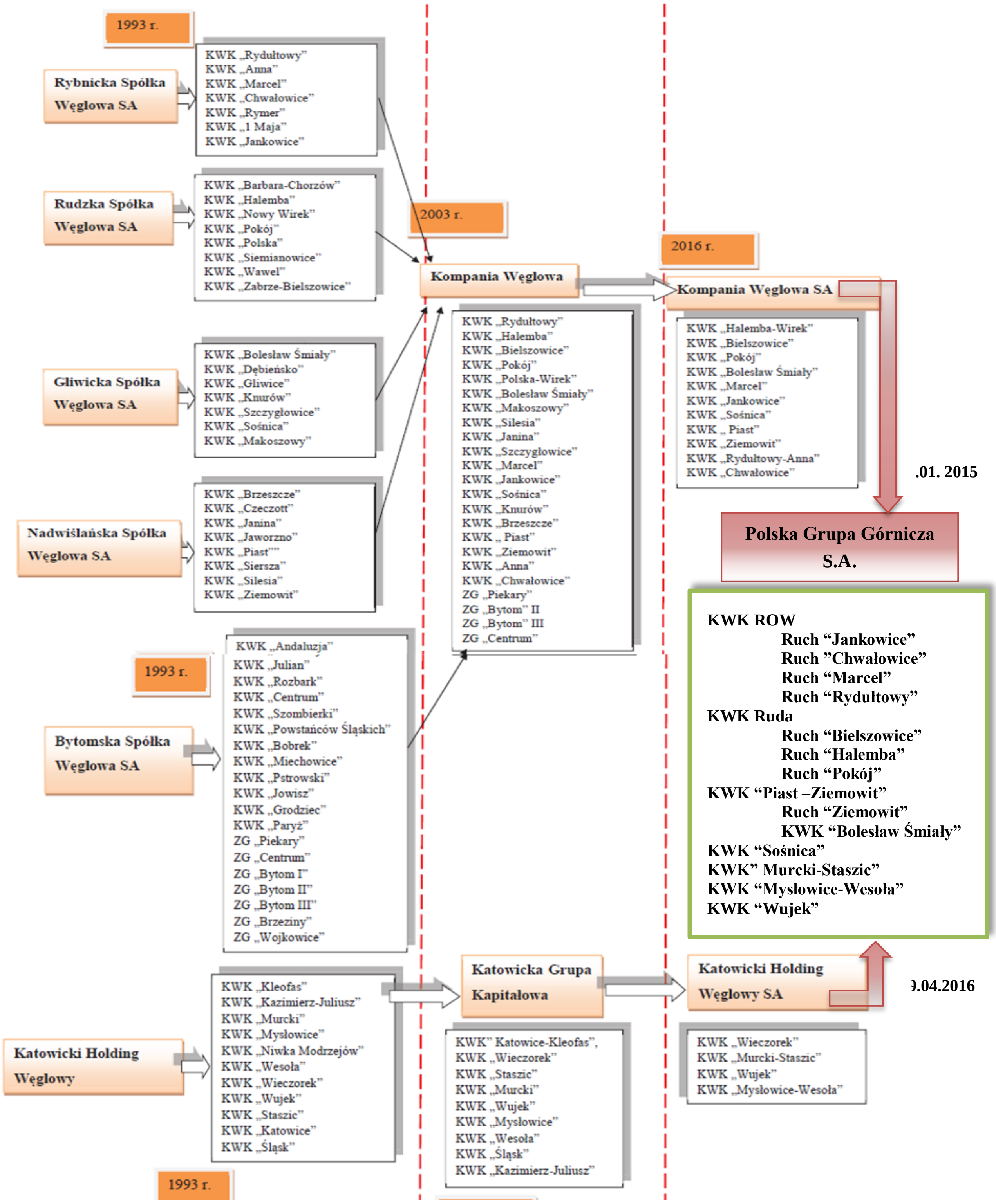
The effects of synergy also resulted from the possibility of efficient cost reduction, which is simultaneously the only way out of a crisis situation. Coal offered by the Polish mines, as compared to imported coal, is characterised by high price related to difficult conditions of ore location. However, making use of the scale effect, it is possible to reduce production costs, and thus make the companies more competitive.

The huge change that occurred as a result of formation of PGG is also a change in the area of employment. At the beginning of operation of PGG, it had 31,429 employees and still operating KHW had 13,036 employees - which in total gave the number of 44,465 employees in both companies, at that time operating separately. Right before the fusion of both companies, i.e. at the end of March 2017, the number dropped. As a result of take-over of KHW by PGG, employment in PGG amounted to 43,378 persons, out of which 30,558 persons were employed in PGG and 12,820 were transferred from KHW (www.pgg.pl). The last available data refer to the beginning of 2018, when the level of employment in the largest coal company in Poland amounted to 43,351 persons (http://nettg.pl/news). In spite of the noticeable downward tendency in the number of employees, PGG commenced a dialogue with local governments pertaining to the education of the young generation of miners who, after completing a technical mining school, would find employment in the company.

Subsequent activities undertaken in the area of organisation refer to the transformation of Polska Grupa Górnicza Sp. z o.o. into a joint stock company - on 29 December 2017 (http://nettg.pl/news) and sale of Wieczorek Mine to SRK S.A.

The picture of organisational transformations pertaining to changes in the mines which currently form a part of PGG S.A. is presented in Figure 1.

Delving deeper into the analysis of organisational changes and consolidation, it is necessary to emphasise the significance of consolidation activities in reference to mines as production entities and entities from the heat and energy sector as recipients of the product. This type of cooperation, oriented at targeted production (specific quality and quantity of coal), is an opportunity to minimise losses. Long-term agreements with recipients offer a possibility of prospective cost planning and allow for thinking about the necessity of modernisation in the coal mining industry, which is imposed by the EU, as well as planning investments and modernisation work. When implementing this type of consolidation, the benefits are common for both sides of the agreement.



Legend: KWK- Hard Coal Mine; ZG –Mining Plant

Figure 1. Organisational changes in the hard coal mining sector between 1993 and 2018

Source: own study based on (Podobińska-Staniec, 2017) and (www.pgg.pl).

It is also worth emphasising that the consolidation of mines of Katowicki Holding Węglowy S.A. and Polska Grupa Górnicza Sp. z o.o. resulted in the fact that companies that operated on the same market ceased to compete with one another. As a single economic entity, PGG has a positive impact on the formation of coal prices. Furthermore the cooperation with domestic coal recipients who guarantee sale of coal, also guarantee a specific level of profits. An additional important factor to the advantage of domestic mines is the certainty of supplies and their volume (http://nettg.pl/news/148508/rynek-wegla-dobra ...). Summing up, the merger of two important "players" in the mining sector may have a favourable effect on the condition of the discussed sector.

7.5. Conclusions

Polska Grupa Górnicza S.A. was set up in order to satisfy the needs of the Polish hard coal consumer, sealing the market and ensuring competitiveness and profitability of Polish mining companies. The establishment of PGG was a continuation of the restructuring process in the discussed sector. The objective set before the management board of PGG is to create a company which will offer hard coal at competitive prices, which is going to satisfy the market of internal clients. On the other hand, it is good to emphasise the fact of creation of a project of integrated mines, which simplifies the management system of mining units and may lead to a decrease in the number of technical supervision in the production process. Changes that are currently introduced in the largest hard coal mining company in Europe have their source in a number of reforms implemented in Poland in the course of the last twenty-eight years. Every government had its own idea on how to lead the mines to profitability, how to make them competitive on the free market and how to satisfy the needs of consumers with greatest possible efficiency of mine operation. Furthermore, the change of employment is the best way to illustrate the scale of organisational changes in the sector. Reaching to data published in the IBS report pertaining to the transformation of the Polish coal sector after 1990, it may be noted that in 1990, 388,000 persons were employed in the mining sector and in 2015, the employment dropped to 98,000. In line with the report, employment has continued to drop since 2015; at the end of 2017, 82,717 people were employed in the industry, out of whom 63,721 worked underground (www.ibs.org.pl). Marked with numerous organisational changes, changes in the number of mines and numerous manners of work organisation, the Polish branch of the mining industry has experienced another historic change. The consolidation of KHW S.A. and KW S.A. into one entity, namely PGG S.A., offers another chance for improved operation of the Polish mines on the global market. Following the expectations of clients and being aware of the reality of the present-day economy, the management of PGG faces a grand task: maintaining the largest possible number of work places and accomplishing satisfactory results.

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References

Bąk, P., Sukiennik, M., Kowal, B. (2016). Kultura korporacyjna w aspekcie procesów zarządczych w polskich przedsiębiorstwach wydobywczych. *Inżynieria Mineralna,* 17 (2), 135 – 144.

Cynarski, W. J. (2003). Globalizacja a spotkanie kultur. Wydawnictwo Uniwersytetu Rzeszowskiego: Rzeszów.

Dubiński, J., Turek, M. (2014). Chances and threats of hard coal mining development in Poland - the results of experts research. *Archives of Mining Sciences,* 59 (2), 395 - 411.

Fornalczyk, A., Choroszczak, J., Mikulec, M., (2008). Restrukturyzacja górnictwa węgla kamiennego. Programy, bariery, efektywność, pomoc publiczna. Wydawnictwo Poltext: Warszawa.

Gierszewska, G., Wawrzyniak, B. (2001). Globalizacja. Wyzwania dla zarządzania strategicznego. Wydawnictwo Poltext: Warszawa.

Hejduk, I. K., (2006). Główne uwarunkowania rozwoju nauk zarządzania w Polsce. *Ekonomika i Organizacja Przedsiębiorstwa,* 3, 34-41.

Informacja o funkcjonowaniu górnictwa węgla kamiennego we wrześniu oraz w okresie styczeń-wrzesień 2016. Ministerstwo Energii: Warszawa.

Jonek- Kowalska, I. (2015). Challenges For Long-Term Industry Restructuring In The Upper Silesian Coal Basin: What Has Polish Coal Mining Achieved And Failed From A Twenty-Year Perspective? *Resources Policy* , 44, 135-149.

Jonek-Kowalska I. (2018a). How do turbulent sectoral conditions sector influence the value of coal mining enterprises? Perspectives from Central-Eastern Europe coal mining industry. *Resources Policy,* 55, 103-118.

Jonek-Kowalska, I. (2018b). Method for Assessing the Development of Underground Hard Coal Mines on a Regional Basis: The Concept of Measurement and Research Result. *Energies*, 11 (6), Article Number: 1370.

Jonek-Kowalska, I., Turek, M. (2010). Koncentracja przedsiębiorstw przemysłowych. Przyczyny-przebieg-efekty. Wydawnictwo Politechniki Śląskiej: Gliwice.

Magda, R. (2000). Selected aspects of restructuring hard coal mining sector. [in:] *9th International Symposium on Mine Planning and Equipment Selection*, 449-452.

Podobińska-Staniec, M. (2017). Management of Intellectual Capital in the Process of Restructuring a Coal Mine Company. Kraków.

Program dla sektora górnictwa węgla kamiennego w Polsce (2018). Ministerstwo Energii; Warszawa.

Szlązak, J., (2004a). Reformowanie polskiego górnictwa węgla kamiennego w latach 1990–2002, zamierzenia i efekty. [in:] Kicki, J., (Ed.) Materiały Szkoły Eksploatacji Podziemnej 2004: forum dyskusyjne: jak wykorzystać szanse poprawy kondycji ekonomiczno-finansowej górnictwa węgla kamiennego? Polska Akademia Nauk. Instytut Gospodarki Surowcami Mineralnymi i Energią, Akademia Górniczo-Hutnicza. Katedra Górnictwa Podziemnego. IGSMiE PAN: Kraków, 107–128.

Szlązak J., (2004b). Restrukturyzacja górnictwa węgla kamiennego w Polsce w latach 1990–2002: analiza skuteczności realizowanych programów Wydawnictwo Nauka – Technika: Kraków.

Turek, M., (2017). Uwarunkowania procesów konsolidacyjnych w polskich przedsiębiorstwach górniczych. *Zeszyty Naukowe Politechniki Śląskiej seria: Organizacja i Zarządzanie*, 101, 483-503.

http://gornictwo.wnp.pl/gornicze-gaszenie-pozarow-czyli-od-kw-do-pgg-z-khw,295405_1_0_0.html.

http://nettg.pl/news/147972/pgg-spolka-zatrudnila-ponad-3-3-tys-nowych-pracownikow.

http://nettg.pl/news/148508/rynek-wegla-dobra-kondycja-spolek-wplywa-na-umocnienie-cen.

www.ibs.org.pl.

www.pgg.pl.

Chapter 8

PARALLAX EFFECT IN RESEARCH ON COMMUNITY OF PRACTICE

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Abstract

At the turn of the 21st century the concept of communities of practice quickly gained popularity as a tool for creating and distributing knowledge in organizations. In recent years, however, we have noticed a decline in interest in this concept from both science and practice. It is suggested that the main reason for this is the concept still lacks a widely accepted definition and can be interpreted in many different ways. Consequently, the term community of practice can be sometimes problematic: everything is and at the same time is not a community of practice. The article presents a critical analysis of the most popular approaches to the concept of communities of practice.

Keywords: community of practice, legitimate peripheral participation, social learning theory, negotiation of meaning, reification, participation.

8.1. Introduction

In multiple scientific publications, in particular in those discussing social sciences, terminological chaos associated with the discussed issue is a subject of many complaints. Quite often, its main reason is not the complex and inter-disciplinary nature of the analyzed problem, but the generality and indistinct nature of the terms used to describe it. This can be seen in the literature on knowledge management that is a source of general yet universal theories and practical solutions that are supposed to be an antidote to the most ailing organizational problems. Their vague and indistinct nature fosters their free implementation and use. As a consequence, we are dealing with a parallax effect that is characterized by a lack of uniform approach to the nature and character of a given phenomenon. Too much space for interpretation is the source of multiple research perspectives as well as inconsistency in terminology that significantly hinders the exploration of a given issue and makes it impossible to establish a consistent theory.

An example of such a situation is the community of practice. This term comes from the situated learning theory developed by J. Lave and E. Wenger (1991). At the turn of the 21st century, the concept of communities of practice quickly gained popularity as a tool for creating and distributing knowledge in organizations. In no time it became a central subject of conferences, workshops and seminars devoted to knowledge management (Zboralski, 2007). In recent years one can notice a decline in interest in this concept from the side of science and practice. It is suggested that the main reason for this is the fact that the concept still lacks a widely accepted definition and can be interpreted in many different ways. Consequently, the term community of practice can be sometimes problematic: everything is and at the same time is not a community of practice (Romhardt, 2002). This results mostly from the ambiguity of the term "community" that can be interpreted from the point of view of numerous fields of study, for example sociology (Tönnies, 1887; Weber, 1914), social sciences (Rheingold, 1995) or management (Hagel and Armstrong, 1997). When adopting a certain research perspective, it results in an emphasis on different characteristics of communities, and – as a consequence – different criteria of their description, which in practice makes it impossible to develop a common typology of communities.

The aim of this article is the presentation and critical analysis of the most commonly used approaches to the community of practice on the basis of well-established works of J. Lave and E. Wenger (1991), J. Orr (1990), J.S. Brown and P. Duguid (1991) and E. Wenger (1998b). The paper presents main research perspectives that view the community of practice as a space for identity establishment, tool for knowledge management in the organization and as an environment of social learning.

8.2. Community of practice as identity establishing

The term community of practice comes from the situated learning theory developed by J. Lave and E. Wenger (1991). Lave and Wenger based their theory on case studies carried out in majority by third parties: tailors' communities from two ethnic groups in Liberia (West Africa) (Lave, 1988), midwives in Maya mountains in Mexico (Jordan, 1989), Alcoholics Anonymous (Cain, no data), butchers employed in markets in the USA (Marshall, 1972) and navigators in the US Navy (Hutchins, 1996). Their aim was to establish how learners coming from different cultures acquire their knowledge and competences: how they settle in the local culture and how the rituals and values of that culture are passed down (Bendkowski, 2012). The obtained results were supposed to reconstruct the western learning theories and theories on how the learning environment is shaped (Lave, 1993).

Lave and Wenger were able to establish that informal learning processes are directly linked with a specific situation and thus they constitute a social construction. Learning takes place by way of legitimate peripheral participation (LPP) that is about learning from masters (experts) and more experienced colleagues (apprentices) and moving towards the community center as new knowledge and competences are being acquired, which is linked with the increase of status and gradual change of identity: from peripheral membership to full membership in the community (Bendkowski, 2012). The communities where this apprentice mechanism in the master-apprentice-pupil system was functioning was defined as "communities of practice"; although in their work they never formally defined this term.

From among other similar social structures of communities of practice that are described and analyzed by Lave and Wenger the following may be distinguished: legitimate peripheral participation, learning understood as establishing professional identity and focus on practices. Despite the significant generality, the above model of communities of practice is still used especially in research on the forming of personnel of communities of practice (Campbell, 2009; Harris, Simons, and Carden, 2004).

Another fundamental work on the communities of practice is the ethnography of Xerox photocopy machine technicians penned by American sociologist Julien Orr (1990). It was prepared at the request of Xerox Palo Alto Research Center to optimize the training program in substantive and financial scope (North, Romhardt, and Probst, 2004). Orr's research proved that in the traditional description of the work position it is not possible to specify it to the fullest extent possible. The management of Xerox assumed that the technicians will be able to carry out their tasks independently, with the help of guidelines and procedures found in the repair manual. However, during observations of the day-to-day work of a group of technicians (Orr referred to them as "professional community" or "work community") it turned out that despite an extensive trainings program and comprehensive technical documentation they often had to face problems that they were unable to solve. To repair the device, the technicians were forced to skip the procedures and create own manners of repairing. For that purpose, they used their lunch breaks during which they could discuss their problems, exchange experience concerning the repairs and together think of new solutions for the failures. Orr called them "war stories". They served two objections: to provide a practical, contextual knowledge on particular photocopy machines and to establish a professional identity of a technician who will do anything to find a solution and repair a device despite limitations and missing information. Common context of activities made the "war stories" an effective tool for sharing private knowledge on the devices. To become a member of the community required not only the knowledge on how to repair a device but also the ability to pass this knowledge down in the form of a "war story" (Murillo, 2011).

When Orr was writing his ethnography, the term of community of practice was not wide-spread (Duguid, 2006). Therefore, Orr analyzed the work of photocopy machines technicians from the point of view of professional community (van Maanen, and Barley, 1984). Still, in the literature of the subject, Orr's work is considered the first ethnography of community of practice (Teigland, 2003; Zboralski, 2007).

8.3. Community of practice as knowledge management tool

The third fundamental work devoted to community of practice is an article of John S. Brown and Paul Duguid titled "Organizational Learning and Communities of Practice: Toward a Unified view of Working, Learning, and Innovation", where they defined community of practice as a strategic tool for the management of knowledge in the organization (1991). Brown and Duguid claimed that despite informal nature, the communities of practice are the key to effective learning at work and creation of innovative solution. As a result, they are an extremely crucial challenge for the managers, especially for managers of organizations based on knowledge. Thus, Brown and Duguid introduced the idea of community of practice into the organizational environment.

The theory of Brown and Duguid was founded in majority on Orr's work described above. The proposed model of community of practice was composed of three dimensions corresponding with the work of technicians: narrative, cooperation and social construction. It goes beyond the intuitive interpretation of community of practice proposed by Lave and Wenger. This may explain why the article of Brown and Duguid is treated by many researchers as the main source of knowledge on the community of practice (Murillo, 2011).

The narrative covers coming up with an exchange of "war stories" concerning repair of defined devices. The story of a broken machine was a convenient way for the technician to create a cause and effect map that makes it possible to solve the problem. The story turned out to be a better solution than the procedure found in the official instruction of repairs, as it was accompanied by a relevant context that influenced the operation of the device.

Cooperation refers to the spontaneous and informal organization of technicians. Its aim is cooperation, exchange of stories and mutual help in terms of analyzing the specific nature of particular devices. What is interesting is that the community of technicians was established even though the mother organization considered their work as independent activity and not as a group one (Murillo, 2011).

Social construction manifested itself in two dimensions. First of all, mutual interactions resulted in common understanding of the problem and thus brought about specific and contextual knowledge of the technicians on the particular devices. Second of all, by way of sharing "war stories", the technicians were establishing their identity and contributed to the development of resources of group knowledge of the community of practice (Bendkowski, 2012).

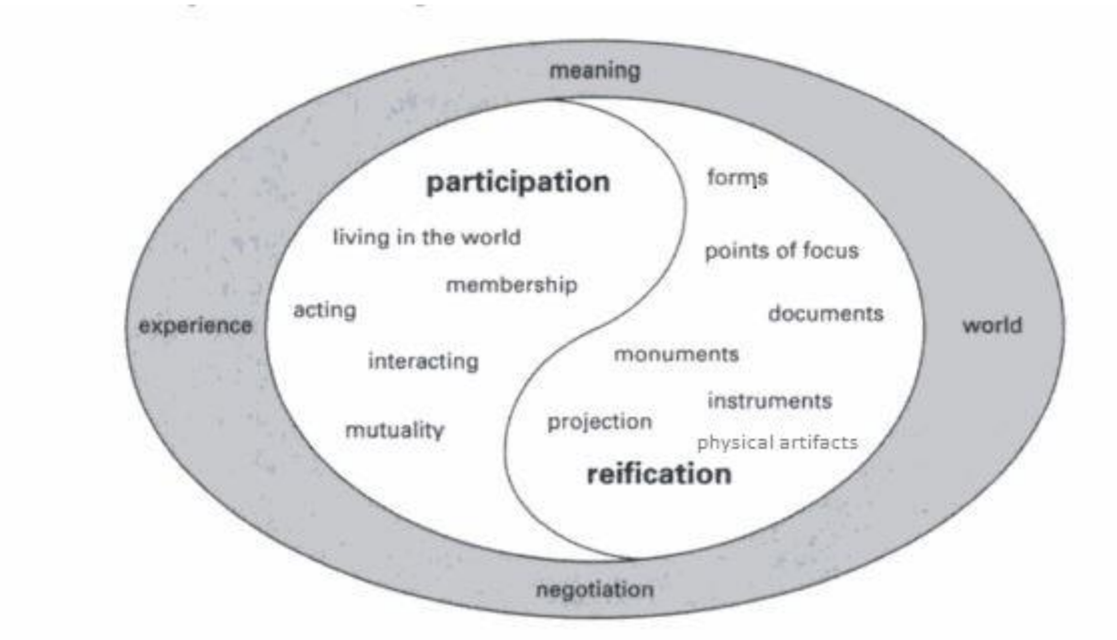

Figure 1. Negotiation of meaning: participation and reification

Adapted from: (Wenger, 1998).

To characterize the activities of the technicians understood as group learning and establishing of an identity of a member of a community functioning within the organizational environment, Brown and Duguid adapted the situated learning theory of Lave and Wenger. As a result, the cooperation model proposed by them is only slightly different from the community as understood by Lave and Wenger. The main difference is about the status of the members. Community of practice as understood by Lave and Wenger was based on the relation master-pupil, while Brown and Duguid argued that the members of communities of practice were equal. The second difference lies in the fact that

Brown and Duguid characterized community functioning within an organizational environment as a community that directly or indirectly implements the objectives of the organization. Thus, it functions in determined power system which significantly influences its functioning. In turn, community of practice as defined by Lave and Wenger was an autonomous being that functions primarily due to the needs of their members and not for the needs of an organization.

As opposed to Lave and Wenger, Brown and Duguid saw the possibility of communities' cooperation. This manifested itself, among others, in their approach to organizations as huge communities composed of smaller communities of practice used to implement superior organizational goals, in particular those associated with knowledge management. Over the next couple of years, many works were written on the communities of practice as a new organizational form and at the same time a key tool of learning and sharing knowledge within the organization (Brown, and Duguid, 1996; Brown, 1998).

As a result of the work of Brown and Duguid, two main research directions emerged in the research on the communities of practice: one treating the community of practice as autonomous organizational form and the other one as a tool of knowledge management. First direction focuses on the development of theory, describing the emerging and informal nature of communities of practice. The second research trend emphasized the business value of communities of practice and was directed to the identification, support and/or intentional establishment of strategic communities of practice as a knowledge management tool (Zboralski, 2007).

Communities of practice as environment of social learning: participation, reification and negotiation of meanings

In 1998, E. Wenger published his famous ethnography devoted to the insurance loss indemnification titled "Communities of Practice. Learning, Meaning and Identity". As opposed to the work written in cooperation with J. Lave in 1991, that focused on the process of establishing the identity of a community member, in this case in the center of Wenger's analysis was practice (activity). The new model of community of practice that was a development of the original intuitive understanding of the community of practice was based on field studies carried out in 1989-1990 in the medical claims processing center operated by one of the largest U.S. insurance companies. Till this day this monograph is the most detailed and exhaustive elaboration on communities of practice (Zhang, and

Watts, 2008). Wenger departs from the cognitive theories of learning, proposing the focus on the process of the negotiation of meaning that he concerns the ultimate learning goal. Focus on the negotiation of meaning along with the assumption that this process takes place within a community results in the fact that the social nature of a human becomes particularly important in the context of learning (Murillo, 2011).

Wenger defines negotiation of meaning as a process by which we experience the world and give a meaning to our practices (1998a). This process is the basis for the community of practice as the result of influence of two other processes known as participation and reification (see Fig. 1). Participation is the membership in the community and active participation in its activities. It is not the same as cooperation, but means deep engagement in the works of the community at all levels. In turn, reification is the process of shaping the experiences by creating objects that are the objectification of these experiences towards which the negotiation of meaning is used.

Figure 2. Model of social learning in community of practice

Adapted from: (Wenger, 1998).

Individual learning is about negotiation of new meanings and not about collecting new information or learning new skills (Wenger, 1998a). Negotiation of meaning takes place within the community of practice understood as a social group that was established to achieve goals considered by its members as important. At the same time, the community defines which members are professionals in the determined field. Learning is a process of social becoming, constant negotiation of identity created within a specific context of cooperation (or its lack) in the community and its activities (Wenger, 1998b).

Even though the concept of community plays a major role, for Wenger it is only a social environment that makes the group negotiation of meaning possible. The model of social learning covers four interconnected elements (see Figure 2) (Wenger, 1998b):

- meaning – the ability of individual and collective experiencing of the world and negotiation of meaning,
- practice – mutual engagement in the community activities,
- community – social environment established for a specific purpose (domain of practice) being a motivation for cooperation (participation),
- identity – feeling of belonging to a community, being its part.

Social learning takes place by negotiation of meanings with the use of four basic mechanisms (Wenger, 1998b);

1. meaning/learning as experience,
2. practice/learning as doing,
3. community/learning as belonging,
4. identity/learning as becoming.

Community of practice understood as an environment of social learning is determined by the following dimensions (Wenger, 1998b):

- mutual engagement – employees become members of a given community by engaging in the community practices. This mutual engagement unites the members of the community into one social structure,
- common domain of practice – field of interest around which the community is centered. It is based on mutual or shared understanding that is constantly being established and redefined by its members,
- shared repertoire of resources – a set of shared community resources that allows for greater engagement in the works of the community.

Presence of these three dimensions is a necessary prerequisite for the community of practice to exist. Wenger provides a list of factors that allow to identify the community of practice. They can be perceived as a manifestation of the main dimensions of the community of practice (see Tab. 2).

Wenger's model is a significant theoretical development of the intuitive model from 1991. Even though in his work he did not provide a clear definition of the community of practice, the model presented therein allows to limit the possibilities in terms of interpretation. Unfortunately, researches use the Wenger's model of 1998 in limited scope (Murillo, 2011). More popular are the approaches defined by Lave and Wenger (1991) or Brown and Duguid (1991).

Table 1. Factors indicating a community of practice

Dimension	Main characteristics
Mutual engagement	Mutual relationships – harmonious or conflictual. Shared ways of engaging in doing things together. Rapid flow of information and propagation of information. Absence of introductory preambles as if conversations and interactions were merely the continuation of ongoing processes, Very quick setup of a problem to be discussed.
Common domain of practice	Substantial overlap in participants' descriptions of who belongs. Knowing what others know, what they can do, and how they can contribute to achieve a goal. Mutually defining identities. Ability to assess the appropriateness of actions and products.
Shared repertoire of resources	Specific tools, representations and other artifacts. Local lore, shared stories, inside jokes, knowing laughter. Jargon and shortcuts as well as the ease of producing new ones. Certain styles recognized as displaying membership. Shared discourse reflecting a certain perspective on the world.

Note: Adapted from: (Wenger, 1998).

In his later works, Wenger modified his unitarian approach to community of practice suggesting that organizations should perceive themselves as systems of social learning composed of numerous communities of practice. Cooperation between members of different communities (by maintaining one's own community identity) is possible thanks to the crossing of borders and transfer (adaptation) of artifacts into a new context of meaning. The above changes were, it seems, dictated by the desire to interest the representatives of practice with the issues of communities of practice, the example of which is a book written together with McDermott and Snyder being a practical guide for organizations that are willing to implement the community of practice in their works (Wenger, Snyder, and McDermott, 2002).

8.5. Conclusions

Community of practice is present in the management literature for more than 25 years. Still till now no consistent terminology as well as methods and research tools were established. Indubitably, the main reason for this is the weakness of traditional theories of communities of practice, and in particular lack of formal definition of the research subject, using for that purpose general and blurry terms, lack of dominating research perspective or establishing theories on the basis of individual research. Chaos in terms of terminology and methodology becomes even greater due to the fact that communities, group learning and identity are the subjects of research of other fields of study such as sociology, anthropology and psychology.

As a result, till now there are not many works of scientific nature devoted to the communities of practice. Majority of them are one sided case studies that present an analysis of a selected aspect of their activities, or compilations developed for the implementation of communities of practice as an element of knowledge management system in an organization. Usage of different research perspectives and methods and tools of analysis resulting from them in majority of cases makes it impossible to compare the research results and thus to create a consistent theory.

The fact that the difficulty in researching the community of practice are its features can be a justification for such a situation. What is meant here are such dimensions of the community of practice as its informal nature, blurry borders or changeable personnel. This makes difficult not only the collection of empirical data but also their comparison. As a result, each community becomes a unique phenomenon.

References

Bendkowski, J. (2012). Interaktywno-sieciowy model kształtowania wspólnot działań w kreowaniu i dyfuzji wiedzy w organizacjach. Wydawnictwo Politechniki Śląskiej: Gliwice.

Brown, J. S., Duguid, P. (1991). Organizational Learning and Communities of Practice: Toward a Unified view of Working, Learning, and Innovation. *Organization Science*, 2(1), 40-57.

Brown, J. S., Duguid, P. (1996). Universities in the digital age. *Change*, 28(4), 10-19.

Brown, J. S., Duguid, P. (1998). Organizing Knowledge. *California Management Review*, 12(2), 90-111.

Campbell, M. (2009). Intersection of trajectories: a newcomer in a community of practice. *Journal of Workplace Learning*, 21(8), 647-657. doi: http://dx.doi.org/10.1108/13665620910996188

Duguid, P. (2006). What "Talking about machines" tells us. *Organization Studies*, 27(12), 1794-1804. doi: http://dx.doi.org/10.1177/0170840606071896

Hagel, J. I., and Armstrong, G. A. (1997). Net Gain: Expanding Markets Through Virtual Communities. Harvard Business School Press: Boston.

Harris, R., Simons, M., and Carden, P. (2004). Peripheral journeys: learning and acceptance of probationary constables. *Journal of Workplace Learning*, 16(4), 205-218. doi: http://dx.doi.org/10.1108/13665620410536291

Hutchins, E. (1996). Learning to navigate. In S. Chaiklin, and J. Lave (Eds.), Understanding Practice: Perspectives on Activity and Context. Cambridge University Press: New York.

Jordan, B. (1989). Cosmopolitical obstetrics: Some insights from the training of traditional midwives. *Social Science and Medicine*, 28(9), 925-944.

Lave, J. (1988). Cognition in Practice: Mind, Mathematics and Culture in Everyday Life. Cambridge University Press: Cambridge.

Lave, J. (1993). Situation learning in communities of practice. In L. B. Resnick, J. M. Levine and S. D. Teasley (Eds.), Perspectives on Socially Shared CognitionAmerican Psychological Association: Washington, DC.

Lave, J., Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. Cambridge University Press: Cambridge, UK.

Marshall, H. (1972). Structural constraints on learning. [in:] B. Geer (Ed.), Learning to Work. Sage Publications: Beverly Hills.

Murillo, E. (2011). Communities of practice in the business and organization studies literature. Information Research, 16(1). Retrieved from: http://InformationR.net/ir/16-1/paper464.html

North, K., Romhardt, K., Probst, G. J. B. (2004). Wissenserzeugung und - austausch in Wissensgemeinschaften. Communities of Practice. QUEM-Report. Arbeitsgemeinschaft Betriebliche Weiterbildungsforschung e.V: Berlin.

Orr, J. (1990). Talking about Machines: An Ethnography of a Modern Job. Dissertation. Cornell University.

Rheingold, H. (1995). The Virtual Community. Finding Connection in a Computerized World. Minerva: London.

Romhardt, K. (2002). Wissensgemeinschaften: Orte lebendigen Wissensmanagements. Dynamik, Entwicklung, Gestaltungsmöglichkeiten. Versus: Zürich.

Teigland, R. (2003). Knowledge Networking: Structure and Performance in Networks of Practice. Dissertation. Stockholm: Stockholm School of Economics.

Tönnies, F. (1887). Gemeinschaft und Gesellschaft. Darmstadt.

van Maanen, J., and Barley, S. R. (1984). Occupational Communities: Culture and Control in Organizations. *Research in Organizational Behavior*, 6, 287-365.

Weber, M. (1914). Wirtschaft und Gesellschaft. Tübingen: J.C.B. Mohr.

Wenger, E. (1998a). Communities of Practice - Learning as a Social System. *The System Thinkers*, 9(5), 1-5.

Wenger, E. (1998b). Communities of Practice. Learning, Meaning, and Identity. Cambridge University Press: Cambridge.

Wenger, E., Snyder, W. M., McDermott, R. (2002). Cultivating Communities of Practice: A Guide to Managing Knowledge. Harvard Business School Press: Boston, MA.

Zboralski, K. (2007). Wissensmanagement durch Communities of Practice. Eine empirische Untersuchung von Wissensnetzwerken. Wiesbaden: Deutscher Universitäts-Verlag.

Zhang, W., Watts, S. (2008). Online communities as communities of practice: a case study. *Journal of Knowledge Management*, 12(4), 55-71. doi: http://dx.doi.org/10.1108/13673270810884255

Chapter 9

THE OPTIMAL STRUCTURE OF COAL OUTPUT IN A GROUP OF COLLIERIES

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Abstract

In this paper, the author presents the results of his research on the optimal structure of coal output in a group of collieries according to the criterion of the maximization of total gross performance ratio. The analysis concerned key parameters that determine the work efficiency in a group of collieries and the determination of the optimal output structure in the context of maximization of work efficiency for several calculation variants. Technical and organizational determinants of work efficiency were analyzed to determine the technical and organizational solutions that allow to limit labor-output ratio of technological processes. Change in the coal production structure in a group of longwalls requires relevant change to the work organization that is allocation of workers to production and non-production stations in a group of collieries. The coal mining structure in a group of longwalls is one of key factors that determine the work efficiency. The presented analysis was carried out for a group of longwalls in two hard coal mines, the input data of which were determined on the basis of work parameters monitoring of the indicated longwalls.

Keywords: daily coal output, work efficiency, group of collieries.

9.1. Introduction

Intensive restructuring of Polish hard coal mining resulted in the changes to the functioning of coal companies and hard coal mines. One can notice significant changes in all areas of collieries' activities, yet the most important changes took place in the technical and technological as well as in organizational and management areas. The superior objective of the activities taken was to limit the unit cost of coal and to improve the safety and stability of production process in hard coal mines (Jonek-Kowalska and Turek, 2016; Jonek-Kowalska, 2015; Jonek-Kowalska, 2018a; Bijańska, 2011).

The determined objectives of restructurization in the hard coal sector aim to achieve the planned coal production with the use of a limited number of collieries and longwalls within mining enterprises. Such a focus of production requires optimal use of productivity of the used machines and devices, collieries infrastructure and work resources (Klank, 2011; Jonek-Kowalska, 2018b; Jonek-Kowalska, 2017; Jonek-Kowalska, 2014; Wodarski et al., 2017). As a result, it is necessary to carry out such a research that will make it possible to determine factors and conditions that influence the work efficiency. It will allow to determine recommendations for mining managers within their activities, as well as technical and organizational solutions to increase the work efficiency level.

The ratio of total work efficiency is determined on the basis of annual output and average employment rate in total in a group of collieries. Both the level of hard coal mining as well as the level of employment are directly or indirectly influenced by the mining and geological conditions and the used technical and organizational solutions. Commercial coal as the effect of production process in a hard coal mine requires effective and safe implementation of production, transport and handling processes that are composed of several technological processes (Gumiński, 2012; Gumiński, 2008). These processes are characterized by varied levels of labor-output levels that depend on many factors, including technical and organizational ones for which the management and technical staff are responsible. Appropriate organization of production within longwalls allows for optimal selection of human resources in terms of quantity and quality structure (Gumiński, 2016a; Klank, 2011). From the point of view of work efficiency analysis it is important to adjust the level and structure of employment within a group of colliery employees and group of external companies' employees to the scope and scale of implemented technological processes (Karbownik and Gumiński, 2011). Optimal level of employment in particular employees' groups is closely related to the effective work time of the employed mine staff and labor-output ratio of particular technological processes (Gumiński, 2016b; Gumiński, 2010).

In the article, the author presents the research results within the determination of optimal daily coal output structure within a group of longwalls. The ultimate result of the analysis on the basis of 4 calculation variants was the determination, according to the criterion of total gross performance ratio maximization, of optimal structure of daily output for varied levels of total daily output within the group of analyzed longwalls. Changes in the output structure influenced the changes in the employees' workload at production and non-production positions for the analyzed longwalls.

The analysis of optimal output structure was carried out for 4 calculation variants for a group of longwalls in two hard coal mines. The input data necessary for the analysis were obtained from the source materials of the analyzed mines.

9.2. Work efficiency in a hard coal mine – determinants and conditions

Analysis of calculation variants necessary to determine optimal structure of hard coal production in a group of longwalls according to the criterion of work efficiency maximization required the work efficiency ratio. For further analysis, the total gross performance ratio was used that can be presented as a following dependency:

$$W = \frac{P_b}{Z} \tag{1}$$

where:

P_b – annual average level of gross hard coal production in the group of analyzed collieries, [t/r],

Z – annual average level of employment in a group of collieries [empl.].

Both the level of employment as well as the level of gross hard coal production are dependent on many parameters and factors that can be presented as a following dependence (Gumiński, 2017):

$$W = \frac{P_b}{Z} = \frac{f_1(p_1, p_2, p_3, ..., p_n)}{f_2(q_1, q_2, q_3, ..., q_n)} \tag{2}$$

where:

$p_1, p_2, p_3, \ldots, p_n$, – parameters determining the gross hard coal production,

$q_1, q_2, q_3, \ldots, q_n$, – parameters determining the level of employment.

P_b – annual average level of gross hard coal production in the group of analyzed collieries, [t/r],

Z – annual average level of employment in a group of collieries [empl.].

The above dependence is implicit as the two amounts present in the formula, f1 and f2, are mutually dependent, that is to some extent changes in the level of employment may determine the changes in the production level and the changes in the production can influence the level of employment. The search for maximum achievable work efficiency comes down to a situation when one of the abovementioned amounts becomes fixed. This means that by way of changes to the technical and organizational solutions, the production level can be maximized provided that the level and structure of employment stay the same. A second case present in the Polish hard coal mining industry is the necessity to act to minimize the workload to achieve the planned production level that is in line with the possibilities in terms of hard coal sale by the coal company on the national and foreign markets. The use of absorption curve concept of work efficiency plays a major role in the analysis of hard coal mine resources productivity. It points to the distribution of changes to the work efficiency once the workload of subsequent processes carried out by the employees of the mine was taken into account in an accumulated manner.

The analysis carried out on the basis of literature research and the experience of the author allowed for initial indication of factors and conditions that influence the level of hard coal mine production (Gumiński, 2017):

- geological and mining conditions,
- natural hazards,
- employment structure and level,
- effective work time of the employees,
- work organization,
- coal production structure,
- underground transport infrastructure,
- mineshaft infrastructure,
- coal mechanical handling unit infrastructure,
- productivity of installed devices and machinery,
- used technical and technological solutions,
- scope and scale of machines and devices failures.

In turn, when analyzing the factors that directly and indirectly decide on the level of employment in a hard coal mine, the following can be indicated (Gumiński, 2017):

- coal production level and structure,
- effective work time of the employees,
- absenteeism level of underground and office workers,
- organizational structure of the mine,
- scope of functions and tasks assigned to particular organizational units,
- labor-output ratio of technological processes,
- level of competences and qualifications of employees,
- geological and mining conditions,
- natural hazards,
- underground transport infrastructure,

- mineshaft infrastructure,
- coal mechanical handling unit infrastructure,
- used technical and technological solutions.

An important issue for each longwall are natural hazards that need to be analyzed to determine their influence on the production process. At the same time, they negatively influence the level and structure of gross daily output in a hard coal mine and on the workload of technological processes, and thus they significantly shape the level of work efficiency. Influence of natural hazards on the work efficiency can be presented in the following way (Gumiński, 2017):

- directly – by limiting the maximum daily progress of a longwall (methane hazard due to the absolute methane content, rock burst hazard due to the necessity of preventive actions that make it impossible to mine the body of coal),
- indirectly – by increasing the time of stoppages of longwall shearer (methane hazard due to increased control, rock burst hazard due to the special conditions of exploitation, endogenous fires hazard),
- directly – by increasing the workload of preventive processes (methane hazard, rock burst hazard, water hazard),
- indirectly – due to the increased scale of failures and down times of machines and devices (methane hazard, rock burst hazard).

9.3. Analysis of the optimal structure of coal output in the analyzed group of longwalls and work efficiency for the selected calculation variants

The following actions were needed to determine the optimal coal output structure in the analyzed group of longwalls to maximize the total gross productivity ratio:

- determining the work efficiency ratio,
- selection of longwalls for analysis,
- determining mining and geological as well as technical and organizational conditions in the longwalls selected for analysis on the basis of source materials sourced from the analyzed collieries,
- monitoring of technical parameters for all of the longwalls selected for analysis for a period of one month,
- determining calculation variants for the analysis of optimal structure of daily output,

- determining the gross daily output level for the group of longwalls being analyzed in every calculation variant,
- determining the optimal gross daily output structure for the group of longwalls being analyzed in every calculation variant,
- determining the total headcount level for the group of collieries being analyzed in every calculation variant,
- determining changes to the level of employment in the group of production workers in the group of collieries being analyzed in every calculation variant,
- determining changes to the level of employment in the group of office workers in the group of collieries being analyzed in every calculation variant,
- determining total gross productivity ratio for the analyzed group of collieries in every calculation variant.

Table 1 presents the basic geological and mining parameters of the longwalls selected for analysis.

Table 1. Geological and mining parameters of analyzed longwalls

Id.	Parameter	Unit	The name of a longwall						
			Longwall A	Longwall B	Longwall C	Longwall D	Longwall E	Longwall F	Longwall G
1.	Coal deposit		205/1	209	209	209	209	206/1	206/1
2.	Methane hazard category		-	-	-	-	-	-	-
3.	Water hazard category		I	I	I	I	I	I	I
4.	Rockburst hazard category		-	I	I	I	I	-	-
5.	Longwall's length	[m]	225,00	230,99	184,92	146,25	169,00	195,00	110,00
6.	Longwall's height	[m]	1,73	2,20	2,62	3,57	4,40	2,10	2,10
7.	Longwall's run	[m]	403 / 1056	1094 / 2184	486,0	281,0	1 995,0	1 485,0	525,0
8.	Longwall's longitudinal slope	[°]	1-3	1-3	0-2	2-5	0-7	1÷8	0-9
9.	Longwall's transverse slope	[°]	3-5	2-5	2-6	0-1	-4,5 +8,5	1÷6	1 ÷ 6,8
10.	Daily longwall advancement	[m/d]	4,43	4,22	4,30	3,90	6,34	2,90	1,60
11.	Longwall's exploitation time	[mies.]	4,4	12,4	5,4	3,6	12,0	15,0	5,0
12.	Shearer's type		KGE-710FM	KGE-710FM	KSW-880EU/1k	KSW-2000E1	KSW-1500 EU	FS 400/1.0	KSW 880 EU
13.	Longwall conveyor's type		Rybnik-850	Glinik 298/800	Rybnik-850	Rybnik-1100	Rybnik 1100	RYBNIK-850	GLINIK-298/800/BP

Source: own study,

Table 2 presents key technical parameters determining longwall shearers' productivity and work productivity in analyzed longwalls.

Table 2. Key technical parameters determining longwall shearers' productivity and work productivity in analyzed longwalls

Id.	Longwall	Colliery	The time to reach a longwall [min]	Non-technological downtime coefficient [%]	Shearer's work time use in technological processes coefficient [%]	Average shearer's productivity [t/h]	Average daily number of productive shifts in a longwall [sh./d]	Average daily number of maintenance shifts in a longwall [sh./d]	The number of workers on a productive shift [workers/sh.]	The number of workers on a maintenance shift [workers/sh.]	Daily longwall gross coal output [Mg/d]
			T_d	W_{pp}	W_{wkpt}	$PrK_{śr}$	$LZPDR_o$	$LZKDR_o$	OZP_o	OZK_o	WDB_o
1	2	3	4	5	6	7	8	9	10	11	12
1.	Longwall A	Colliery X	85,0	34,4	56,8	399,2	3,90	0,50	30,9	32,5	3 570
2.	Longwall B	Colliery X	50,0	17,0	74,3	298,8	3,50	0,50	30,3	38,0	4 423
3.	Longwall C	Colliery X	85,0	34,2	75,3	287,1	3,50	0,50	34,0	39,0	3 414
4.	Longwall D	Colliery X	65,0	24,2	66,0	267,2	3,50	0,50	34,8	45,0	3 209
5.	Longwall E	Colliery Y	115,0	18,7	72,2	688,3	5,25	0,75	24,3	44,9	9 696
6.	Longwall F	Colliery Y	85,0	36,5	69,8	194,1	3,85	0,78	20,4	33,9	2 064
7.	Longwall G	Colliery Y	100,0	29,5	52,2	90,6	4,34	0,66	22,3	34,4	800

Source: own study.

Using the model of work efficiency analysis (Gumiński, 2017), taking into account the work parameters of the analyzed group of longwalls and collieries, the necessary calculations were carried out to determine optimal structure of daily output for 4 calculation variants. The basic status (variant 0) were the parameters of longwalls determined during the monitoring carried out for a period of one month (total gross daily output in the analyzed longwalls at the level of 27,176 Mg/d).

The following calculation variants were identified for the further analysis:

- variant I – good economic condition of hard coal market, favorable prices and lack of problems in terms of coal sale. Assumption of maximum gross daily output that can be achieved in a group of analyzed longwalls taking into account that the extraction can be carried out on Saturdays and Sundays,
- variant II – good economic condition of hard coal market, favorable prices and lack of problems in terms of coal sale. Assumption of maximum gross daily output that can be achieved in a group of analyzed longwalls without taking into account that the extraction can be carried out on Saturdays and Sundays,

- variant III – bad economic condition of hard coal market, unfavorable prices and problems in terms of coal sale. Assumption of reduction of gross daily output by 50% as compared with basic variant, with an additional prerequisite to maintain the extraction at a minimum level for all analyzed longwalls,
- variant IV – bad economic condition of hard coal market, unfavorable prices and problems in terms of coal sale. Assumption of reduction of gross daily output by 50% as compared with basic variant, with the possibility to cease extraction in one of the analyzed collieries.

For each calculation variant, the analysis of changes to the employment level was carried out, taking into account determined optimal structure of daily output. Next, changes to the value of total gross performance ratio for all of the analyzed variants were determined.

For each variant that takes into account optimal daily output structure, a total gross productivity ratio was determined in a group of analyzed mines according to the following dependency (Gumiński, 2017):

$$W = \frac{\sum_{i=1}^{m}\sum_{j=1}^{m_j} P_{b-ij}}{\sum_{i=1}^{m}\left[\sum_{j=1}^{m_i}\frac{OZP_{ij}\cdot LZP_{ij} + OZK_{ij}\cdot LZK_{ij}}{(1-WA_{ij})} + Z_{pp-d-i} + Z_{pp-p-i}\right]} \tag{3}$$

where:

m – number of mines in the analyzed group of collieries,

m_i – number of longwalls in ith mine,

P_{b-ij} – annual gross coal production level in jth longwall of ith hard coal mine [t/r],

OZP_{ij} – workload of jth longwall in the ith mine during a production shift [empl.],

LZP_{ij} – number of production shifts in jth longwall of ith coal mine,

OZK_{ij} – workload of jth longwall in the ith mine during maintenance shift [empl.],

LZK_{ij} – number of maintenance shifts in jth longwall of ith coal mine,

WA_{ij} – total absenteeism ratio for jth longwall of ith coal mine [%],

Z_{pp-d-i} – level of employment of non-production workers in the underground of ith mine [empl.],

Z_{pp-p-i} – level of employment of non-production workers in the offices of ith mine [empl.].

Table 3 presents synthetic results for the analyzed calculation variants.

Table 3. The result parameters of simulation calculation in a group of analyzed collieries

Id.	Parameter	Unit	The initial state	Variant I	Variant II	Variant III	Variant IV
1.	Total daily gross coal output	[Mg/d]	27 176,0	41 700,0	30 320,0	13 588,0	13 588,0
2.	Longwall A	[%]	13,1%	13,7%	13,8%	6,7%	0,0%
3.	Longwall B	[%]	16,3%	15,0%	15,0%	9,3%	0,0%
4.	Longwall C	[%]	12,6%	14,5%	14,5%	7,2%	0,0%
5.	Longwall D	[%]	11,8%	11,9%	11,9%	6,7%	0,0%
6.	Longwall E	[%]	35,7%	34,2%	34,2%	64,7%	76,3%
7.	Longwall F	[%]	7,6%	7,5%	7,6%	3,9%	16,9%
8.	Longwall G	[%]	2,9%	3,0%	3,0%	1,4%	6,8%
9.	The employment level in a group of collieries	[worker]	9 410	10 754	9 584	7 801	4 143
10.	The employment level change of productive workers	[worker]	0	657	174	-778	-677
11.	The employment level change of non-productive workers	[worker]	0	687	0	-831	-4 590
12.	Gross work productivity indicator	[Mg/y/worker]	727,8	975,5	797,2	438,9	826,5

Source: own study.

Variant I makes use of the whole extraction potential of the analyzed longwalls, taking into account an assumption that the extraction can be carried out on Saturdays and Sundays. This resulted in an increase of gross daily output within a group of collieries from 27,176 Mg/d to 41,700 Mg/d, that is by 53.4%. At the same time, it was necessary to increase the employment level from 9,410 employees to 10,754 employees, that is by 14.3%. As a result, a significant increase of total gross productivity ratio was obtained from 727.8 Mg/y/worker to 975.5 Mg/y/worker, that is by 34.0%.

Variant II makes use of the whole extraction potential of the analyzed longwalls, without taking into account an assumption that extraction can be carried out on Saturdays and Sundays. This resulted in an increase of gross daily output within a group of collieries from 27,176 Mg/d to 30,320 Mg/d, that is by 11.6%. At the same time, it was necessary to increase the employment level from 9,410 employees to 9,584 employees, that is by 1.9%. As a result, an increase of total gross productivity ratio was obtained from 727.8 Mg/y/worker to 797.2 Mg/y/worker, that is by 9.5%.

In variant III, due to the assumed problems with the coal sale it was assumed that the daily output must be reduced by 50% but it was decided to maintain minimum production for all longwalls. The limited reduction of total level of employment in the analyzed group of collieries from 9,410 employees to 7,801 employees, that is by 17.1%, resulted in a significant decrease of total gross efficiency ratio from 727.8 Mg/y/worker to 438.9 Mg/y/worker, that is by 39.7%.

In variant IV, due to the assumed problems with the coals sale it was assumed that the daily output must be reduced by 50% and it was decided to cease the coal production in several longwalls. The total goal of daily output was taken over by 3 longwalls (E, F and G) grouped in one mine, which resulted in employment reduction from 9,410 employees to 4,143 employees, that is by 56.0%. This made it possible to achieve a high level of gross productivity ratio that is 826.5 Mg/y/worker, which in turn means an improvement when compared with the basic variant by 13.6%. This decision, however, brings about social problems, that is the necessity to ensure a social plan for the dismissed miners. Another problem is the expensive maintenance of mine infrastructure, if it is economically justified in a long run.

To summarize, determining an optimal structure of daily output that allows to maximize the total gross productivity ratio requires varied decisions from the side of the management and engineering and technical employees in the group of collieries. Proper allocation or change in the size of used resources, that is change in the production workers and non-production workers workload are of key importance for the optimal use of technical infrastructure of collieries.

9.4. Conclusions

The research and variant calculations indicate a significant influence of the daily output structure in the longwalls group on the level of work efficiency. Detailed conclusions resulting from the research are as follows:

1. Irrespective of the level of total gross daily output in the group of collieries it is justified to determine the optimal structure of the output to maximize the work efficiency.
2. Optimal structure of coal output results in the necessity to allocate mining crew between particular longwalls within the analyzed group of collieries. This applies both to production as well as non-production workers. As a result, optimal coal output structure determines the employment structure and level in

particular hard coal mines and thus is a key factor that influences the level of work efficiency.

3. Further restructurization of employment towards more effective use of work resources, including appropriate allocation of those employed within the group of collieries is necessary to improve the work efficiency. As a result, management should prepare allocation plans for the mining crew for various economic conditions on the coal market.

References

Bijańska, J. (2011). Prognozowanie kształtowania się rentowności produkcji w kopalniach węgla kamiennego w latach 2010 – 2020. Wydawnictwo Politechniki Śląskiej: Gliwice.

Gumiński, A. (2010). Model planowania poziomu zatrudnienia w kopalni węgla kamiennego i w grupie kopalń. Wydawnictwo Politechniki Śląskiej: Gliwice.

Gumiński, A. (2010). Efektywny czas pracy zatrudnionych w kopalni węgla kamiennego. *Przegląd Górniczy,* 9, 104-107.

Gumiński, A. (2012). Czynniki decydujące o wydajności pracy w wybranych kopalniach węgla kamiennego. *Wiadomości Górnicze,* 10.

Gumiński, A. (2011). Czynniki obniżające efektywny czas pracy zatrudnionych w kopalni węgla kamiennego. *Zeszyty Naukowe Politechniki Śląskiej., seria: Organizacja i Zarządzanie,* 56, 89-104.

Gumiński, A. (2016a). Efektywne wykorzystanie zasobów ludzkich jako kluczowy warunek funkcjonowania przedsiębiorstwa górniczego w perspektywie długoterminowej. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, 89*, 163-176.

Gumiński, A. (2016b). The influence of effective work time on an employment level in a colliery – case study. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie,* 91, 111-122.

Gumiński, A. (2017). Model analizy wydajności pracy w grupie kopalń węgla kamiennego. Wydawnictwo Politechniki Śląskiej: Gliwice.

Gumiński, A. (2017). Analiza wrażliwości wskaźnika wydajności brutto w ścianie wydobywczej. *Wiadomości Górnicze,* 11, 526-535.

Gumiński, A. (2017). The coal output reserve in a group of collieries. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie,* 111, 83-95.

Jonek-Kowalska, I. (2014). The effects of evolutionary employment restructuring in the Polish mining enterprises in the context of sector risk. *International Journal of Contemporary Management,* 13 (4), 21-40.

Jonek-Kowalska, I. (2015). Challenges for long-term industry restructuring in the Upper Silesian Coal Basin: What has Polish coal mining achieved and failed from a twenty-year perspective? *Resources Policy,* 44, 135–149.

Jonek-Kowalska, I. (2018a). Economic and social conditions of the implementation of new technologies in coal mining industry. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie,* 115, 113-123.

Jonek-Kowalska, I. (2018b). Method for assessing the development of underground hard coal mines on a regional basis: the concept of measurement and research results. *Energies* 11 (6), art. no. 1370, 1-23.

Jonek-Kowalska, I. (2017). Coal mining in Central-East Europe in perspective of industrial risk. *Oeconomia Copernicana,* 8 (1), 131-142.

Jonek-Kowalska I., Turek M. (2016). Fixed and variable costs and production efficiency in Polish coal mines. *Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie,* 97, 153-167.

Karbownik, A., Gumiński, A. (2011). Zakres i skala procesów technologicznych realizowanych przez firmy zewnętrzne w kopalniach węgla kamiennego. *Przegląd Górniczy* 9, 65-69.

Klank, M.(2011). The determinants in the development of coal mining sector productivity. *Archive of Mining Sciences,* 56 (3), 507–516.

Wodarski, K., Bijańska, J., Gumiński, A. (2017). The method of validity evaluation of hard coal excavation in residual seam parts. *Archives of Mining Sciences,* 62 (4), 675-687.

Chapter 10

STUDYING OF THE IMPACT OF CALCIUM SYNTHETIC SILICATES AND HYDRATED SILICATES STRUCTURE ON SORPTION PROCESSES

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Abstract

The highly extended active surface of finely dispersed xonotlite and wollastonite powder make them effective sorbents for organic substances and extractants. As sorbing and filtering powders they can effectively be used in petrochemical, chemical, industrial rubber, food and other branches of industry, as well as sorbents for thin-layer chromatography. Wollastonite is used for water-purification filter production. Purpose of the article is suggesting the improvement of oil and petroleum product refining with the removal of sulphur-bearing and other heteroatomic compounds using cheaper catalyst systems, subject to regeneration. Based on conducting specific studies of oil disperse system on model mixtures, consisting of the prescribed and thoroughly studied liquideous hydrocarbons. We had chosen the mixture hexane, benzene, cyclohexane, i.e. the substances reflecting the main features of the oil disperse system. The obtained results are seen useful for modelling the oil disperse system in general and for practical improvement of technological processes for obtaining end products from oil, as well as for developing technologies of waste products utilization and processing of end product production from oil disperse systems. Synthetic calcium silicates, as opposed to natural, are more uniform in terms of composition and structure, have less impurities, and are characterized by fine-crystalline particle structure, sizing up to thousandths of micron, and in connection with the specified advantages they have a wider practical application. The development of effective methods of calcium silicate synthesis was performed. The study of the impact of various factors on calcium silicate synthesis, as well as optimization of the synthesis conditions of obtained inorganic adsorbents. The study of mineralogical and chemical composition of the synthesized products. The study of sorptive properties of synthetic xonotlite and wollastonite towards the components of oil and petroleum products.

Keywords: calcium silicates and hydrosilicates, sorption.

10.1. Introduction

The highly extended active surface of finely dispersed xonotlite and wollastonite powder make them effective sorbents for organic substances and extractants. As sorbing and filtering powders they can effectively be used in petrochemical, chemical, industrial rubber, food and other branches of industry, as well as sorbents for thin-layer chromatography. Wollastonite is used for water-purification filter production.

The problems of obtaining and usage of calcium silicates and hydrosilicates, which stoichiometric ratio can be expressed by the formulas $mCaO{\cdot}nSiO_2$ and $mCaO{\cdot}nSiO_2{\cdot}pH_2O$ respectively, draw increasingly greater attention lately.

10.2. Literature studies

Analysis of the principal directions of synthetic calcium silicates production showed that currently the most commonly used are the methods of solid-phase synthesis (consisting in sintering of calcium and silicon containing raw materials in the presence or absence of liquid phase) and synthesis in aqueous medium at elevated temperature and normal atmospheric pressure or at elevated temperature and pressure (hydrothermal synthesis).

As key parameters, optimized when synthesizing the calcium silicates, the following should be marked out: end product yield and quality, power consumption and material costs, removal of all harmful impurities (metal oxides, calcite, silica, etc.) The major establishing factors, impacting the parameters to be optimized, are: composition and ratio of the feed mixture components, initiating additives and catalysts, feedstock preliminary processing parameters, fusion temperature, drying time, burning duration and conditions.

When sintering calcium and silicon containing components at the temperature range of 1,000-1,300°C the end product is obtained in the granulated form with further classification for the required particle size. As a result the synthetic wollastonite, supplied to the market, has 65 wt.% of particle size 44-74 μm. The process of wollastonite solid-phase synthesis takes place when burning the mixture, consisting of silicon and calcium containing raw materials with and without various additives, at the temperatures below the fusion temperature of basic components and formed silicates. The key condition for solid-phase reactions is the availability of mass transfer between the reacting solid substances at the expense of diffusion. The important factors, impacting the process of solid-phase synthesis, are: particle-size composition of the mixture (including dispersity, uniformity), chemical composition and temperature. The reduction of particle size in the mixture increases the specific surface energy of grains and reduces the inside diffusion path, which leads to the process rate increase, end product yield, quality improvement, as well as permits reducing the temperature and specific power consumption when burning. However the reduction of particle size is accompanied with the increase of costs for grinding and increase losses at the expense of dust formation. The optimal granularity is determined taking into account product yield and general costs for synthesis. Relationship between the reaction rate and the temperature is determined by the nature of the controlling step of a reaction. In the case of diffusion process the reaction rate changes rather slowly with temperature change, and in the case of chemical interaction the reaction rate temperature dependence is rather significant. The nature of relationship between the reaction rate and the temperature depends on the chemical and grain size composition, grain uniformity in terms of size and from specific contact area between grains. The effect of pressure on the process of solid-phase synthesis may show itself in the change of reaction kinetics because of change in the shape of grains and their spatial relationship when prepressing the mixture before burning, as well as in the drift of reaction equilibrium when conducted under pressure. Impurities contained in the feed mixture may both slow down and speed up the processes, taking place when in the process of solid-phase synthesis, impacting the composition and properties of the obtained materials.

In the system of CaO–SiO2 the following compounds exist: calcium metasilicate CaO·SiO2, tricalcium disilicate 3CaO·2SiO2, calcium orthosilicate 2CaO·SiO2, tricalcium silicate 3CaO·SiO2. The main reactions of this compounds formation from oxides: mCaO+nSiO2 = mCaO·nSiO2. The change of Gibbs thermodynamic potential of the reaction unambiguously points out that for the ratio of CaO·SiO2 = 1 the most stable compound is wollastonite (CaO·SiO2), and for other ratios – calcium orthosilicate (2CaO·SiO2): the process accompanied by the most significant decrease in ΔG^{o} is the most probable.

The formation of wollastonite is only possible for the ratio of CaO:SiO2 = 1 from the reaction 2CaO·SiO2+SiO2=2(CaO·SiO2). In other cases 2CaO·SiO2 is the most stable formation.

The means of producing of synthetic calcium silicates, based on the interaction of input components in the aqueous medium at the elevated temperature and pressure, shall be rated as efficient and ecological. The method of hydrothermal synthesis is based on the ability of water to change the properties of reagents (solubility, diffusion rate, reactivity) at high temperature. In "soft" conditions it's possible to synthesize compounds that are usually formed at higher temperatures. The hydrothermal method has a variety of advantages over high temperature methods and its prospects for industrial application. It provides ample opportunities for obtaining particles that are uniform in terms of composition, shape and size. The possibility to vary a lot of parameters (temperature, vapour pressure, synthesis duration, and chemical composition of hydrothermal solutions) permits flexible process control. As opposed to high temperature methods, the methods of synthesis in aqueous medium permit obtaining calcium hydrosilicates (tobermorite, xonotlite) that have high technological characteristics and promising practical application (Burakov, 2014; Mei, 2017; Papynov, 2017; Shabarov, 2016; Walter, 2015). At the same time the process of calcium hydrosilicate formation with the designated stoichiometric ratio is the major stage of anhydrous calcium silicate (wollastonite) synthesis.

Among calcium hydrosilicates, xonotlite is of particular interest. It has enhanced thermal stability and promising practical application.

10.3. Methodology

Our research is aimed at studying of sorptive characteristics of synthetic xonotlite and wollastonite towards the components of oil and petroleum products.

Oil is a natural colloid disperse system, which characteristic property is in the existence of so-called supermolecular structures – the internal adsorption complexes, build of asphaltene and resin molecules that are 10–1,000 times larger than molecular. The primary role in supermolecular structures formation is assigned to oil asphaltene molecules.

The structural units of oil disperse system (underlying supermolecular structures, their intermediate and end types) have complex structure, caused by the nature and geometry of high-molecular compound macromolecules, surface forces between them, interaction of dispersed phase with dispersion medium and other factors.

The prominent nature of complex structural unit is the difference of surface forces between the supermolecular structure and solvation layer and between the solvation layer and dispersion medium. Therefore complex structural units may interact with the dispersion medium. Studying this interaction by using sorbents is a topical task.

Complex structural units of the oil disperse system may form free-disperse systems (sols) and connected-disperse systems (gels).

Oil disperse systems (free- and connected-disperse) are characterized by structural and mechanical strength, i.e. the capability to resist external forces and actions. The higher the interacting forces of high-molecular compound macromolecules in the associate and between the associates in the system, the higher the structural and mechanical strength of the oil disperse system.

The structural and mechanical strength of oil disperse systems is determined mainly by the thickness of solvate shell around the supermolecular structure. These shells have certain elasticity and initiate disjoining pressure, which affects the oil disperse system particles and tend to push them from one another.

The thinner the solvate shell is, the higher the structural and mechanical strength of oil disperse system.

In terms of structural and mechanical strength of the oil disperse system structural unit the series is as follows: gel, sol, complex structural unit.

The temperature value has significant influence on the structural and mechanical strength of disperse system. With temperature increase the structural and mechanical strength of the system is decreased and tends toward zero. The system passes into the molecular solution state.

Therefore the temperature value affects the disperse system stability, preventing breakdown.

The oil disperse system kinetic stability is understood to be the ability of the dispersed phase to keep for a certain time the homogeneous distribution of the complex structural unit in the dispersion medium.

System instability has significant influence on the conduction of target processes (production, transportation, and storage) and makes necessary the development and takes corresponding technological measures for protection against breakdown.

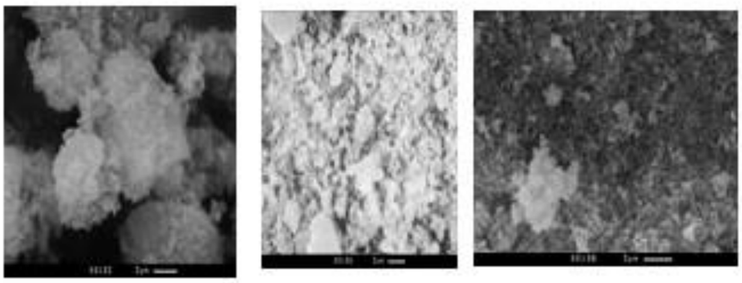
The instability is shown in the form of dispersed phase particles aggregation under the influence of intermolecular interaction with each other. At that the kinetic stability is lost and the phase separation occurs, i.e. coagulation takes place. At that the phase boundary is decreased. Associates coalesce and precipitate.

To figure out the mechanism of oil disperse systems behaviour in target technological processes it's necessary to develop a physico-chemical models of these systems, taking into consideration the nanodimensions of the component elements.

In different types of oil the basic component elements are carbon, hydrogen and sulphur, more rarely - oxygen and nitrogen. Individual type of oil may have up to 80 different chemical elements. Carbon content may vary from 82 to 87%, hydrogen - from 11 to 14%, sulphur - from 0.01 to 8%. Oil density changes in the range from 0.7 to 1 g/cm3.

Based on the above it's reasonable to conduct specific studies of oil disperse system on model mixtures, consisting of the prescribed and thoroughly studied liquideous hydrocarbons. In this study we had chosen the three-component mixture, containing in the ratio of 5:1:1 (by weight) hexane, benzene, cyclohexane, i.e. the substances similar in terms of physico-chemical properties, but at the same time reflecting the main features of the oil disperse system.

Generally the oil disperse systems form colloidal solution with spherical shape particles. The general body is composed of particles 2.2 – 3.8 nm in diameter, forming under association of three to five polyaromatic molecules and retaining by hydrogen bonds. The larger particles 8 - 10 nm in diameter appear as a result of association of major aggregates. These particles may form even larger aggregates 22 nm in diameter. In certain objects by using the electron microscopy the particles 300 - 400 nm in size were discovered. To study the selected oil disperse system we used calcium silicate based sorbents, see Figure 1.



a b c

Figure 1. SEM – images of plate-like sorbent surfaces, obtained from calcium silicate powders by standard synthesis (a), with PVA addition (b), by microemulsion method with quaternary ammonium base (c)

On the first stage we prepared three phases of aqueous solutions – gypsum, calcium chloride and quaternary ammonium salt. Following which we mixed the solutions in the ratio of 1:1:1 and conducted the hydrothermal synthesis at the temperature of 800C for 8-10 hours. As a result a suspension was formed, from which the sediment with 65-75% water content was precipitated. The sediment was washed by distilled water combined with anhydrous ethanol and sent for drying and crystallization. Five fractions of calcium silicate powders (A) 5-10 nm, (B) 15-50 nm, (C) 60- 100 nm, (D) 150-250 nm and (E) 300-500 nm in size were isolated. Each of the isolated fraction of calcium silicate powders was pressed by sintering, forming plate-like adsorbing materials 1.5 mm thick and 5 cm2 in area with particle sizes (A), (B), (C), (D) and (E) respectively. The obtained specimens were burned at the temperature of 600-750 K with the reception of different porosity sorbent specimens - (A1), (B1), (C1), (D1) и (E1). For illustrative purposes the images, received by using scanning electron microscope (SEM), indicating sorbent surfaces with different porosity are shown: a) – 0.02-0.029 m3/g (A1), b) - 0.01-0.02 m3/g (B1), c) – 0.005 -0.01 (C1) m3/g.

10.4. Research results

When studying the physico-chemical properties of calcium silicate based sorbents (A1), (B1), (C1), (D1) and (E1) it was discovered that when heating in air environment up to the temperatures of 900 – 1,000K they do not melt and change their form and porosity.

By using the dipping method in a certain succession of plates (A1), (B1), (C1), (D1) and (E1) into the oil disperse system, a part of dispersed phase was selectively adsorbed on each plate. The remainder of the non-adsorbed part of the oil disperse system in the conducted tests didn't exceed 2 wt.%.

Studying of physico-chemical properties of each isolated part of the oil dispersed system showed that with the increase of the oil disperse system temperature the amount of non-adsorbed part (on the sorbent with the maximum value of porosity equalling 0.1-0.5 m3/g (E1)) is decreasing to almost zero with a rise in temperature from 20 to 50 0C. At that the weight of fractions on all sorbent plates is practically unchanged with the increase of sorption time, starting from 100- 120 minute of test.

With the increase in the sorbent porosity from 0.005 - 0.01 m3/g to 0.1- 0.5 m3/g the share of semi-volatile fractions (resinous high-viscosity substances) on the sorbent increases. The amount of latter increases on all sorbents with the temperature increase of initial oil disperse system.

The liquideous initial organic matter or a mixture of organic substances by using a peristaltic pump is transferred to the sorption vessel, in which the plate-like nanopatterned sorbents with different porosity (A1), (B1), (C1), (D1) and (E1) are placed. From the sorption vessel after the conduction of adsorption process the liquid is returned to the initial vessel via a return circuit. Over the parallel circuit the liquid is supplied to a flow-through cell, located inside the spectrophotometer ПЭ-5400В. The measurement of solution concentration is conducted by using the standard method of spectrophotometric analysis with a calibration curve for at the wave length of 580 nm. For translating the experimental data of the optical density of solutions to adsorption capacity values the extrapolational dependences according to experimental data in Freundlich coordinates were used (Lgx/m - LgC, where x – is the amount of adsorbed material, m – adsorbent weight, C – concentration of substance in the solution after the establishment of adsorption equilibrium). By weighting the liquid mass before and after the adsorption, the weight of the adsorbed material was determined. By weighting the sorbent plate before and after the adsorption, the weight of the adsorbed material was also determined, and verification of the previous measurements was conducted. By carrying out these measurements in the course of time, the adsorbent capacity by each substance and characteristic time of adsorption was determined to high precision.

At the first step a plate adsorbent with specified porosity that reaches its capacity faster was determined for each substance (hexane, benzene, cyclohexane).

At the second step the adsorption on each plate adsorbent was controlled sequentially, by comparing the adsorbed material mass with the reference for each substance (hexane, benzene, cyclohexane).

10.5. Conclusions

The tests showed that depending on the porosity the plate adsorbents have a selective ability towards the selected organic substances. Thus, the longer the molecule of the organic substance is, the more effective the adsorbent with lesser porosity (Akat'eva, 2016; Berlinskii, 2016; Fox, 2006; Nistor, 2016; Shin, 2004).

The obtained results are seen useful for modelling the oil disperse system in general and for practical improvement of technological processes for obtaining end products from oil, as well as for developing technologies of waste products utilization and processing of end product production from oil disperse systems.

References

Akat'eva, L. V., Ivanov, V. K., Kozyukhin, S. A., Gladun, V. D., Baranchikov, A. E., Zhilov, V. I., Khol'kin, A. I. (2016). Using extraction and sorption processes to obtain nanosized powders of calcium silicates and functional materials on their basis. *Theoretical Foundations of Chemical Engineering,* 50(4), 490-497. doi: http://dx.doi.org/10.1134/s0040579516040023

Berlinskii, I., Kuzhaeva, A. (2016). *The study of calsium-silicate based adsorbents properties.* Paper presented at the 16th International Multidisciplinary Scientific Geoconference (SGEM 2016). Bulgaria: Albena.

Burakov, A., Romantsova, I., Kucherova, A., Tkachev, A. (2014). Removal of Heavy-Metal Ions from Aqueous Solutions Using Activated Carbons: Effect of Adsorbent Surface Modification with Carbon Nanotubes. *Adsorption Science & Technology, 32*(9), 737-747. doi: http://dx.doi.org/10.1260/0263-6174.32.9.737

Fox, P. M., Davis, J. A.,Zachara, J. M. (2006). The effect of calcium on aqueous uranium(VI) speciation and adsorption to ferrihydrite and quartz. *Geochimica Et Cosmochimica Acta,* 70(6), 1379-1387. doi: http://dx.doi.org/10.1016/j.gca.2005.11.027

Mei, H. Y., Meng, Y. E., Gong, Y., Chen, X. J., Chen, C. L., Tan, X. L. (2017). Effect of silicate on the sorption properties of kaolinite: removal of U(VI) and mechanism. *Journal of Radioanalytical and Nuclear Chemistry, 311*(3), 1899-1907. doi: http://dx.doi.org/10.1007/s10967-016-5119-4

Nistor, C. L., Ianchis, R., Ghiurea, M., Nicolae, C. A., Spataru, C. I., Culita, D. C., Donescu, D. (2016). Aqueous Dispersions of Silica Stabilized with Oleic Acid Obtained by Green Chemistry. *Nanomaterials, 6*(1). doi: http://dx.doi.org/10.3390/nano6010009

Papynov, E. K., Trukhin, I. S., Mayorov, V. Y., Patrusheva, O. V., Vostroknutov, A. A., Avramenko, V. A. (2017). Sorption of phosphates on macroporous synthetic calcium silicates. *Doklady Physical Chemistry, 473*, 61-65. doi: http://dx.doi.org/10.1134/s0012501617040030

Shabarov, A. N., Nikolaeva, N. V. (2016). Complex utilization of treatment wastes from thermal power plants. *Journal of Mining Institute, 220*, 607-610. doi: http://dx.doi.org/10.18454/pmi.2016.4.607

Shin, E. W., Han, J. S., Jang, M., Min, S. H., Park, J. K., Rowell, R. M. (2004). Phosphate adsorption on aluminum-impregnated mesoporous silicates: Surface structure and behavior of adsorbents. *Environmental Science & Technology, 38*(3), 912-917. doi: http://dx.doi.org/10.1021/es.030488e

Walter, M. J., Thomson, A. R., Wang, W., Lord, O. T., Ross, J., McMahon, S. C., Kohn, S. C. (2015). The stability of hydrous silicates in Earth's lower mantle: Experimental constraints from the systems MgO-SiO2-H2O and MgO-Al2O3-SiO2-H2O. *Chemical Geology, 418*, 16-29. doi: http://dx.doi.org/10.1016/j.chemgeo.2015.05.001

Chapter 11

REMOVAL AND SEPARATION OF LANTHANIDES IN POLYCOMPONENT SYSTEMS BY ION FLOTATION METHOD

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Abstract

The technologies of the modern industry development require the growing amount of new materials for their sustainable development. The rare-earth metals (REM) play significant role in the metallurgy, glass, ceramic and many other industry sectors. The rare-earth metals are divided into two subgroups: yttrium and cerium. The innovative technologies are directed to the individualization of the rare-metal products. The separated pure rare-earth metals possess the extrinsic value. Therefore, the actual problem that the article addresses is the increase of the separation effectiveness of similar, in terms of properties, rare-earth metals, permitting reducing the individual rare-earth metals and their oxides cost, and expanding the possibilities of their application. Purpose of the article is to offer methods for more effective removal and separation of rare-earth metals. Methodology includes the analysis of froth pulp and flotation tail by photometric method with arsenazo III, mercurimetric titration with mixed indicator and potentiometric titration with 0.002 M cetyltrimethylammonium chloride solution with ion-selective electrode. This research was done in accordance with the project "Intensification of rare-earth elements froth concentration processes when processing the polycomponent industrial solutions". The realization of the results will promote the development of mineral economics. The products (rare-earth raw materials) can be used in many industry sectors, such as ferrous and non-ferrous metallurgy, as the reducers in the metal-ceramic reactions, as deoxidizers and desulphurizers, for improving the steel strength and forgeability, the improvement of cast iron physical-mechanical properties; in electrical engineering and electronics as getters, emitters, dielectrics, activators and semiconductor materials; in glass and ceramic industry for glass colouration and ceramic production; in chemical industry for manufacturing catalysts, lacquers and paints. The scientific research is aimed at the solution of topical and significant problem of optimization and increase of removal efficiency of target component from heterogeneous systems, as well as obtaining the rare-earth products, including individual.

Key words: ion flotation, sodium dodecyl sulphate, distribution coefficient, separation coefficient, removal.

11.1.Introduction

The rare-earth raw materials can be used in many industry sectors, such as ferrous and non-ferrous metallurgy, as the reducers in the metal-ceramic reactions, as deoxidizers and desulphurizers, for improving the steel strength and forgeability, the improvement of cast iron physical-mechanical properties; in nuclear engineering when manufacturing the nuclear reactor control rods and the manufacturing of the material for the rods; in electrical engineering and electronics as getters, emitters, dielectrics, activators and semiconductor materials; in glass and ceramic industry for glass colouration and ceramic production; in chemical industry for manufacturing catalysts, lacquers and paints (Bazhin, 2018).

Nowadays, subsequent to the depletion of the mineral raw material reserves, more complex and lean ores are drawn into the production process, as well as their conversion products: slags, cakes, dust, etc., containing heavy and rare metals (Pashkevich, 2016). The examples that are given below prove the necessity of developing the technologies, including the complex use of technogenic wastes in non-ferrous metallurgy, which are a major step for preserving the natural raw material sources, as well as the decrease of impact on the environment. With respect to the red muds processing, the receiving of rare-metal raw materials concentrates is possible. The currently used pyrometallurgical technologies of germanium extraction require large volumes of investments and power inputs (Shumilova, 2018). Besides, the process is accompanied with the considerable quantity of effluent gas and dust. In addition, the derived middling products are still processed by using the hydrometallurgical technologies. The applied hydrometallurgical technologies, based on the sulphuric acid and hydrochloric acid solutions, do not possess selectivity towards the target component recovery (Pashkevich, 2017). When processing the lean raw materials, the consumption for the ballast oxides is high. And because a slag generally has high-silicon content, during the acid break-down the difficult to filter silica gels are formed that are sorbing the germanium.

The decrease in the risk of the raw materials dependence from the outside suppliers and the ensuring of the metallurgical industry needs in individual rare-earth metals, which means the development of the effective rare-earth metals recovery and separation technology, applicable for lean rare-metal raw materials processing, is topical, and the realization of current project will facilitate this (Alekseenko, 2017).

The scientific project is directed to solving the actual and significant problem of the target component recovery from heterogeneous systems and efficiency increase, as well as the obtaining the rare-metal products, including individual products. The formulated problem can be solved by combining the experimental data on the rare-earth metals thermodynamic quantities and the dependencies of the rare-earth metals distribution and separation ratios during the recovery when varying the solution pH value and anion nature. The method of ion flotation should ensure the more effective rare-earth metals recovery and the separation of the similar, in terms of chemical and physical properties, components at the expense of using the surfactants.

11.2. Methodology

According to data by foreign researchers an increase of effectiveness in current technologies at the expense of accompanying extraction of valuable components from production wastes is possible due to ion flotation methods in mining industry. Thereby their toxicity level will be decreased as well as the risk of damaging the environment. A.V. Vershkov proposes the use of ion flotation for rare-earth metals removal from apatite sulphuric acid processing products by different types of anion surfactants. The possibility of rare-earth metals removal from hemihydrate phosphogypsum by ion flotation by using dialkylphosphoric acid was established. When manufacturing phosphate fertilizers the involvement of ion flotation process for accompanying rare-earth metals reduction from phosphate nitric-acid processing products with the subsequent regeneration of collector agent is proposed (Alexandrova, 2016). As opposed to extraction methods, ion flotation permits preventing the formation of voluminous sediments, rare-earth metals loss and usage of expensive extractants.

During ion flotation no high REM separation coefficients are observed, therefore studying of chloride ions and aqueous phase acidity impact on these values is of interest.

The ion flotation process was conducted on the make 137 В-ФЛ laboratory flotation machine with the cell volume of 1 dm^3 for 5 minutes.

Figure 1. Flotation machine 137 В-ФЛ

Source: own study.

The 0.001 mol/l solutions of chemically pure grade yttrium and ytterbium nitrates were used as model test solutions. Volume of the solution is 200 ml. Dry sodium dodecyl sulphate with general formula of $C_{12}H_{25}OSO_3Na$, combining the properties of foaming and collecting agents, was used as surfactant, which concentration corresponds with stoichiometry of the following reaction:

$$Me^{3+} + 3DS^{-} = Me(DS)_3 \qquad (1)$$

where:

i.e. is 0.003 M,

DS^- - dodecyl sulphate ions.

Sodium chloride was added to the initial solution in the amount corresponding with the concentration of 0.01 and 0.05 mol/l. The obtained froth pulp and flotation tail were separated and studied. The froth was destroyed by the effect of 1 M sulphuric acid. REM concentration was determined by photometric method with arsenazo III, chloride ions concentration – by mercurimetric titration with mixed indicator (diphenylcarbazide alcohol liquid 0.5 % by wt, and bromphenol blue 0.05 % by wt), dodecyl sulphate ion concentration – by potentiometric titration with 0.002 M cetyltrimethylammonium chloride solution with ion-selective electrode, consisting of silver-chloride-ЭВЛ-1М3, put into NaDS and NaCl solution, and a membrane, selective to DS^- ion (Chirkst, 2009).

Figure 2. Spectrophotometer КФК-3КМ

Source: own study.

The membrane is made in the ionometry laboratory of the SPbU physical chemistry department. pH of solution varied from 4 to 9 with 0.5 step and fixed by the nitric acid solution or sodium hydroxide.

11.3. Research results

Distribution coefficients of metal cations between the froth pulp and flotation tail was calculated by the $[Me^{3+}]$ ratio in the froth pulp and $[Me^{3+}]$ concentration in the flotation tail according to the formula:

$$D = \frac{C_{org}}{C_{aq}} \tag{2}$$

and separation coefficients:

$$K_{Me_1/Me_2} = \frac{D_{Me_1}}{D_{Me_2}} \tag{3}$$

In Tables 1, 2 the calculated values of distribution coefficients between the froth pulp and flotation tail for ion flotation for yttrium and ytterbium cations are specified (Chirkst, 2011).

Table 1. Yttrium distribution coefficients at different pH values of solutions and chloride concentrations

pH	D	pH	D	pH	D
C_{NaCl} = 0 M		C_{NaCl} = 0,01 M		C_{NaCl} = 0,05 M	
2,99	8,96	3,92	3,41	5,17	3,08
3,65	8,41	4,50	4,58	6,40	3,10
4,10	9,41	5,13	4,28	7,03	9,42
4,59	11,17	6,03	3,81	7,40	7,23
5,10	12,57	6,72	3,87	7,87	4,47
6,12	30,46	7,41	279,34	8,53	1,13
6,67	264,48	7,80	379,49		
6,95	855,64	8,11	50,60		
7,99	736,18	8,50	8,39		
		8,97	3,12		

Source: own study.

Table 2. Ytterbium distribution coefficients at different pH values of solutions and chloride concentrations

pH	D	pH	D	pH	D
C_{NaCl} = 0 M		C_{NaCl} = 0,01 M		C_{NaCl} = 0,05 M	
5,03	9,51	5,86	3,10	6,02	1,88
5,50	9,22	6,30	7,31	6,33	2,84
6,00	13,77	6,85	20,76	6,71	12,44
6,40	95,42	7,36	48,35	7,47	1,36
7,06	281,39	7,85	7,63	7,83	0,52
7,38	365,37	8,57	4,00	8,20	0,53
8,30	403,74			8,40	0,61
9,10	318,41			8,85	0,70

Source: own study.

During the yttrium (III) cations flotation in acidic medium at the NaCl concentration of 0.01 M in the range of pH < 6.7 there's almost no removal. Surge in K_{distr} is observed at pH 6.7. Maximum K_{distr} is 379 at pH 7.8, and in the nitrate medium – 856 at pH 6.95. Chloride ions suppress the removal of yttrium (III) cations to froth and shifts the pH of maximum removal towards higher values range from 6.95 in nitrate medium to 7.8 at NaCl concentration of 0.01 M. With sodium chloride concentration increase up to 0.05 M the yttrium (III) cations removal from the aqueous phase to froth dropped significantly. In the range of pH 4.0-9.0 the K_{distr} not to exceed 10. pH of the maximum removal at the chloride concentration of 0.05 M will shift slightly to the higher values range from 6.9 in nitrate medium to 7.0.

Ytterbium (III) cations removal at the NaCl concentration of 0.01 M starts at pH 5.9 and reaches its maximum of 48 at pH 7.4. Maximum K_{distr} at chloride ions concentration of 0.05 M is 12 at pH 6.7. In the pH range from 4 to 6 and from 7.5 to 9 there is almost no removal.

Yttrium removal at the absence of chloride ions at the maximum removal pH 6.9 is in a form of $\mathrm{YOH(DS)_2}$, and at the concentration of chlorides of 0.01 M – in a form of $Y(OH)_3$, because the pH_{hydr} and pH_{compl} are 7.2 and 6.3 respectively. At the maximum removal pH 7.0 at the chloride ions concentration of 0.05 M the $\mathrm{Y(OH)_2DS}$ go into the froth, because pH_{compl} $Me(OH)_2^+$ equals 7.0, and pH_{hydr} is 7.2.

Ytterbium (III) hydroxododecyl sulphates $\mathrm{YbOH(DS)_2}$ up to the pH_{compl} $Me(OH)_2^+$ of 6.3, ytterbium (III) dihydroxododecyl sulphates $\mathrm{Yb(OH)_2DS}$ in the pH range from pH_{compl} $Me(OH)_2^+$ 6.3 to pH_{hydr} 6.6 and ytterbium (III) hydroxides at pH > pH_{hydr} 6.6 go into the froth. In the area of maximum removal pH 6.7 ytterbium (III) goes into the froth in the form of $\mathrm{Yb(OH)_3}$, because pH_{hydr} equals 6.6. The start of removal pH 6.0 is in the range of pH_{compl} $MeOH^{2+}$ 5.8 and pH_{compl} $Me(OH)_2^+$ 6.3, therefore Yb^{3+} is recovered in a form of $\mathrm{YbOH(DS)_2}$.

The impact of chloride ions on distribution coefficient is explained by comparing the instability constants of chloro- and hydroxocomplexes (see table 3).

$$\Delta_f G_{298}^0 \left\{\mathrm{MeCl}_{aq}^{2+}\right\} = \Delta_f G_{298}^0 \left\{\mathrm{Me}_{aq}^{3+}\right\} + \Delta_f G_{298}^0 \left\{\mathrm{Cl}_{aq}^{-}\right\} + R \cdot T \cdot \ln K_n \quad (4)$$

By expressing the instability constant from the equation, we received the following:

$$K_n = e^{-\frac{\Delta_{compl} G_{298}^0}{R \cdot T}} \quad (5)$$

Gibbs energies of chlorocomplexes and lanthanides cations formation in aqueous solution were accepted according to the data base. Instability constants of hydroxocomplexes were accepted according to data (Data base TKB).

When adding chlorides, lanthanides are partly fixed in chlorocomplexes, which are not flotative. A decrease in hydroxocomplexes part results in flotation suppression and shifting the maximum removal to the range of higher pH values. As a result, the conditions for yttrium and ytterbium separation are created (Chirkst, 2010).

Table 3. Instability constants of yttrium and ytterbium hydroxo- and chlorocomplexes

Compound	K_n	$\Delta_{compl}G^0_{298}$, kJ/mol	Compound	K_n	$\Delta_{compl}G^0_{298}$, kJ/mol
YCl^{2+}	0,054	– 7,22	$Y(OH)^{2+}$	$1{,}56 \cdot 10^{-8}$	– 44,56
$YbCl^{2+}$	0,110	– 5,46	$Yb(OH)^{2+}$	$4{,}99 \cdot 10^{-9}$	– 47,39

Source: own study.

Yttrium cations (III) are fixed in rigid chlorocomplex that is not flotative, therefore the significant decrease of distribution coefficients is observed. In connection with rather high value of chlorocomplex instability constant ytterbium (III) shows a decrease of start of removal pH and maximum removal pH values at the increase of chloride concentration.

Considering different stability of chloro- and hydroxocomplexes, a different shift of removal pH and flotation suppression occurs, and consequentially the conditions for yttrium and ytterbium separation arise (Chirkst, 2009). The stronger the chlorocomplex and the weaker the hydroxocomplex, the more significant the shift towards the higher removal pH values is.

Table 4. Separation coefficients of ytterbium and yttrium in the absence of chloride ion

pH	$K_{Y/Yb}$
5,03	1,32
6,00	2,21
6,40	2,77
7,06	3,04
8,30	1,82

Source: own study.

On the basis of yttrium and ytterbium K_{distr} the calculation of separation coefficients was done (tables 4, 5, 6) (K_{sep}) at the specified pH values depending on the chloride ion concentration.

Table 5. Separation coefficients of ytterbium and yttrium at the chloride ion concentration of 0.01 M

pH	$K_{Y/Yb}$
5,86	1,23
6,85	0,19
7,36	5,78
7,85	49,73
8,57	2,10

Source: own study.

Table 6. Separation coefficients of ytterbium and yttrium at the chloride ion concentration of 0.05 M

pH	$K_{Y/Yb}$
6,33	1,09
6,71	0,76
7,47	5,30
7,83	8,62
8,40	1,86

Source: own study.

Maximum separation coefficient is observed at the chloride concentration of 0.01 M and equals 50 at pH 7.8. In the nitrate medium the K_{sep} is minimal and equals 3 at pH 7.0, and at the sodium chloride concentration of 0.05 M the K_{sep} equals 9 at pH 7.8.

11.5. Conclusions

The set tasks can be accomplished by the combination of experimental data on rare-earth metals thermodynamic quantities and the distribution coefficients and separation coefficients during the ion flotation and extraction process as a function of solution pH variation and anion nature. The declared methods should provide the more effective rare-earth metals removal and separation of similar, in terms of chemical and physical properties, components at the expense of surfactant, characterized by low price and non-toxicity, as well as simplicity of processing.

The tests proved that chloride ions are not flotative. Therefore, the lower the stability of chlorocomplexes and the higher the stability of hydroxocomplexes are, the more effective the rare-earth metals removal by ion flotation is. This explains the increase of K_{distr} of samarium (III) at chloride concentration of 0.01 M compared to the nitrate medium and the significant flotation suppression at 0.05 M of NaCl.

The model of ion flotation provides the removal of basic components by more than 99 %, and by adding chlorides into the system it permits increasing the rare-earth metals separation coefficients compared to the known analogues.

In the process of ytterbium ion flotation when adding chloride ions a trend for decreasing the K_{distr} and for shifting the maximum removal to the range of lower pH values is observed. K_{distr} for yttrium also decreases, and the maximum removal pH at the chloride concentration of 0.01 M is shifted to the higher values range compared to the nitrate medium.

Yttrium at maximum removal pH goes into the froth at chloride concentration of 0.01 M in the form of $Y(OH)_3$, and at chloride ions concentration of 0.05 M it goes into the froth in the form of $\mathrm{Y(OH)_2DS}$. Ytterbium (III) hydroxides are recovered to the froth at the maximum removal pH at NaCl concentration of 0.01 M, as pH_{hydr} 6.6. In the maximum removal pH range of 6.7 at the sodium chloride concentration of 0.5 M ytterbium (III) goes to the froth in the form of $\mathrm{Yb(OH)_3}$.

The estimated results of the scientific research can be used in the analytical chemistry scientific field for the separation of the similar, in terms of chemical and physical properties, target components by flotation methods. The analysis of the experimental data permits using the applied methods and techniques for the development of new technology solutions and the creation of the subsequent research and development models. In the longer term of the extended laboratory studies conduction, the results of the scientific research will have the tremendous significance for the development of the industry, expecting the possibility of the research utilization when developing the effective methods of rare-earth elements recovery from lean or technogenic raw materials (eudialyte concentrate). The developed solutions correspond with the world level or research and promote the ensuring of rare-earth raw materials base development. The processing of poor mineral raw materials will be cost-efficient at the expense of the capital costs reduction.

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References

Alekseenko, V. A., Pashkevich, M. A., Alekseenko, A. V. (2017). Metallisation and environmental management of mining site soils. *Journal of Geochemical Exploration*, 174, 121-127. doi: http://dx.doi.org/10.1016/j.gexplo.2016.06.010

Alexandrova, T. N. (2016). Key directions in processing carbonaceous rocks. *Journal of Mining Institute*, 220, 568-572. doi: http://dx.doi.org/10.18454/pmi.2016.4.568

Bazhin, V. Y., Aleksandrova, T. A., Kotova, E. L., Gorlenkov, D. V., Susorov, R. S. (2018). Metallurgists of the mining university and development of monetary industry. 245 years of history. *Journal of Mining Institute*, 230, 131-138. doi: http://dx.doi.org/10.25515/pmi.2018.2.131

Chirkst, D. E., Lobacheva, O. L., Berlinskii, I. V. (2010). Gibbs energies of formation of hydroxides of lanthanides and yttrium. *Russian Journal of Physical Chemistry A*, 84(12), 2047-2050. doi: http://dx.doi.org/10.1134/s003602441012006x

Chirkst, D. E., Lobacheva, O. L., Berlinskii, I. V., Dzhevaga, N. V. (2011). Effect of chlorides on cerium(III) and samarium(III) ionic flotation. *Russian Journal of Applied Chemistry*, 84(2), 341-344. doi: http://dx.doi.org/10.1134/s1070427211020315

Chirkst, D. E., Lobacheva, O. L., Berlinskii, I. V., Sulimova, M. A. (2009). Recovery and Separation of Ce^{3+} and Y^{3+} Ions from Aqueous Solutions by Ion Flotation. *Russian Journal of Applied Chemistry*, 82(8), 1370-1374. doi: http://dx.doi.org/10.1134/s1070427209080096

Chirkst, D. E., Lobacheva, O. L., Berlinskii, I. V., Sulimova, M. I. (2009). The thermodynamic properties of hydroxo compounds and the mechanism of ion flotation for cerium, europium, and yttrium. *Russian Journal of Physical Chemistry A*, 83(12), 2022-2027. doi: http://dx.doi.org/10.1134/s0036024409120036

Data base TKB. Parameters and definitions // http://www.chem.msu.su

Pashkevich, M. A., Petrova, T. A. (2016). Creation of a system for industrial environmental monitoring in hydrocarbon producing and transporting companies of western siberia. *Journal of Mining Institute*, 221, 737-741. doi: http://dx.doi.org/10.18454/pmi.2016.5.737

Pashkevich, M. A., Petrova, T. A. (2017). Technogenic impact of sulphide-containing wastes produced by ore mining and processing at the Ozernoe deposit: investigation and forecast. *Journal of Ecological Engineering*, 18(6), 127-133. doi: http://dx.doi.org/10.12911/22998993/76700

Shumilova, L. V., Kostikova, O. S. (2018). Sulfidization of silver-polymetallic ores of Goltsovoe deposit for decreasing loss of silver in mill tailings. *Journal of Mining Institute*, 230, 160-166. doi: http://dx.doi.org/10.25515/PMI.2018.2.160

Chapter 12

MINING OUTPUT STREAM RATE IN THE FUNCTION OF PROBABILITY – CALCULATIONS SCHEME FOR BIDIRECTIONAL SHEARER CUTTING

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Abstract

This paper proposes the use of the mining output stream rate index in the function of probability. This will allow an evaluation of the level of this index in the function of probability. This is possible with the assumption of some parameters of the production cycle (those that show variability) in the form of random variables. The purpose of this article is to show that the assessment of the efficiency of the production cycle can be done using the mining output stream rate index. The article provides a detailed scheme for the calculations that should be made in order to obtain such a characteristic of this index. The calculation scheme was divided into four stages: stochastic simulation of the index for the assumed random variables, determination of the empirical probability distribution of the index, determination of the empirical distribution function of the index, practical use of the output stream rate index in the function of probability.

Keywords: output stream rate, longwall production faces, production process efficiency, mineral extraction.

12.1. Introduction

The production cycle, carried out at the longwall faces of hard coal mines, is of particular importance from the point of view of the effectiveness of the extraction process due to the fact that when analysing its course, unnecessary interruptions are eliminated, which results in decreasing its duration and improvement of its efficiency. These issues have been discussed, for example, by: (Brzychczy et al., 2014; Kęsek, 2017; Kopacz et al., 2018; Krauze, 2010; Magda, 2011; Snopkowski et al., 2016; Snopkowski et al., 2015; Snopkowski and Napieraj 2012; Snopkowski, 2012; Snopkowski and Sukiennik, 2012; Snopkowski and Sukiennik, 2013; Snopkowski, 2009; Sukiennik andNapieraj, 2015).

The effectiveness of the production cycle, as proposed by the authors of the paper, can be measured by the rate of the mining output stream. The method of its determination is presented in (Snopkowski et al., 2017).

In this paper, an attempt was made to determine this index, assuming that its nature would be undetermined. This will make enable the assessment of the level of this index (in fact, the stream of mining output from a longwall) in the function of probability. As a result, it will be possible to assess the efficiency of the production process, what was the purpose of this paper.

This is possible with the assumption of some parameters of the production cycle (those that show variability) in the form of random variables.

The calculation of the index in the function of probability was preceded by the following derivation of the formula for the calculation of this index in its determined version, as the formula is applied in further calculations.

Figure 1 presents a diagram of the production cycle in bidirectional longwall shearer cutting technology.

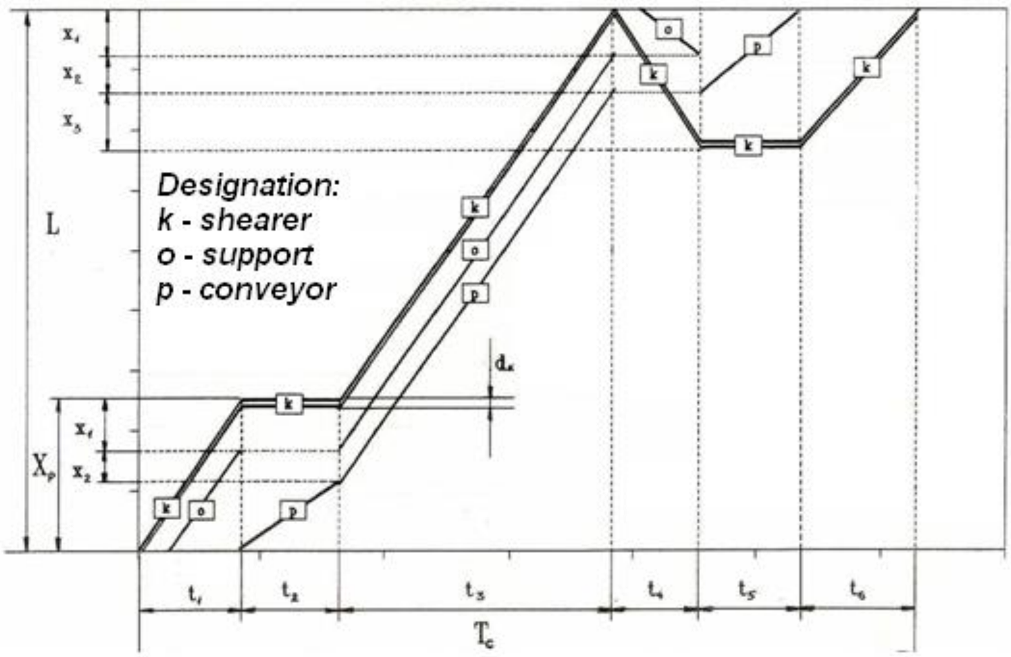

Figure 1. Diagram of the production cycle for the bidirectional shearer cutting technology

Source: (Snopkowski and Napieraj, 2012).

The following designations are used in the figure:

- L - longwall length [m],
- T_c - production cycle duration [min],
- $t_1, t_2, \dots, t_6$ - durations of individual production cycle elements [min],
- d_k - shearer length [m],

- x_1, x_2, x_3 - mutual distances of performed activities and operations within the shearer-support-conveyor system [m],
- x_p - distance from the shearer stop position to the junction between the longwall and the gate road [m].

The vertical axis represents the length of the longwall, while the horizontal axis represents the units of time. In accordance with the adopted technology, mining with a shearer is carried out to full height in both directions.

The scheme takes into account all activities and operations comprising coal cutting along the entire longwall to the depth of one web cut, the drives of the armoured face conveyor are in the perpendicular layout (recesses are not made).

The output stream rate φ_{2k} was determined using formula 1:

$$\varphi_{2k} = \frac{W_c}{T_c} \tag{1}$$

where:

φ_{2k} - output stream rate index in the bidirectional shearer cutting technology [Mg/min];

W_c - the output from the production cycle is determined using formula (2):

$$W_c = H \cdot z \cdot L \cdot \gamma \cdot \rho \tag{2}$$

where:

H – longwall height [m],

z – shearer web [m],

L – longwall length [m],

γ – bulk density of coal [Mg/m3],

ρ – web use index [-].

After appropriate substitutions, the formula determining the mining output stream rate index in the bidirectional shearer cutting technology takes the following form (3):

$$\varphi_{2k} = \frac{H \cdot z \cdot L \cdot \gamma \cdot \rho}{\frac{1}{V_{cz}}(x_p - d_k) + \frac{1}{V_r} \cdot (L - x_p) + \left(\frac{1}{V_z} + \frac{1}{V_r}\right) \cdot (x_2 + d_k + p + s) + t_2 + t_5} \tag{3}$$

A more detailed description of the quantities included in formula (3) – due to the volume limitations of this paper they are not included here – can be found in the paper (Snopkowski, 2009).

12.2.Mining output stream rate in the function of probability – specification of random variables

The course of the production process carried out at a hard coal longwall face, depends on a number of factors. They can be divided into two groups: geological/mining conditions and technical/organisational conditions (Napieraj, 2012; Sukiennik, 2012; Sukiennik and Napieraj, 2015).

The geological/mining conditions include, among others:

- roof type,
- floor type,
- coal cuttability,
- seam thickness and inclination,
- natural hazards.

The technical/organisational conditions, which have a significant impact on the production process, include:

- mechanisation system,
- technical specifications of the machines,
- equipment failure rate,
- the organisation of the production cycle, which includes the form of organisation of works, the form of organisation of labour, working system, training and experience of the employees.

It can be noted that the shearer advancement speed as well as, for example, the time devoted to works at the ends of the longwall - due to the influence of the above mentioned factors - can be treated as random variables, as they are variable and cannot be predicted in advance (they show variability in each production cycle).

In the calculation example, which was later included in the paper, these values were assumed to be random variables, which at the same time does not exclude the possibility of carrying out these calculations for other random variables. It should also be noted that for another set of random variables, the calculation scheme will not change and will remain as presented below.

Determined data, assumed in the calculation example, have the following values and designations:

L – longwall length 25 [m],

H - longwall height 3 [m],

z – web depth 0.6 [m],

γ – bulk density of coal 1.3 [Mg/m3],

ρ – web use index 1 [-],

x_p – distance from the shearer stop position to the junction between the longwall and the gate road 25 [m]

d_k – shearer length 12 [m]

x_2 – distance of the advancing conveyor from the supports 10 [m]

p – minimum distance of the advancing conveyor from the shearer 10 [m]

s – distance of the advancing roof supports from the shearer 9 [m]

The random variables used in the calculation example are the shearer advancement speed and the drive and boot end movement times. The designations and functions adopted for these variables are as follows:

V_{cz} – shearer maneuvering speed (shearer speed when clearing the shearer route) [m/min],

V_r – shearer working speed [m/min],

V_z – shearer working speed when cutting [m/min],

t_2 – boot end movement time [min],

t_5 – drive movement time [min].

The shearer manoeuvring speed V_{cz} is given with gamma distribution and the parameter of: α = 28; β = 1 with the analytical expression of: $f(x) = \frac{1}{\Gamma(28)} \cdot \mathrm{x}^{27} \cdot \mathrm{e}^{-\mathrm{x}}$ and presented in Figure 2.

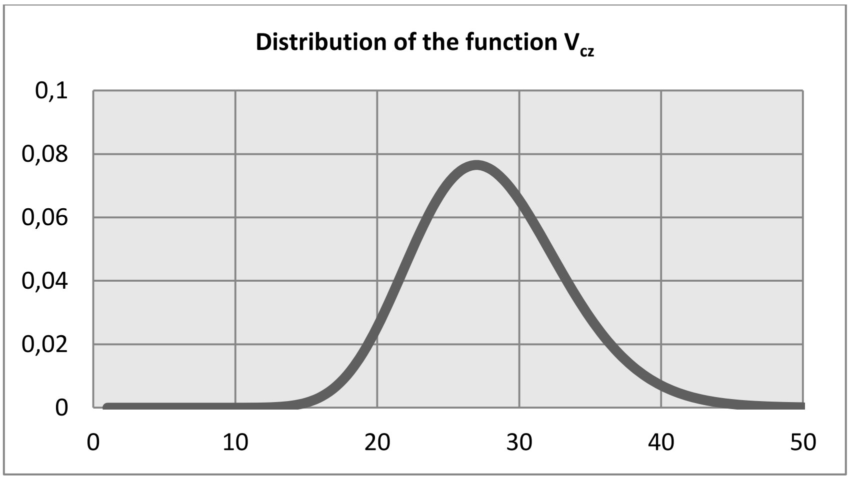

Figure 2. Distribution of the function describing the shearer manoeuvring speed Vcz

Source: self-reported data.

The shearer working speed V_r is given with gamma distribution and the parameter of: $\alpha = 13$; $\beta = 1$ with the analytical expression of: $f(x) = \frac{1}{\Gamma(13)} \cdot x^{12} \cdot e^{-x}$ and presented in Figure 3.

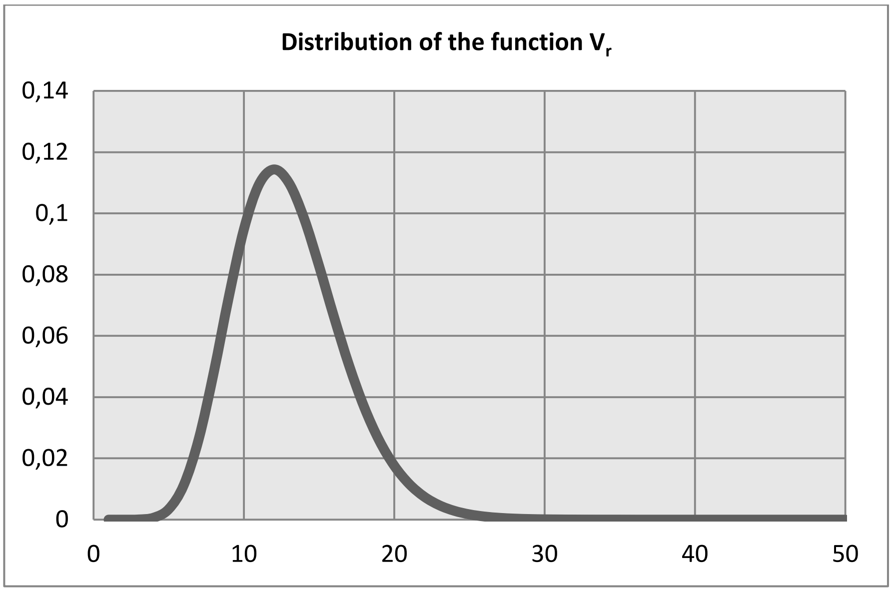

Figure 3. Distribution of the function describing the shearer working speed Vr

Source: self-reported data.

The shearer working speed when cutting V_z is given with gamma distribution and the parameter of: $\alpha = 6$; $\beta = 1$ with the analytical expression of: $f(x) = \frac{1}{\Gamma(6)} \cdot x^{5} \cdot e^{-x}$ and presented in Figure 4.

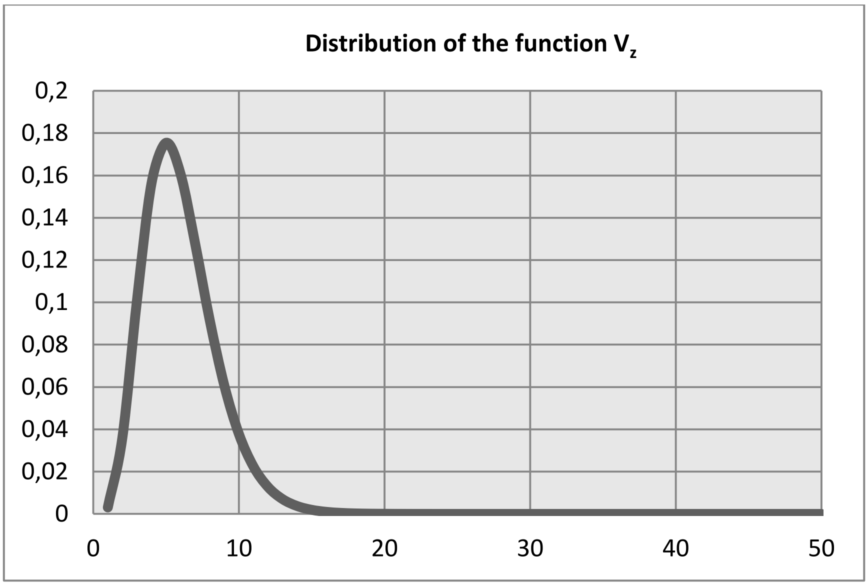

Figure 4. Distribution of the function describing the shearer working speed when cutting Vz

Source: self-reported data.

The boot end movement time t_2 is given with gamma distribution and the parameter of: α = 15; β = 1 with the analytical expression of: $f(x) = \frac{1}{\Gamma(15)} \cdot \mathrm{x}^{14} \cdot \mathrm{e}^{-\mathrm{x}}$ and presented in Figure 5.

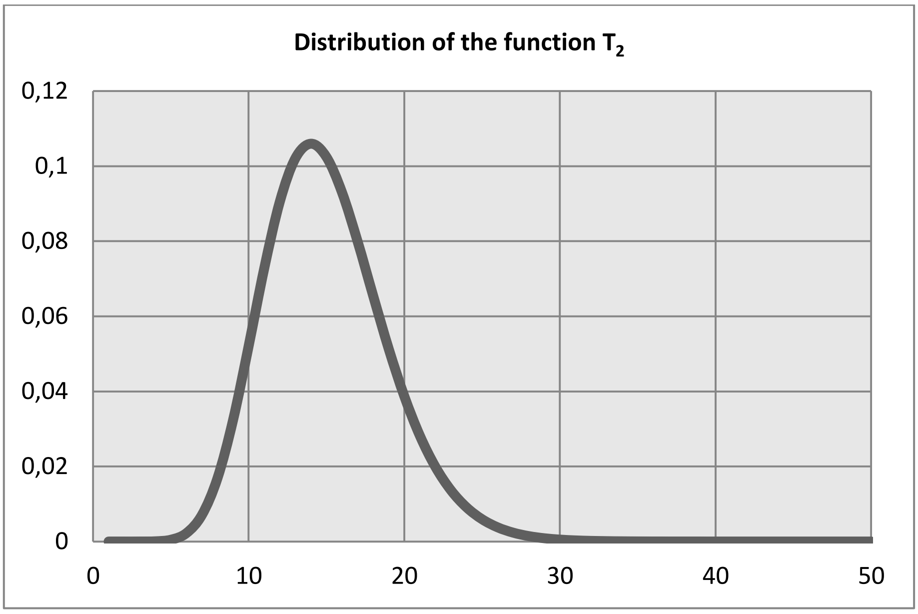

Figure 5. Distribution of the function describing the boot end movement time T2

Source: self-reported data.

The drive movement time t_5 is given with gamma distribution and the parameter of: α = 11; β = 1 with the analytical expression of: $f(x) = \frac{1}{\Gamma(11)} \cdot \mathrm{x}^{10} \cdot \mathrm{e}^{-\mathrm{x}}$ and presented in Figure 6.

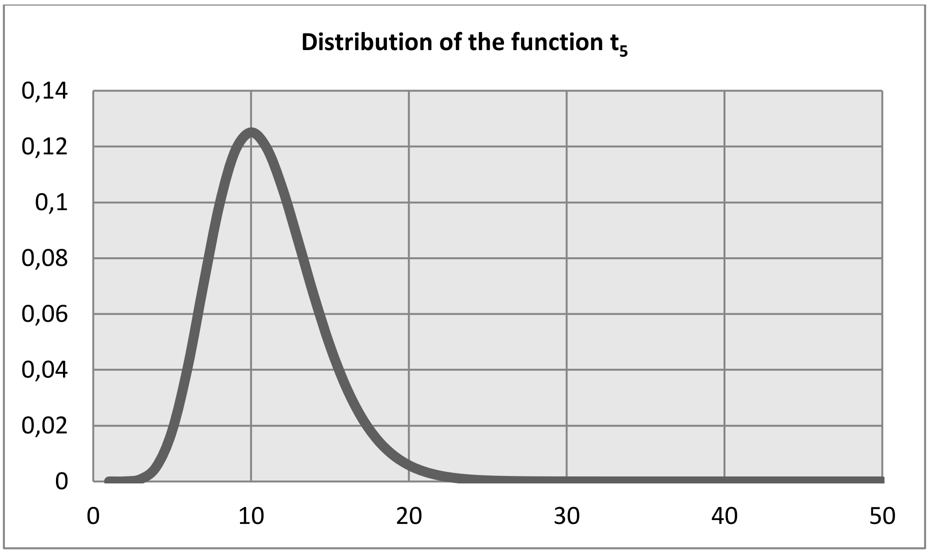

Figure 6. Distribution of the function describing the drive movement time t_5

Source: self-reported data.

12.3. Mining output stream rate in the function of probability – calculations scheme

The calculation scheme to be used to determine the mining output stream rate in the function of probability involves several stages:

Stage I: Stochastic simulation of the φ_{2k} index for the adopted random variables.

Stage II: Determination of the empirical probability distribution of the φ_{2k} index.

Stage III: Determination of the empirical distribution function of the φ_{2k} index.

Stage IV: Practical application of the mining output stream rate index φ_{2k} in the function of probability.

Stage I:

Figure 7 presents a scheme for the calculation of the output stream rate index in the bidirectional shearer cutting technology.

The calculations use the stochastic simulation method described in the paper by [14], among others. The method consists in iterative (n-fold) generation of values (realisations) of random variables, described by functions f(Vcz), f(Vr), f(Vz), f(t2) and f(t5), their substitution to equation (3) and calculation of the value of the φ_{2k}. index.

Generating values (realisations) of random variables is done using the distribution function reversal method (Snopkowski, 2007).

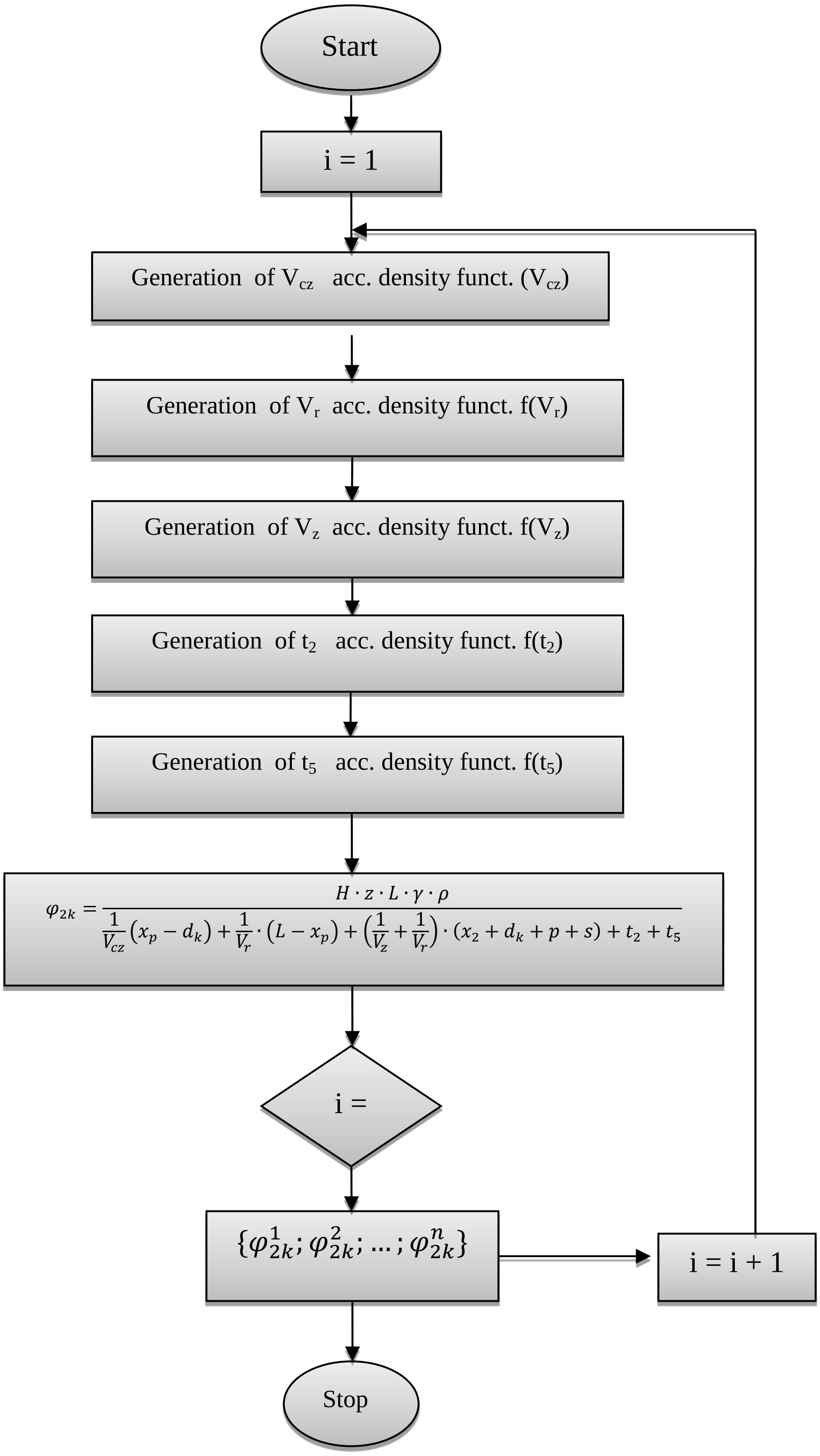

Figure 7. Calculation scheme for the output stream rate index in the bidirectional shearer cutting technology

Source: self-reported data.

As a result of the calculations, a set of values $\{\varphi_{2k}^1;\ \varphi_{2k}^2;\ \ldots;\ \varphi_{2k}^n\}$ for the output stream rate index in the bidirectional shearer cutting technology is obtained.

Stage II:

On the basis of the set $\{\varphi_{2k}^1;\ \varphi_{2k}^2;\ \dots;\ \varphi_{2k}^n\}$ of the recorded values of the φ_{2k} index, a histogram is created, which in the tabular form contains the ranges of values of the indicator and the corresponding absolute numbers.

Dividing the absolute numbers by the total number of iterations, equal to "n", provides the values of the empirical probability distribution of the φ_{2k} index, which are presented in graphic form in Figure 8.

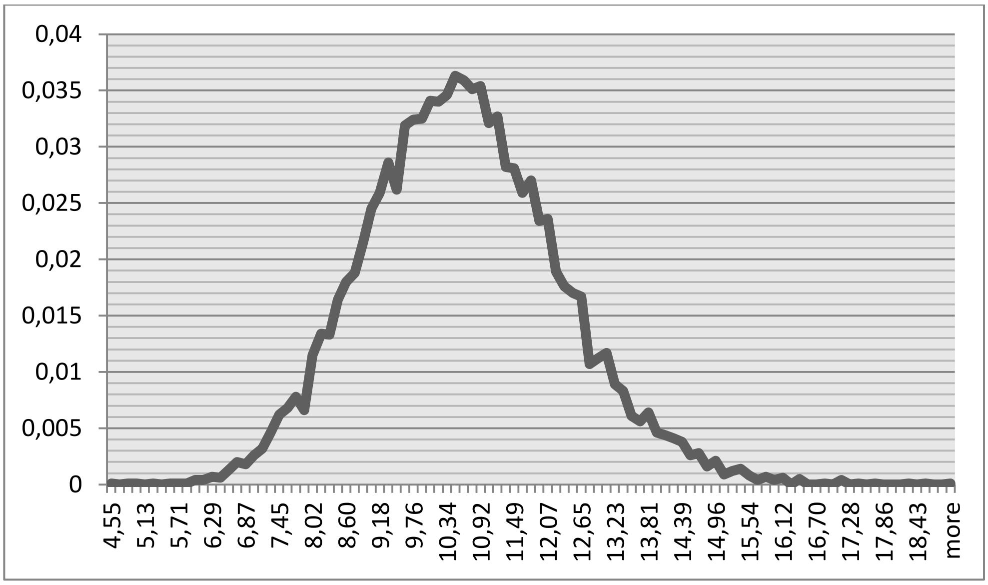

Figure 8. Empirical probability distribution of the output stream rate index φ_{2k}

Source: self-reported data.

Stage III:

The next step is to determine the empirical value of the distribution function of the output stream rate index φ_{2k}.

For this purpose, the values of the empirical probability distribution must be added. The addition should be carried out for the values - on the X-axis - starting from zero, up to the maximum value of the φ_{2k} index.

The left-hand boundary of the empirical distribution function is of course zero, while the right-hand boundary is the value of "1".

The empirical distribution function of the output stream rate index φ_{2k} obtained in this way is depicted in Figure 9.

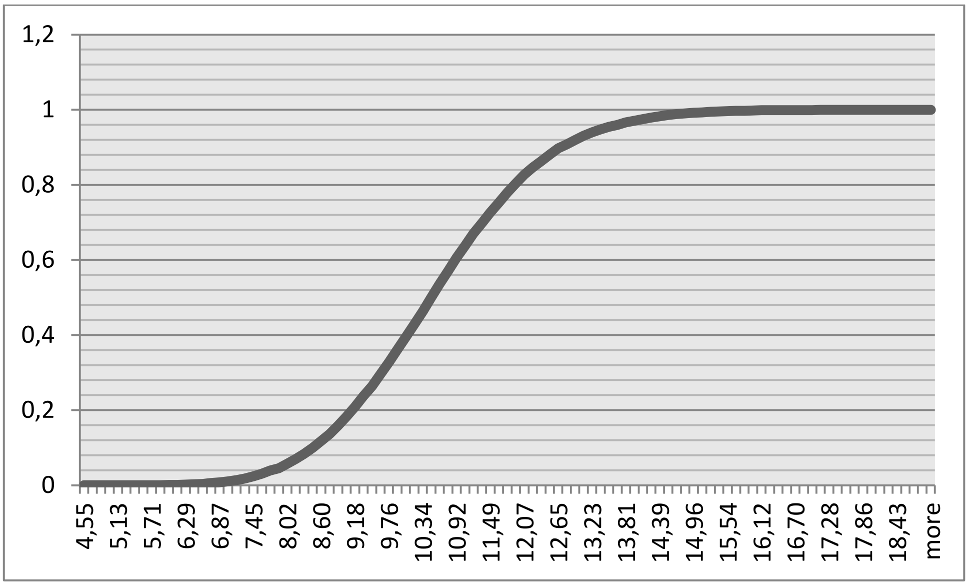

Figure 9. Empirical distribution function of the output stream rate index

Source: self-reported data.

Stage IV:

Determination of the empirical probability distribution for the output stream rate index φ_{2k} (stage II of the calculations) and the empirical distribution function of the index φ_{2k} (stage III of the calculations) enables the assessment evaluation of the effectiveness of the production cycle (in fact, the assessment of the mining output stream rate) in the function of probability.

Question examples:

1. What is the probability that the output stream rate will not exceed 7 [Mg/min]?

In order to answer this question, the empirical value of the distribution function at the point equal to 7 should be determined, i.e.

$P\ (\ \varphi_{2k} < 7\ [Mg/min]\ ) = F(7) = 0.0105$

It can be noted that the calculated probability is very low, so the chance that the output stream rate for this longwall face will not exceed 7 [Mg/min] is very low.

2. What is the probability that the output stream rate will be between 5 and 15 \[Mg/min]?

In order to answer this question, the difference of the empirical values of the distribution function at the point equal to 15 and 5 should be determined, i.e.

$P\ (\ 5 < \varphi_{2k} < 15\ ) = F(15) - F(5) = 0.9921 - 0.0003 = 0.9918$

The calculated probability is very high.

12.4. Conclusions

If the impact of geological/mining and technical/organisational conditions on the production cycle at the longwall face is so significant that it results, for example, in a variable (unstable) shearer advancement speed, then the assessment of the effectiveness of such a production process (made, for example, by evaluating the output stream generated in it) should take into account its unstable (undetermined) character.

This paper proposes the use of the mining output stream rate index φ_{2k} in the function of probability for this purpose.

The article provides a detailed scheme for the calculations that should be made in order to obtain a characteristic of the φ_{2k} index.

The calculation scheme has been divided into four stages:

Stage I: Stochastic simulation of the φ_{2k} index for the adopted random variables.

Stage II: Determination of the empirical probability distribution of the φ_{2k} index.

Stage III: Determination of the empirical distribution function of the φ_{2k} index.

Stage IV: Practical application of the mining output stream rate index φ_{2k} in the function of probability.

The last stage is also an interpretation of the obtained results, presenting some practical possibilities of their application. The source data for this interpretation are the empirical probability distribution and the empirical distribution function, the determination of which for the φ_{2k} index is described in detail in this paper.

The φ_{2k} index proposed in this paper, together with the method of its determination, may be useful in mining practice to assess the effectiveness of the production cycle carried out in the longwall face, with the use of bidirectional shearer cutting technology.

Acknowledgments

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References

Brzychczy, E., Kęsek, M., Napieraj, A., Sukiennik, M. (2014). The Use Of Fuzzy Systems In The Designing Of Mining Process In Hard Coal Mines. *Archives of Mining Sciences,* 59 (3), 741-760.

Kęsek, M., (2017). Visual Basic as a Tool for Monitoring and Analyzing Machines. *Inżynieria Mineralna-Journal of The Polish Mineral Engineering Society,* 2, 195-200.

Kopacz, M., Sobczyk, E., Galica, D. (2018). The Impact Of Variability And Correlation Of Selected Geological Parameters On The Economic Assessment Of Bituminous Coal Deposits With Use Of Non Parametric Bootstrap And Copula-Based Monte Carlo Simulation. *Resources Policy,* 55, 171-183, DOI: 10.1016/j.resourpol.2017.11.015.

Krauze, K. (2010). Model-Based Estimation Of Daily Production Output For Various Technologies Of The Longwall Operation. *Archives Of Mining Sciences,* 55 (4), 891-906.

Magda R. (2011). Modelling the mine production process in terms of planning the output volume with regard to the aspects of uncertainty and risk. *Gospodarka Surowcami Mineralnymi-Mineral Resources Management,* 27 (4), 45-57.

Napieraj, A., (2012). Metoda probabilistycznego modelowania czasu trwania czynności cyklu produkcyjnego realizowanego w przodkach ścianowych kopalń węgla kamiennego (The method of probabilistic modelling for the time operations during the productive cycle in longwalls of the coal mine), Wydawnictwa AGH: Kraków.

Snopkowski, R., Napieraj, A., Sukiennik, M. (2017). Examples of using the intensity indicator of winning stream for various longwall shearer-based mining technologies. *Zeszyty Naukowe Politechniki Śląskiej, seeria: Organizacja i Zarządzanie*, 3rd International Scientific Conference MEET 2017 (Management, Economics, Ethics, Technics).

Snopkowski, R., Napieraj, A., Sukiennik, M. (2016). Method Of The Assessment Of The Influence Of Longwall Effective Working Time Onto Obtained Mining Output. *Archives Of Mining Sciences,* 61 (4), 967-977.

Snopkowski, R., Napieraj, A., Sukiennik, M. (2015). Wybrane aspekty ryzyka w procesie produkcyjnym realizowanym w przodkach ścianowych kopalń węgla kamiennego (Selected aspects of risk in the production process in longwall fronts in coal mines). *Przegląd Górniczy,* 71 (8), 86–89.

Snopkowski, R., Napieraj, A.(2012). Method of the production cycle duration time modeling within hard coal longwall faces. *Archives of Mining Sciences,* 57 (1).

Snopkowski, R., (2012). Stochastyczne metody analizy procesu produkcyjnego realizowanego w przodkach ścianowych kopalń węgla kamiennego. Wydawnictwo AGH: Kraków.

Snopkowski R., Sukiennik, M. (2013). Longwall Face Crew Selection With Respect To Stochastic Character Of The Production Process - Part 2-Calculation Example. *Archives Of Mining Sciences,* 58 (1), 227-240.

Snopkowski, R., Sukiennik, M. (2012). Selection Of The Longwall Face Crew With Respect To Stochastic Character Of The Production Process - Part 1-Procedural Description. *Archives Of Mining Sciences,* 57 (4), 1071-1088.

Snopkowski, R., (2007). Symulacja stochastyczna. Wydawnictwo AGH: Kraków.

Snopkowski, R. (2009). Stochastic model of the longwall face excavation using two-way shearer mining technology. *Archives of Mining Sciences,* 54.

Sukiennik, M. (2012). Metoda wyznaczania obsady w przodkach ścianowych kopalń węgla kamiennego z uwzględnieniem stochastycznego charakteru procesu produkcyjnego (The method to determine a longwall face staff in coal mines considering the stochastic nature of the production process) Wydawnictwa AGH: Kraków.

Sukiennik, M., Napieraj, A. (2015). Ocena ryzyka w procesie produkcyjnym realizowanym w przodku ścianowym kopalń węgla kamiennego (Evaluation of the risk in production process within hard coal longwall faces). *Zeszyty Naukowe Uniwersytetu Szczecińskiego,* 855.

Sukiennik, M., Napieraj, A. (2015). Proces produkcyjny realizowany w przodkach ścianowych kopalń węgla kamiennego w Polsce w ujęciu logistycznym. *Logistyka,* 4.

Chapter 13

THEORY OF INVENTORY MANAGEMENT WITH A VIEW OF STOCHASTIC MODELS

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Abstract

Study will deal with inventory management issues. Already since the 20th century, emphasis has been placed on the continuous improvement of the efficiency of business activities. Due to often uncertain market trends and fluctuating demand or production and changing delivery times, inventory management is very difficult. Inventory management is part of the daily business process. If the company does not figure out correct timing of the replenishment of the inventory and the quantity, the demand may not be met, and this may lead to lost sales. Decision-making on inventory management strategy is one of risk-taking situations. This study analyses issues of inventory management using stochastic models. Stochastic models are used in fluctuating demand, which is relevant with extractive industries and energy sector. The aim is to compare stochastic models. To what extent do results differ in their use in the specific conditions. The goal of study is to introduce the least costly and least risk model for the company from the point of view of inventory management.

Keywords: inventory theory, inventory management, stochastic models, supply chain.

13.1.Inventory

All types of companies, both Czech and foreign, are struggling with the problem of the amount of inventory in stock for both raw materials and goods or products. It can be said that the supplier is unable to meet the demand immediately if he does not have enough inventory in stock (Winston 2004). Many authors are concerned with various inventory optimization models. The basic inventory management models are deterministic, but they are a decision-making model behind certainty that does not consider the variable consumption over time (Polanecký, 2018). Deterministic models are no longer used today.

Many companies have a variable consumption over time and they do not know predict consumption in the future. Therefore, we will deal with stochastic models dealing with risk-taking in this article, so consumption is counted as a random variable. The aim of the article is therefore to optimize inventories using stochastic models.

The main question is why company must manage its inventory? How does it manage? Inventory must manage because they take your many. If company does not manage inventory, it cannot meet the demand of its customers. The result may be a lack of money but a surplus of materials in stock.

13.2.Stochastic models for inventory optimization

If the company does not use inventory management, it may encounter several problems. The first of them is the obsolescence of the stored products. A lot of raw material on stock after a certain storage period they become unusable. The second one is the financial problems. The amount of inventories and the ways in which they are managed have a direct impact on business profitability and the need for available financial resources. This is due to the fact that inventory is tied to company capital. If those units are stored for a long time in the company, the capital that they represent cannot be used or invested somewhere else. The third issue is the cost related to the holding inventories, which includes the handling costs, the building space for inventory. These issues should be solved through efficient inventory management that matches a particular company (Baglin et al., 2001).

This model, otherwise known as the Miller-Ori model is based on the assumption that the state of the current assets (inventory, cash) in the enterprise changes over time. Against the deterministic models where demand-type variables, consumption, acquisition time were known and constant (determined). In practice we usually encounter stochastic models where the values of these variables are random and only to some extent predictable (Malliaris and Brock, 1982).

Which is a more realistic approach than deterministic models. Stochastic models can be seen as a regulatory tool for optimizing inventory in the company. These models work with demand forecast based on previous periods. Two quantities are used to control inventory, which is the quantity ordered and the length of the ordering interval. Stochastic models differ from deterministic models by demand, which is expressed by a random variable with probability distribution. The most common assumption is the normal distribution with mean value and standard deviation (Bartmann, 1992). There are two basic systems for stochastic models (Bartmann, 1992), namely Q system and P system.

13.2.1. Q system

Model has a constant delivery quantity. To accomplish such a task, it is necessary to determine the probability distribution of random demand over a period and also to estimate its median and the standard deviation. The commonly used probability source is data on past demand for a sufficiently long past period. It is a convenient solution to categorize data of demand by intervals by days into a table divided by the frequency and then determining the required values. When inventory optimization is set, the lower limit and the value of the delivery is constant throughout. Therefore, if the stock level drops below the lower limit (level), you need to order a given amount (Mahadevan, 2009).

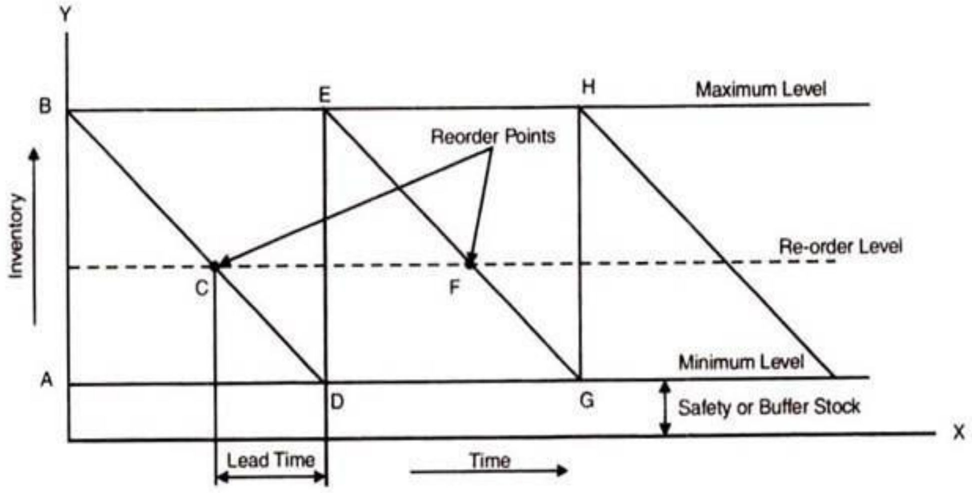

Figure 1. Q system

Source: (Vaishnavi, 2018).

13.2.2.P-system

Model has a fixed ordering interval for stock replenishment. This model specifies the time of the order, which repeats all the time and the upper order limit. At a given time, we will find the inventory status of stocks and add stocks up to the upper limit. Because there is fixed ordering time the uncertainty interval is longer than the previous system. For example, if there was not ordered enough quantity at one time, you need to wait until the next appointment. In order to create a sufficient supply, the uncertainty interval must be equal to the sum of the average order completion date and the average delivery cycle. The order quantity in this model is dependent on demands, safety stock and current inventory (Mahadevan,2009).

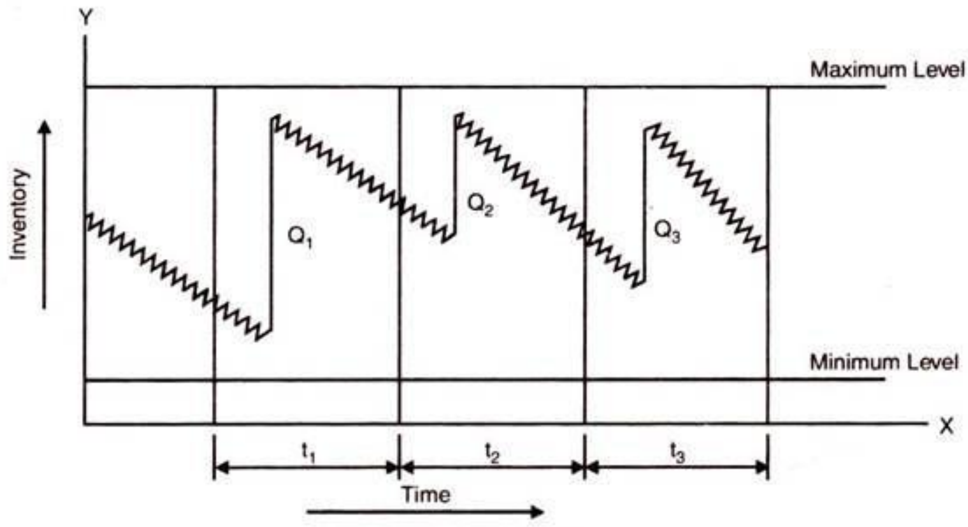

Figure 2. P system

Source: (Vaishnavi, 2018).

13.3. Data

Data was provided to me by ABC ltd. whose main activity is the production of refractory materials. There is a single product and a single location. We choose demand for bauxite because is it is the basic raw material for production of refractory materials. It is a Czech company, so We calculated costs related with inventory in CZK.

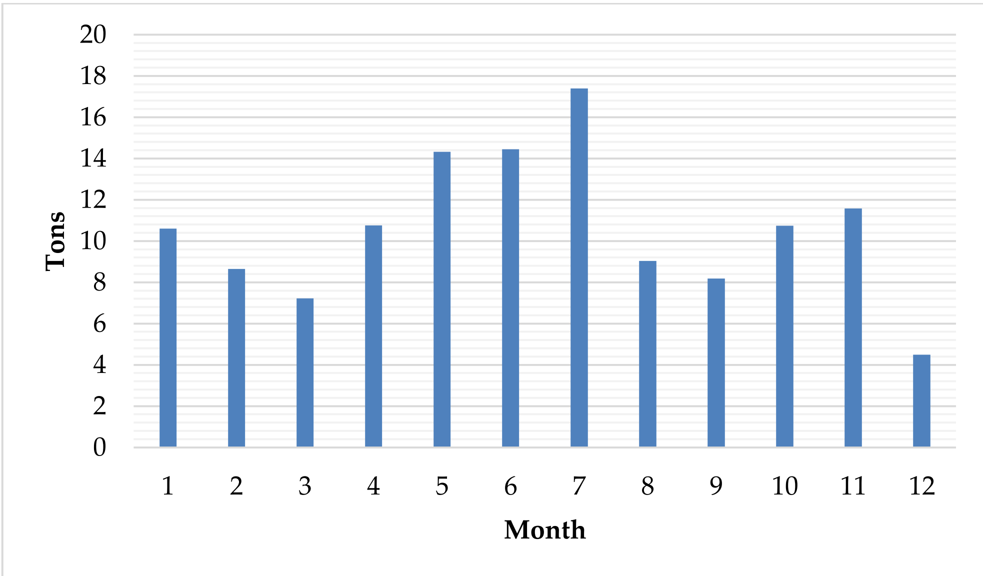

Figure 3. Total sum for demand for bauxite in the company

Source: own processing.

The data shows the demand for raw material (bauxite) during 2017, which you can see in Table 1, and also total sum demand per month for bauxite you can see in the Figure 3.

Table 1. Demand for bauxite in tons

Date	02.01.	09.01.	16.01.	23.01.	30.01.	06.02.	13.02.	20.02.	27.02.
Demand	4,11	1,1	1,53	0,54	3,32	1,75	2,99	1,86	2,04
Date	06.03.	13.03.	20.03.	27.03.	03.04.	10.04.	17.04.	24.04.	01.05.
Demand	1,89	1,12	2,51	1,62	2,51	5,25	2,49	0,5	2,16
Date	08.05.	15.05.	22.05.	29.05.	05.06.	12.06.	19.06.	26.06.	03.07.
Demand	6	3,25	0,48	2,43	4,05	1,35	2,3	6,75	2,7
Date	10.07.	17.07.	24.07.	31.07.	07.08.	14.08.	21.08.	28.08.	04.09.
Demand	3,12	1,62	2,7	7,25	2,23	3,6	2,8	0,4	2,64
Date	11.09.	18.09.	25.09.	02.10.	09.10.	16.10.	23.10.	30.10.	06.11.
Demand	1	1,96	2,59	1	2	2,9	3,72	1,12	2,89
Date	13.11.	20.11.	27.11.	04.12.					
Demand	2,3	3,48	2,91	4,49					

Source: ABC ltd.

Table 2. Auxiliary calculations for probability distribution of demand

Intervals	Demand (tons)	Centre of the interval s'_i	Frequency n_i	$s'_i \times n_i$	$n_i\ (s'_i - \bar{s})^2$
I1	0-0,5	0,25	3	0,75	15,53
I2	0,6-1	0,75	3	2,25	9,46
I3	1,1-1,5	1,25	5	6,25	8,13
I4	1,6-2	1,75	8	14	4,81
I5	2,1-2,5	2,25	8	18	0,61
I6	2,6-3	2,75	9	24,75	0,45
I7	3,1-3,5	3,25	4	13	2,1
I8	3,6-4	3,75	3	11,25	4,5
I9	4,1-4,5	4,25	2	8,5	5,95
I10	5-5,5	5,25	1	5,25	7,42
I11	5,6-6	5,75	1	5,75	10,4
I12	6,5-7	6,75	1	6,75	17,85
I13	7,1-7,5	7,25	1	7,25	22,32

Source: own processing.

The first step is to find out the probability distribution of demand. Because we have a lot of data, we have to sort them into 13 intervals which we have specified the centre the frequency of the data at individual intervals. The other columns are helpful for determining average demand and standard deviation for determination probability distribution of demand. The most commonly used theoretical distributions are the normal, exponential, Poisson distribution, or the empirical distribution. The best way how to find out is to illustrate the data and combine it with a curve. Then we will compare the curve with the curve with a particular distribution and calculate if that's true.

$$\bar{s} = \frac{\sum_{i=1}^{n} s'_i \times n_i}{n} \tag{1}$$

$$\sigma_s = \sqrt{\sum_{i=1}^{n} (s'_i - \bar{s})^2 \, n_i / n} \tag{2}$$

The average demand for bauxite from formula nr. 1 is therefore 2.53 tons and a standard deviation which we calculated from the formula is 1.5 tons. The standard deviation indicates how far the individual surveyed values differ from each other. If it is small, the elements of the set are mostly similar to each other and a large standard deviation signifies big differences to each other (Bartmann,1992).

In the next step, it is necessary to determine the normalized variable of the normal probability distribution for the upper limit of the intervals according to the relation (3) and find out the distribution function value from the statistical tables. The theoretical frequencies are calculated from Gross (4). We adjust these frequencies as the last three intervals are less than 1, so we add up and result is 11 intervals.

$$u = \frac{(h - \bar{s})}{\sigma_s} \tag{3}$$

$$n^T = \Delta * n \tag{4}$$

Now I have to calculate partition values x^2. The condition for using this relationship is that sums of theoretical and empirical frequencies are equal. In the statistical tables of quanta, the chi quadratic (x^2) distribution can be found for the chosen significance level (95% for common practice) and the number of degrees of freedom c-3 (where c is the number of intervals) is the appropriate q (calculated quantity). If the calculated values apply to $x^2 \leq$ q then it is not possible to reject the assumption of distribution normality. If the demand complies with the normal probability distribution it is possible to estimate the amount of the insurance stock at this point regardless of the cost of maintaining the stock the size. So, the test of the normal distribution must meet the condition that the critical quantity must be less than the calculated quantity (Gros, 2009; Karpíšek, 2018):

- $v = c - 3 = 11 - 3 = 8$, where c…number of intervals

- $x^2 = 50{,}6 - 49 = 1{,}6\ldots$ critical quantity
- ${x_{0,95}}^2(8) = 15{,}5\ldots$ calculated quantity
- $15{,}5 > 1{,}6$... so, the condition is met

In this example, the normal distribution criterion is confirmed, i.e. normality is accepted
at 8 degrees of freedom at 95%. For the exponential, Poisson distribution, or the empirical distribution, applies the same procedure with other criteria. After we found a distribution probability we need to get additional data for the calculation. We can use some computer programs for these calculations, but we need to know how to calculate the result and know which distribution probability we use.

Table 3. Probabilistic distribution of demand for bauxite

Intervals	Upper limit h	Standard variable u	Distribution function F	Difference Δ	Teoretical frequency n^T	Adjusted frequency n^T	Real frequency	Share n^2/n^T
	$-\infty$	$-\infty$	0	0	0			
I1	0,5	-1,35	0,09	0,09	4,36	4,36	3	2,06
I2	1	-1,02	0,16	0,07	3,38	3,38	3	2,66
I3	1,5	-0,69	0,25	0,09	4,26	4,26	5	5,86
I4	2	-0,35	0,36	0,12	5,78	5,78	8	11,07
I5	2,5	-0,02	0,5	0,14	6,71	6,71	8	9,53
I6	3	0,32	0,63	0,13	6,13	6,13	9	13,22
I7	3,5	0,65	0,74	0,12	5,73	5,73	4	2,79
I8	4	0,99	0,84	0,1	4,7	4,7	3	1,91
I9	4,5	1,32	0,91	0,07	3,38	3,38	2	1,18
I10	5,5	1,99	0,98	0,07	3,38	3,43	1	0,29
I11	6	2,32	0,99	0,01	0,69	1,18	3	7,65
I12	7	2,99	1	0,01	0,44			
I13	7,5	3,33	1	0	0,05			
	∞	∞	1	0	0			
SUM					49	49	49	50,6

Source: own processing.

Auxiliary data for inventory optimization at normal demand breakdown by ABC ltd. are shown in Table 4. To ensure continuous production, 127.38 tons of bauxite must be delivered. The cost including transport is 3,333 CZK per ton. The cost of handling and delivery is 3,000 CZK. The annual inventory maintenance costs are approximately 20% of the average stock value per year. It is necessary to determine how large the deliveries and how often the production of refractory materials needs to be provided to keep costs as low as possible.

Table 4. Additional company information

Data	Designation	Amount	Units
Annual demand	S	127,38	tons/year
Standard deviation	σ_{Qd}	1,5	tons
The purchase period	t_v	20	days
Unit acquisition costs	n_s	20	% of the average stock per year
Cost of order execution	n_j	3 000	CZK
Price per unit	c	3 333	CZK

Source: ABC ltd.

Basic formulas for Q and P systems calculation (Winston, 2004):

- optimal quantity delivery:

$$Q_{opt} = \sqrt{\frac{2Sn_j}{Tn_s c}} \tag{5}$$

- costs related to delivery:

$$N(Q_{opt}) = \sqrt{2STcn_s n_j} \tag{6}$$

- safety stock at 95%:

$$w \geq z_{0,95} \times \sigma_{Qd} \tag{7}$$

- safety stock at 99%:

$$w \geq z_{0,99} \times \sigma_{Qd} \tag{8}$$

- signaling stock status (reorder level):

$$r = \mathrm{S} \times t_v + w \tag{9}$$

$$t_c = \frac{T}{S/Q_{opt}} \tag{10}$$

- order time:

$$\sigma_{t_{vo}+t_c} = \sqrt{(t_{vo} + t_c)\sigma_{Qd}^2} \tag{11}$$

- upper order limit:

$$x_{h95} = S(t_{vo} + t_c) + z_{95}\sigma_{t_{vo}+t_c} \tag{12}$$

Results that a less costly is P system. P system include the lower cost of the specified quantity and the ordered quantity of material. But this is a riskier model, because there may be a sudden depletion of inventory, but the company can refill this material until the 17th day of the order. At the example ABC company with P system inventory management there will be more inventory depletion than inventory management with Q systems.

Table 5. Calculated values Q and P system

Data	Designation	Q system Value for z=0,95	P system Value for z=0,95	Q system Value for z=0,99	P system Value for z=0,99	Units
Optimal quantity delivery	Q_{opt}	6,18	6,18	6,18	6,18	tuns
Costs related to delivery	$N(Q_{opt})$	5747,92	5577,91	7728,73	5840,1	CZK
Safety stock	w	2,46	0,79	3,48	1,12	tuns
Signalling stock status	r	9,44	7,87	10,46	8,20	tuns
Order time	t_c	-	17	-	17	days
Upper order limit	x_{h95}	-	13,95	-	14,28	tuns

Source: own processing.

You can see from Table 5 also that signaling stock status of the Q system. This mean if inventory in stock will fall to 9,44 tons we have to order 6,18 tons material. But the con is that we do not have inventory right now, but we need to count delivery time. From Table 5 we also see the upper order limit of the P system is 13,95 tons. But con in this model is when we find out after 17th day that our inventory in stock is 9,44 tons, we have to order 4,51 tons (add up to 13,95 tons) and what do we do when the next day comes the demand for 6 tons? P system counts with 17 days tracking, so we will not know about consumption between this period. The loss in the amount of unsatisfied demand will be reflected in money and sales.

Given the high risk of stock depletion during variable demand, I propose to combine the Q and P system, when inventory management considers the Q-system stock signal status and if the stock falls below this lower limit, then the company orders the quantity that remains in the upper order limit of P-system. This reduces storage costs and reduces the risk of stock depletion. The state of stock depletion can be seen in Table 6, where the yellow cell means the ordering time of the material.

Table 6. Stock status for each inventory management methods (tons)

Demand	Stock monitoring	Month monitoring	Q system for z=0,95		P system for z=0,95		Combination Q and P system for z=0,95	
			Inventory status in stock	Time ordering + quantity in stock	Inventory status in stock	Time ordering + quantity in stock	Inventory status in stock	Time ordering + quantity in stock
6,00	08.05.	5	1,72		5,29		7,43	
3,25	15.05.	5	-1,54	4,65	2,04	4,70	4,18	
0,48	22.05.	5	4,17	10,35	4,22		3,70	10,22
2,43	29.05.	5	7,92		1,79		7,79	
4,05	05.06.	6	3,87		-2,26	7,47	3,74	
1,35	12.06.	6	2,52	8,70	6,12		2,39	8,55
2,30	19.06.	6	6,40		3,82	10,30	6,25	
6,75	26.06.	6	-0,35	5,83	3,55		-0,50	11,06
2,70	03.07.	7	3,13		0,85		8,36	
3,12	10.07.	7	0,01	6,19	-2,27	8,13	5,24	
1,62	17.07.	7	4,57		6,51		3,62	9,21
2,70	24.07.	7	1,87	8,05	3,81	9,63	6,51	
7,25	31.07.	7	0,80		2,38		-0,74	9,59
2,23	07.08.	8	-1,43	4,75	0,15		7,36	
3,60	14.08.	8	1,15	7,33	-3,45	8,12	3,76	

Source: own processing.

From Table 6 we can see if we want in 95% fulfilment demand of bauxite we will bear the smallest losses with combination Q and P system. If we count Q system will bear a loss of 3.32 tons, P system counts a loss of 7,98 tons and combination of Q and P system will bear a loss of 1,24 tons. The number of orders with combination Q and P system will be the same as for the Q system. So, the best result is combination Q and P systems. The result of z=99% is the best choice combination Q and P system as the least risk option for inventory management. For the Q and P system combinations we apply signalling stock status from Q system (10,46 tons for z=99%) and upper order limit from P system (14,28 tons for z=99%).

13.4. Conclusions

The aim was to propose improvements in inventory management that will lead to a reduction costs and speeds up the process of ordering the material and thereby stabilizing the business. Every company is forced to have inventory to take charge of their management and decision what is more advantageous for them and what they do not. If it orders a large amount of inventory it achieves the smooth running of the production satisfies the needs of its customers in full it can make use of quantity discounts for suppliers. But from a second perspective, some storage costs may increase by increasing warehouse capacity or utilizing rent. Also, the funds embedded in large amounts of inventory could use the companies better. Conversely if it keeps stocks low there may be interruptions in production failure to meet deadlines in the worst-case loss of customers. Therefore, the management of the company or the responsible managers should choose the appropriate compromise. Our study has answered the question of how to efficiently manage inventory using Q and P systems. Q system use when the order quantity is fixed for all the orders and P system is used when orders have to be placed at fixed time intervals such as weekly, biweekly, or monthly. This information has been constituted of two elements: the inventory level and the demand forecast. In our opinion for our example with bauxite none of these models is effective for a given demand. That's why we combined these models with Q-system stock signal status and the upper order limit of P-system designed the optimal solution that companies could follow. It has to be said that the demand for bauxite had the character of a normal distribution. If demand for raw material had different distribution, e.g. F-distribution, Student´s distribution, etc. we have to calculate average demand and standard deviation other formulas for specific distribution. Then we can continue count example with basic formulas. For further research we want to check this combination Q and P system in demand with different distribution and we want to propose a better inventory management system for companies. Given that demand forecasts are generally determined by random changes, we have shown the impact of uncertainty, which is the main source of uncertainty. We choose this topic because a lot of companies have problem with management inventory. Companies have a lot of money in stock and they do not know how to manage this and do business more effectively.

References

Baglin, G., Bruel,O., Garreau, A., Greif, M., van Delft, C. (2001). Management Industriel et Logistique. Economica: Paris.

Bartmann, D., Beckmann, M. J. (1992). Inventory Control. Models and Methods. SpringerVerlag: Berlin.

Gros, I. (2009). Matematické modely pro manažerské rozhodování. University of chemistry and technology Prague: Prague.

Jensen, A. P., Bard, F. J. (2001). Operations Research Models and Methods: www.me.utexas.edu/~jensen/ORMM/supplements/models/inventory/sq_variations.pdf [25.1.2018]

Karpíšek, Z. Statistické tabulky: http//mathonline.fme.vutbr.cz/ [25.1.2018]

Kořenář, V. (2010). Stochastické procesy. Oeconomica: Prague.

Lukáš, L. (2005). Pravděpodobnostní modely. Západočeská univerzita: Plzeň.

Mahadevan, B. (2009). Operation Management: Theory and Practice. Dorling Kindersley (India), licensees of Pearson Education in South Asia: New Delhi.

Malliaris, A., Brock, W. (1982). Stochastic Methods in Economics and Finance. North- Holland: Amsterdam.

Polanecký, L. (2017). Teorie řízení zásob pohledem matematickým modelů: https://search-proquest-com.ezproxy.lib.vutbr.cz/docview/1929035082?accountid=17115 [25.1.2018]

Vaishnavi, N. (2018). Essay on Materials Management. http://www.businessmanagement ideas.com/essays/materials-management-essays/essay-on-materials-management-top-6-essays-production/12031 [29.6.2018]

Winston A., Wayne, L. (2004). Operations Research: Applications and Algorithms. Belmont: Brooks/Cole - Thomson Learning.

PART III

Social and environmental aspects of management in extractive industries

Chapter 14

THE CORPORATE SOCIAL RESPONSIBILITY PRACTICES IN AUSTRALIAN MINING SECTOR

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Abstract

There is in the paper a description of Australian system of CSR activities and practices. Purpose of the article is to analyze CSR practices used in Australian mining industry. There is in the paper an analysis of Australian industry practices in CSR. Also we concentrate on sustainable mining, impact of mining industry on CSR practices, and some examples of CSR practices used in Australian mining industry. The main method using in the research in this paper was the critical literature analysis. The analysis of the paper of the Corporate Social responsibility systems in Australian mining industry has been done. Practical implication: we can use the practices using in Australian mining industry in Polish or Russian mining industry. It's important because the mining industry is detrimental for the natural environment and the use of CSR practices can cope with this situation. The main limitation of this paper is the use only data from published papers and not from companies because author doesn't have access to primary sources from Australia. Also the limitation is that the analysis is based only on one country in the future analysis the more complex comparative analysis can be conducted.

Key words: Corporate Social Responsibility, CSR, mining industry, CSR practices, CSR reporting.

14.1. Introduction

In last year Corporate Social responsibility has become an increasingly significant phenomenon around the world. The mining industry also try to follow this trend and conduct social responsibility action and participate in CSR reporting systems (Azapagic, 2004; Cowell, 1999, Esteves, 2008, Górecki, 2010; Vintro and Comajuncosa, 2010; Wheeler et al. 2002). In many countries mines try to implement and improve their CSR policy and practice according to world leading trends (Worral et. al., 2009). Mining generates strong and sustainable benefits for Australia for example" export, revenue, employment and technology transfer. The aim of presented paper is to analyze CSR practices used in Australian mining industry.

Purpose of the article is to analyze CSR practices used in Australian mining industry. There is in the paper an analysis of Australian industry practices in CSR. The main method using in the research in this paper was the critical literature analysis. The analysis of the paper of the Corporate Social responsibility systems in Australian mining industry has been done.

14.2. Research background

The beginnings of modern corporate social responsibility can be traced back to the 1920s. The concept rose into the public domain during the mid-20th century and has gained increasing attention over past two decades (Hąbek and Wolniak, 2016; Wolniak and Hąbek, 2016; Hąbek and Brodny, 2017; Ryszko, 2017; Hąbek, 2017). Very important triggers in this process were: the introduction of the Global reporting Initiative in 2002 (GRI) and United nations Global Compact in 2000 (Truscott, 2007).

One of the classic definition of CSR concept say that a business organization's configuration of principles of social responsibility, processes of social responsiveness, and policies, programs, and observable outcomes as they relate to the firm's societal relationships (Wood, 1991).

Other CSR definition is the definition use by European Union. According this definition CSR is the responsibility of enterprises for their impact on society. CSR should be company led. Public authorities can play a supporting role through a smart mix of voluntary policy measures and, where necessary, complementary regulation (Communication, 2011).

Very interesting material about the realization of CSR conception in Australia is in the report preparing by ACCSR. In this report there are annual review of the state of CSR in Australia and New Zealand. The newest report date from 2017. We can distinguish the main actors within the Australian CSR industry (Truscott, 2007):

- peak and industry bodies,
- CSR consultants,
- research centers,
- media,
- business,
- state and local government,
- federal government,
- third sector organizations,
- regulatory bodies.

According to mentioned report the main CSR strategy priorities in the CSR practices in Australia are as follows (ACCSR, 2017):

- building stronger relationships with stakeholders,
- managing the implication of technology (data security, privacy, etc.),
- managing regulatory impacts,
- strengthening our social license to operate,
- building internal understanding and support for CSR sustainability approach,
- developing new products or services with environmentally responsible attributes,
- improving supply chain policies and practices,
- working to address labor relations issues,
- addressing human rights issues within sphere of influence,
- working to combat business corruption.

In recent years building stronger relationship with stakeholders remains the highest priority for almost all organization. 83% Australian organization point out that this is the key priority in CSR strategy. Australian organization participate in the case of CSR practices in many actions for example (ACCSR, 2017):

- no poverty,
- zero hunger,
- good health and wellbeing,
- quality education,
- gender equality,
- clean water and sanitation,
- affordable and clean energy,
- decent work and economic growth,
- industry, innovation and infrastructure,
- reduced inequalities,
- sustainable cities and communities,
- responsible consumption and production.
- climate action,
- life below water,
- life on land,
- peace, justice and strong institution,
- partnership for the goals.

The most likely action are assessing organizational impacts connected to Climate Action and engaging in strategic partnership which aim is to reduce poverty (Rao, 2016). Australian organization think that sustainability reporting should be mandatory for organization in certain size (53% of respondents). 40% thinks that this reporting should be obligatory only for big companies. Only 7% of respondents think, that CSR reporting shouldn't be obligatory.

Reporting CSR activities is very useful according to respondents view. They can point out following advantages of CSR reporting for they organizations (ACCSR, 2017):

- built our reputation for being a responsible business,
- contributed to brand positioning,
- engaged senior leadership in strategic conversation about organization,
- improved stakeholder engagement,
- identified opportunities for performance improvement,
- improved employee engagement,
- helped the organization to better understand the material issues that affect organization,
- helped to better understand the risk the organization faces,
- helped to identify opportunities to improve efficiency,
- lead to improved investor engagement.

CSR has become an increasingly powerful phenomenon in Australia. The governmental response has been one of encouragement, evident in the introduction of the Prime Minister's Business Community Partnership (PMCBP) awards, parliamentary enquiries into CSR and related reports commissioned by government departments. Meanwhile, the corporate sector has developed CSR positions, departments and committees, while also seeking expert advice on CSR strategy development from niche CSR consultancies. CSR conferences and events have also become a regular occurrence in Australia, reflecting the topical nature of the subject and the wide range of actors interested in its development (Truscott, 2007; Evans, 2010; Galbreath, 2010).

14.3. Research results

The main method using in the research in this paper was the critical literature analysis. The analysis of the paper of the Corporate Social responsibility systems in Australian mining industry has been done.

Australian mining industry is one of the better developing mining industries in the word. While in many countries the amount of mining industry production decrease in Australian industry is an incredible 10 years of growth largely due to strong demand for resources from emerging economies such as China (Jones et al., 2007; Ross, 2016). New mining operations in Australia are mostly established in remote areas or in regional, non-metropolitan, areas which are typically rural and serviced by a small number of towns (Thirarungrueang, 2013).

Mining lifecycle is very long (fig 1). It has many relation with society, that need to carefully considered development of social sustainable approach (Skotnicka-Zasadzień, 2014). The key interactions of mining industry with society are as follows (Sustainable mining, 2015):

- community engagement,
- resource governance,
- indigenous agreement-making,
- negotiations and agreements,
- occupational health and safety,
- precompetitive data,
- regional development,
- post mining economy,
- environmental and water management,
- mineral economics and policy,
- mine closure and post mining land use,
- local content and enterprise,
- education, training and skills,
- revenue design and administration,
- infrastructure planning and delivery,
- mine waste management.

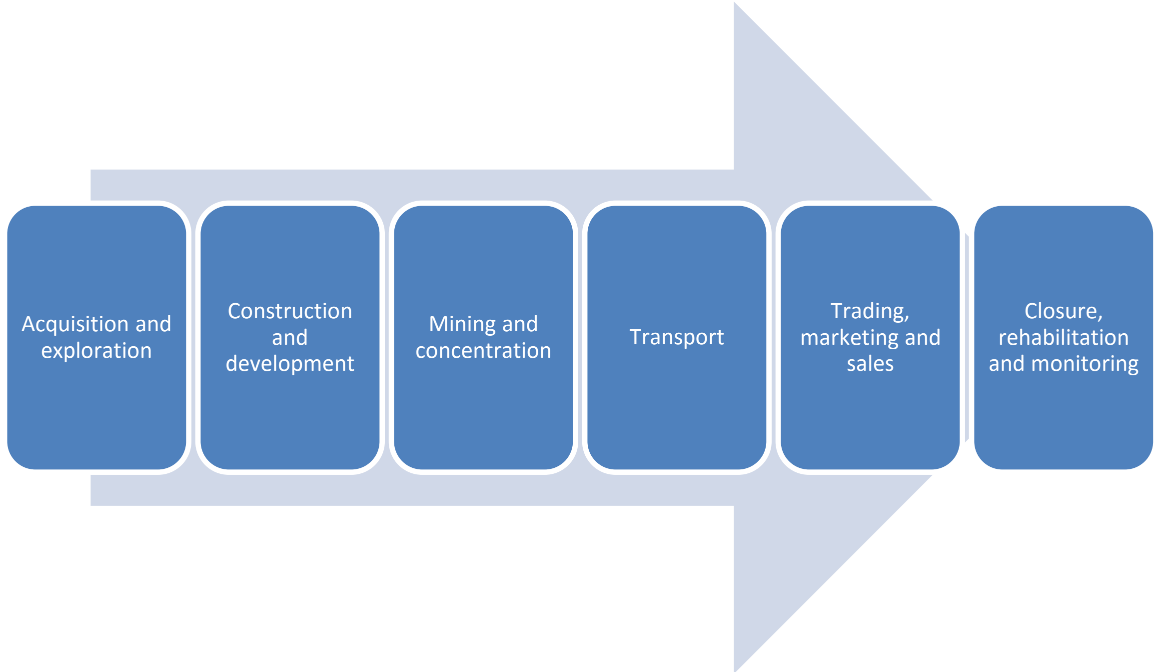

Figure 1. Mining lifecycle

Source: (Sustainable mining, 2015).

Mining industry need sustainability approach because of its big impact on natural environment (Aloi, 2007). Historically in Australian mining industry we can distinguish four approaches to mining – from concentration on maximising revenue to sustainable mining approach (Tab. 1).

Many key studies about Australia mining industry reports that mines consider in their activities many factors connected with CSR. The most important asset of Australian mining industry are as follows (Satchwell, 2014):

- education and training – crucial to dealing with challenges and opportunities of the 21th century, advanced education should be integrated with research,
- complementary to traditional infrastructure – knowledge-intensive and knowledge creating, adaptable and capable to deal with uncertainty and to engage with the emerging new global economy,
- public sector and industry collaboration – development of technical colleges and teaching centres, knowledge spillovers (trained workers can move easily between projects and firms, taking skill set and culture with them).

Table 1. Australian approaches to mining

Approach	Characteristic
Only revenue maximising	Using efficient methods to address landscape and community legacies associated with focus on revenue maximising.
Efficient	Enhancing performance through individual activities. Developing, testing and deploying of leading edge technology and processes to deliver industry capability to meet their efficiency goals.
Effective	Improve benefits and performance through the connectivity with environment. Integration of capability (engineering, science and social science) and operating environment (life cycle, value, chain and mining regions).
Sustainable approach	Embedding sustainability in all decision making and business practices to consider the economic and environmental needs of current generations without compromising the needs of future generations. Implementation and measure of sustainable development in an industrial context, positioning the mining and minerals industry as a lead case for global industry.

Source: own work based on: (Satchwell, 2014).

The key factors which can ensure long-term prosperity of Australian mining industry are closely connected with sustainable approach. We can distinguish following indispensable factors (Sustainable mining, 2015):

- building institutions and governance of the resources sector,
- developing infrastructure,
- ensuring robust fiscal policy and competitiveness,
- supporting local content,
- spending resources windfall wisely,
- transforming resource wealth into broad, inclusive socioeconomic development,
- gaining community support for responsible development.

On the base of study that has been done by Basu (Basu et al. 2015) we can distinguish

We can distinguish some examples of CSR practices in Australian mining companies (Ranangen, 2013):

- donated items from Australia are shipped over by sea and distributed to a variety of local groups and institutions in the surrounding communities,
- some Australian mining companies are supporting hospital premature baby ward and has continuously provided equipment as well as monthly donations of cleaning items, basic medical items and baby packs,

- the company has provided the visually impaired at the Ndola school with walking canes,
- the company has also introduced a community health day, to which employees, their families and other community members are invited. On this day, information about wellness is provided as well as health checks for ailments such as hypertension, high cholesterol, sickle cell, diabetes and tuberculosis,
- the company has been helping to restore the water bore in the Salem children's village in Kitwe.

Table 2. The impact of mining industry on CSR

Impact of mining industry on CSR	Characteristic
Positive	• mining may bring employment and economic diversity to Indigenous communities and rural areas, • mining is positively associated with household income, housing affordability, communication access, education and employment in regional and remote Australia, • through the relationship the mutual goal of improving environmental outcomes has been achieved.
Neutral	• the mining boom in Australia since 2000 with economic improvement, as reflected in a host of economic indicators (e.g. GDP, household incomes, employment), • manufacturing and other industries have found it hard to compete internationally because of the high value of the dollar which has also resulted from the mining boom, • community appeared to have positively benefitted but because there were no performance indicators it was not possible to properly assess the performance of the funding and to learn from the experience what the best strategy for future community investment would be.
Negative	• there is considerable evidence to suggest that coal mining has been detrimental socially, environmentally and to public health, • the concerns of communities are often marginalised by the mining industry, • proper monitoring and regulation of air pollution that threatens the health of local people needs to be undertaken

Source: own work based on: (Basu et al., 2015).

14.4. Conclusions

The problem of CSR and sustainable development in mining industry is very important and there are many problems with this kind of activity. There are many suggestions that mining activities has been detrimental socially and to public health, also in many mines the social problems are neglected. But in some mines we can find some CSR and sustainable practices connected with social activities. This is important but mines should do more in this case. On the basis of literature analysis we can say that CSR is not good developed in Australian mining industry comparing to for example Polish (Jarosławska-Sobór, 2011; Jonek-Kowalska, 2014; Hąbek and Biały, 2017; Wolniak, 2017), Russian (Ponomarenko et. al., 2016; Yakovleva, 2005) or Spanish (Mogrovejo et. al., 2007; Wolniak, 2017). There is many to do to increase social activities in mines and to achieve good level of CSR practices in Australian mining industry.

Practical implication: we can use the practices using in Australian mining industry in Polish or Russian mining industry. It's important because the mining industry is detrimental for the natural environment and the use of CSR practices can cope with this situation.

The main limitation of this paper is the use only data from published papers and not from companies because author doesn't have access to primary sources from Australia. Also the limitation is that the analysis is based only on one country in the future analysis the more complex comparative analysis can be conducted.

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References

ACCSR. Re-imagining sustainable value: the Sustainable Development Goals gather pace. Annual Review of the State of CSR in Australia and New Zealand, 2017, https://www.google.pl/url?url=https://www.sbc.org.nz/__data/assets/pdf_file/0007/127591/ACCSR-State-of-CSR-Report

Aloi, D. M. (2007). Reducing Social Risk and Impact by Engaging Local Communities. Iron Ore Conference, 20-22 August Perth, Western Australia. The Australian Institute of Mining and Metallurgy.

Azapagic A. (2004). Developing a framework for sustainable development indicators for the mining and minerals industry. *Journal of Cleaner Production*, 12, 639-662.

Basu, P. K., Hick, J., Krivokapic-Skoko, B., Sherley, Ch. (2015). Mining operations and corporate social responsibility: A case study of a large gold mine in regional Australia. *The Extractive Industries and Society*, **2**(3), 531-539. doi: https://doi.org/10.1016/j.exis.2015.03.002

Bice S. (2014). What Gives You a Social Licence? An Exploration of the Social Licence to Operate in the Australian Mining Industry, *Resources,* 3, 62-80, doi: https://doi.org/10.3390/resources3010062

Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions A renewed EU strategy 2011-14 for Corporate Social Responsibility, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0681, [access 27.08.2018].

Cowell, S. J. (1999). Sustainability and the primary extraction *industries: theories and practice. Resource Policy,* 25, 277-286.

Esteves, A. M. (2008). Mining and social development: Refocusing community investment using multi-criteria decision analysis. *Resources Policy,* 33, 39-47.

Evans, N. (2010). CSR and stakeholders of small businesses in regional South Australia. *Social Responsibility Journal*, 6(3), 433-451, https://doi.org/10.1108/17471111011064799

Galbreath, J. (2010). How does corporate social responsibility benefit firms? Evidence from Australia. *European Business Review* 22 (4), 411-431, https://doi.org/10.1108/09555341011056186

Górecki, J., Sermet, E. (2010) Społeczna odpowiedzialność górnictwa. *Surowce i Maszyny Budowlane,* 1.

Hąbek P. (2017). Corporate social responsibility reporting. Practices of Visegrad Group countries. Gliwice, P.A. NOVA.

Hąbek, P., Biały, W. (2017). Komunikacja społecznej odpowiedzialności przedsiębiorstw. Praktyki przemysłu górniczego. [in:] Mechanizacja, automatyzacja i robotyzacja w górnictwie. IV Międzynarodowa konferencja, Wisła, 21-23 czerwca 2017 r. Streszczenia referatów, 44.

Hąbek P., Brodny J. (2017). Corporate social responsibility report - an important tool to communicate with stakeholders. 4th International Multidisciplinary Scientific Conference on Social Sciences and Arts. SGEM 2017, 24-30 August 2017, Albena, Bulgaria. Conference proceedings. Book 1, Modern science. Vol. 5, Business and management. Sofia: STEF92 Technology, 241-248.

Hąbek P., Wolniak R. (2016). Assessing the quality of corporate social responsibility reports: the case of reporting practices in selected European Union member states. *Quality and Quantity*, 50(1), 339-420.

Hąbek P., Wolniak R. (2016). Factors influencing the development of CSR reporting practices: experts' versus preparers' points of view, Engineering Economy, 26(5), 560-570.

Hąbek P., Wolniak R. (2016). Relationship between management practices and quality of CSR reports. *Procedia - Social and Behavioral Sciences*, 220, 115-123.

Jarosławska-Sobór S. (2011). Społeczna odpowiedzialność biznesu (CSR) i wykorzystanie społecznego potencjału przedsiębiorstwa górniczego w budowaniu wizerunku branży. Studium przypadku. *Przegląd Górniczy*, 10.

Jonek-Kowalska, I. (2014). Corporate Social Responsibility a środowiskowe i społeczne skutki likwidacji kopalń. *Zeszyty Naukowe Wyższej Szkoły Bankowej Wydział Zamiejscowy Chorzów,* 16, 27-45.

Jones, M., Marshall, S., Mitchell, R. (2007). Corporate Social Responsibility and the Management of Labour in Two Australian Mining Industry Companies. *Corporate Governance,* 15 (1), 57-67.

Mogrovejo, M., Pimentel, R., Zuniga, A. (2007). Modelos de inversión social para empresas mineras. Experiencias y propuestas. *Cuadernos de Difusión,* 12, 115-143.

Ponomarenko, T. V., Wolniak, R., Marinina, O. A. (2016). Corporate Social responsibility in coal industry (Practices of russian and european companies), *Journal of Mining Institute,* 222, 882-891.

Ranangen, H. (2013). Corporate Social Responsibility Practice in the Mining Industry. Lulea University of Technology: Lulea.

Rao, K. (2016). Board diversity and CSR reporting: an Australian study. *Meditari Accountancy Research,* 24(2), 182-210. https://doi.org/10.1108/MEDAR-08-2015-0052

Ross, D. (2016). Corporate Social Responsibility Initiatives in Australia's Mining Industry: An Applied Stakeholder Approach. [in:] Idowu (Ed.), Key initiatives in corporate social responsibility. Springer: Heidelberg.

Ryszko, A. (2017). Circularity issues in the corporate social responsibility reporting - case study from Poland, [in:] Carpathian Logistics Congress. CLC 2017, June 28th - 30th 2017, Liptovsky Jan, Slovakia. Conference proceedings, 312-317.

Satchwell, I. (2014). Mining and sustainability: experience from Australia, International Mining for Development Cenntre, Mendoza, https://www.google.pl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiz1o_v57aAhVBEVAKHZ0JDYcQFggoMAA&url=https%3A%2F%2Fim4dc.org%2Fwp-content%2Fuploads%2F2013%2F07%2FMining-and-sustainability-in-Australia-English.pdf&usg=AOvVaw3TPxCcGTjjwjpw3bSC8if9, (03.04.2018).

Skotnicka-Zasadzień, B. (2014). Zatosowanie inżynierii jakości i niezawodności do analizy awaryjności obiektów technicznych na przykładzie maszyn i urządzeń górniczych. Wydawnictwo Politechniki Śląskiej: Gliwice.

Sustainable mining in Latin America: Australian's competitive advantage. (2015). Australia-Latin American Business Council, 3 February, 2015, https://www.google.pl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwiz1o_v57aAhVBEVAKHZ0JDYcQFggwMAE&url=https%3A%2F%2Fim4dc.org%2Fwpcontent%2Fuploads%2F2013%2F07%2FALABCpresentation.pdf&usg=AOvVaw2UXFNwJmmqdhk735l0J4jc, (03.04.2018).

Thirarungrueang, K. (2013). Rethinking CSR in Australia: time for binding regulation? *International Journal of Law and Management* 55 (3), 173-200. doi: https://doi.org/10.1108/17542431311327628

Truscott, R. A. (2007). Corporate Social Responsibility in Australia: Constructing Reputation. in: Proceedings 2007 Australia And New Zealand Marketing Academy Conference (ANZMAC), Dunedin: New Zealand.

Vintro, C., Comajuncosa, J. (2010). Corporate Social responsibility in the mining industry: Criteria and indicators, DYNA, 161.

Wheeler, D., Fabig, H., Boele, R. (2002). Paradoxes and dilemmas for stakeholder responsive firms in the extractive sector: lessons from the case of Shell and the Ogoni. *Journal of Business Ethics,* 39, 297-31.

Wolniak, R. (2017). The corporate social responsibility practices in mining sector in Spain and in Poland – similarities and differences. *Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacji i Zarządzanie,* 111, 111-120.

Wolniak, R. Hąbek, P. (2016). Quality assessment of CSR reports – factor analysis. *Procedia - Social and Behavioral Sciences,* 220, 541-547.

Wood, D. J. (1991). Corporate Social Performance Revisited. *Academy of Management Review,* 16 (4), 691-718.

Worrall, R., Neil, D., Brereton, D., Mulligan, D. (2009). Towards sustainability criteria and indicators framework for legacy mine land. *Journal of Cleaner Production*, 17, 1426-1434.

Yakovleva, N. (2005). Corporate social responsibility in the mining industries. Ashgate Publishing: Hampshire.

Chapter 15

THE RELATIONSHIP BETWEEN INDICATORS OF NON-FINANCIAL REPORTING OF POLISH COMPANIES

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Abstract

The purpose of this article is to indicate the relationship between the reporting about non-financial activities of companies in terms of corporate social responsibility (CSR) and the value of intellectual capital. This article contains information about market value, book value, intellectual capital efficiency and the information on the presence of CSR reporting. This presentation aims to search for the links between these factors in response to the question: how to increase the value of a company? In this paper, the author presents the book and market values for selected companies. The author also indicates the intellectual capital efficiency with the use of the VAIC (Value Added Intellectual Coefficient) method. The research was conducted for three selected companies from the mining sector, listed on the Warsaw Stock Exchange, for the period between 2009 and 2016. In addition, a particular year was indicated as of which the selected enterprises have been preparing their corporate social responsibility reports. This analysis allowed the author to draw conclusions about non-financial reporting in the aspect of intellectual capital and CSR.

Key words: non-financial reporting, intellectual capital (IC), corporate social responsibility (CSR).

15.1. Introduction

In the era of knowledge in which we currently live one of the basic premises that underlies decisions that people make in order to manage their life or run a company is information. People undertake specific activities based on the information that they possess and the knowledge that is built on such information. Every company is aware of the fact that a broad group of stakeholders, both external (shareholders, contractors, suppliers, local environment, etc.) or internal (employees) make specific decisions pertaining to relations with the company, its operation and its products on the basis of information that reaches them. Thus, access to most comprehensive information is in the interest of both of the above-mentioned groups. This does not refer exclusively to the financial standing and the condition of the company with respect to material aspects, but also to the forecasts of such condition in the future and non-financial aspects of the company's operation.

The number of entities which decide to prepare corporate social responsibility reports is nowadays on the rise. Public presentation of the above-mentioned reports for companies specified in the Act (Act Amending the Accounting Act of 15 December 2016, Journal of Laws of 2017, item 61, 12. *Ustawa z 15 grudnia 2016 r. o zmianie ustawy …*) has become an official requirement as of 2017. Apart from non-financial reporting contained in the CSR, it is also worth paying attention to the necessity of reporting about intellectual capital. Work on the principles of new accounting has been under way for quite a while; such new principles are going to contain guidelines on reporting about the company's intangible assets. By emphasising the significance of presenting the stakeholders with ever increasing volume of information, this paper presents a comparison of CSR reporting and reporting information about intellectual capital efficiency with respect to the market value of the examined companies.

15.2. Non-financial reporting: directions of activities

Whilst operating on a market, every company is intent on multiplying its' assets, generating maximum profits and growing in a long-term perspective. In the recent years, strategic targets such as financial stability and the above-mentioned accomplishment of specific profits were extended onto two issues, namely support strategies based on innovation and corporate social responsibility and support and development of personnel. By means of innovation, production companies wish to influence their productivity and expand their outlet markets. By investing in the development of employees and their skills and expanding knowledge, companies strive to fulfil the terms of innovation, offering their personnel a possibility of constant improvement of their competence. Simultaneously, by acting pro-socially in the place of its' operation, a company influences the positive image of its brand. Thanks to it, the company receives social support, which facilitates performance of tasks; this is a particularly important aspect in the mining sector in Poland. Furthermore, harmonious and good cooperation between the environment and a company may contribute to the procurement of well-qualified employees who - if they come from the area where the company is located - will immediately identify with the company, work loyally and with zeal.

This is quite a general and simple mode to present the effects of a company's activities in the area of determining its' targets and activities on intangible elements, both of the company and its' environment, which are difficult to measure and assess. The intangible elements of a company, namely the intangible assets which generate added value, constitute its' intellectual capital. People, and more specifically the knowledge that they possess, their skills, experience, willingness to work, as well as projects, scientific and research work, patents, or the organisation culture, brand and several other aspects form a large group of elements that build a company's intellectual capital. This is the capital that should be assessed and managed efficiently. In order to perform such activities, it is worth preparing a report on the non-financial operation of a company.

On the other hand, it may be acknowledged that non-financial reporting is, at the present time, associated not with the above-mentioned intellectual capital, but with the broadly promoted CSR - corporate social responsibility, a concept according to which, at the stage of building a strategy, social needs and environmental protection are taken into account, along with relations with the company's stakeholders [3]. To illustrate this issue in more detail, CSR activities in Jastrzębska Spółka Węglowa S.A.[13] are presented below. The company includes eight aspects in the CSR area (Fig. 1).

Figure 10. CSR areas in JSW S.A.

Source: (www.jsw.pl).

Another example is provided by a leading resource concern, KGHM Polska Miedź S.A., which declares (www.kghm.com) that the group's activities in the area of corporate social responsibility are primarily focused on forming and improving cooperation with the local communities and internal organisations, as well as solidification of the position of a trusted and stable business partner. In the CSR aspect, KGHM S.A. also remembers about its' employees, wishing to play a role of a responsible employer who implements activities increasing work safety and invests in competence of the personnel. Furthermore, the company informs that it continues initiatives related to the protection of the natural environment and health protection activities.

The above-listed two areas of non-financial reporting which, on the one hand, include information about intellectual capital - intangible assets and on the other information about CSR, spanning care for the local environment, natural environment and employees, are the activities currently implemented in large foreign companies. CSR is also present in Poland, especially in the case of listed companies. However, activities pertaining to the reporting about intellectual capital are still a novelty for Polish companies. Thus, there is an issue worth considering, which constitutes one of the premises for the discussion in this paper, namely: what is the relation between reporting information about intellectual capital and reporting information about corporate social responsibility? Such question is justified on account of the intangible nature of both types of information, which is difficult to assess.

The search for the relations between the intellectual capital and CSR has already been conducted around the world and it is possible to read about it in the papers of Luthan E., Yohana A.&D. (Luthan and Yohana, 2016) Aras G., Aybars A., Kutlu O. (Aras, 2011) oraz Sułkowski Ł., Fijałkowska J. (Sułkowski and Fijałkowska, 2013), Altuner D., Celik S., Gulec T. (Altuner et al., 2015), Branwijck D. (Branwijck, 2012), Razafindrambinina D., Kariodimedjo D. (Razafindrambinina and Kariodimedjo, 2010).

15.3. Intellectual Capital (IC) efficiency in added value formation

Knowledge and experience of employees, brand, relations with stakeholders, structural sphere, including work systems, procedures of conduct, patents and also trademarks are only some elements from an extensive catalogue of items that make up the intellectual capital. This is the capital that is manifested as the effect of work of every person, every link that is a part of an organisation. The infrastructure that the managerial personnel has designed and that relies on its' intellect is a tool to form the intellectual capital. A collection of intangible activities that are difficult to assess, and which are performed on a daily basis in the company is the result of the intellect of people working for such company.

In 1975, the first work of G.R. Feiwel (Dietz et al., 1977) entitled "Intellectual Capital of Michal Kawecki: A Study in Economic Theory and Policy" was published and sparked a discussion pertaining to the intellectual capital. The 1990s marked the flourish of this trend; thanks to the works of the Conrad Group, K. E. Sveiba, L. Edvinsson, M. S. Malone, A. Brooking, L. Prusak and also Polish scientists such as D. Dobija, G. Urbanek and A. Ujwary-Gil, the knowledge about intangible resources forming an important element of a company value, i.e. intellectual capital, has been widely popularised.

A number of works devoted to intellectual capital were written, emphasising its' intangible nature and, on the other hand, a number of methods were designed to assess the intangible elements. In order to perform an assessment, methods are prepared to verify and to quantify intellectual capital in various centres of the world. These methods may be divided into the ones that are based on market capitalisation, on return on assets or on result charts; there are also several other methods that attempt at direct assessment of intellectual capital. The starting point for the above-mentioned work on the assessment methods was to pay attention to the differences in the value of the company which result from the book value and the market value. The market value versus book value (MV/BV) was one of the first determinants offering information whether a company possesses intellectual capital (MV/BV>1) or whether it does not possess such capital (MV/BV<1).

A more complex method which allows for ascertaining absence or presence of intellectual capital and, more precisely, indicating a tendency in its' level is a method based on the return on assets - VAIC (Value Added Intellectual Coefficient), which allows for determining the efficient use of human, structural, employed and intellectual capital. Additionally, the method assumes that the added value constitutes an assessment criterion for a company's operation, whereas the intellectual capital is a factor determining its' formation. Application of a broad sectoral analysis allows for procuring useful information available thanks to the use of this method. If the values of VAIC received for competing companies are compared, it is possible to indicate which of them manage their intellectual capital better. In reference to this paper, the information on the level of VAIC, i.e. efficiency of intellectual added value, is significant due to the fact that it illustrates how employed, human and structural capital is engaged in the creation of intellectual capital which, in the next step, may be juxtaposed with the market and book value of a company.

For analysis purposes, the following aspects are taken into account: operating profit, value of human capital expressed by the costs incurred on employees, depreciation/ amortisation of fixed assets, intangible and legal assets and equity. Based on the above-mentioned values, the following aspects are calculated (Pulic, 2000):

- human capital efficiency (HCE) in added value formation;
- capital employed efficiency (CEE) in added value formation;
- structural capital efficiency (SCE) in added value formation;
- intellectual capital efficiency (intellectual capacity) of a company (ICE = HCE + SCE).

For selected companies from the mining sector, such as JSW S.A., LW Bogdanka S.A., KGHM Polska Miedź S. A., the value of VAIC determined for years 2009-2016 is presented in Table 1. In compliance with the performed analyses, KGHM recorded a clear advantage with respect to the level of the coefficient between 2009 and 2012. In the subsequent years, the value of the coefficient dropped for the copper potentate. A company with quite a fixed level of VAIC and best results between 2014 and 2016 is LW Bogdanka S.A. Furthermore, a stable level of the examined coefficient is consistent with the stable level of the market value (Fig. 2) of LW Bogdanka S.A. Thanks to the visualisation of capital efficiency in added value generation, it may be noted that along with the collapse of the market value of companies (Fig. 2) in 2015, the examined level of VAIC also dropped. Thus, it may be concluded that there is a certain inter-dependence in the case of VAIC and the market value. However, the years 2011 and 2012 showed a contrary tendency for KGHM: in 2011, capital efficiency increased, whereas the market recorded a drop; in 2012, there was a positive increase in the value of KGHM market prices, yet the efficiency of managing capital in the formation of added value was reduced.

Table 1. VAIC for the examined companies between 2009 and 2016

VAIC [-]	2009	2010	2011	2012	2013	2014	2015	2016
JSW S.A.	N.D.	3.45	3.46	2.76	2.28	1.66	-2.66	2.83
LW Bogdanka S.A.	2.73	2.97	2.99	3.48	3.49	3.31	1.50	3.06
KGHM Polska Miedź S.A.	3.19	4.20	6.44	3.98	3.29	3.05	-0.97	0.40

Source: own study based on (Fijałkowska, 2013) and consolidated financial reports of the examined companies.

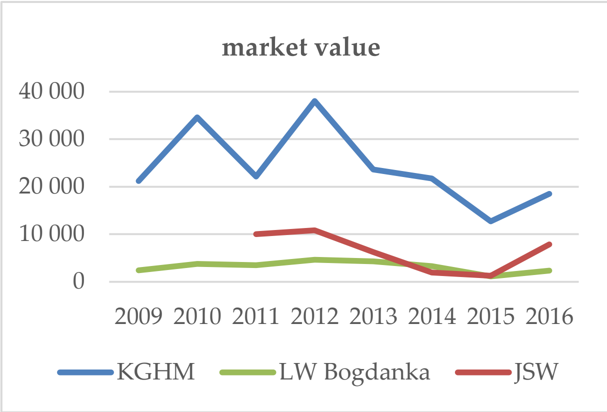

Figure 2. Level of VAIC for the examined companies

Source: own study based on (Fijałkowska, 2013) and consolidated financial reports of the examined companies.

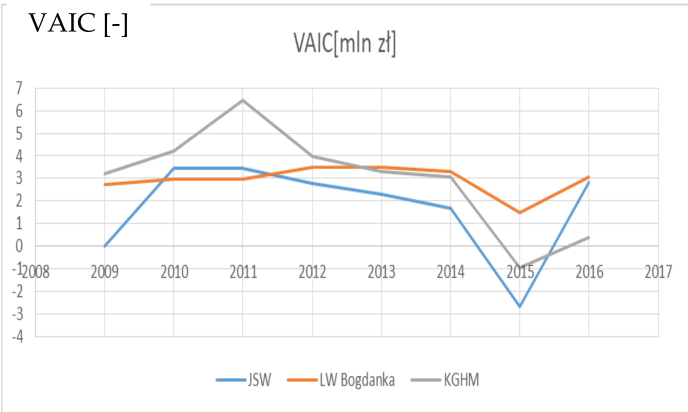

Figure 3. Market value of examined companies

Source: own study based on (Fijałkowska, 2013) and consolidated financial reports of the examined companies.

In reference to the relation between the capital efficiency with respect to added value formation and the intellectual capital efficiency (ICE) of a company, the inter-dependence is very strong (Fig. 4). VAIC is the aggregate efficiency of capital employed, human and structural capital in the formation of added value, whereas the ICE is the sum of two components, namely human capital and structural capital. Presenting the results of JSW S.A. and KGHM, it is possible to conclude that the value of capital employed excluded from the value of ICE does not have any major significance, as the level of VAIC and ICE for the above-mentioned companies is very close and, as of 2014, has almost overlapped. In the case of LW Bogdanka S.A., the level of capital employed constitutes a significant difference between the level of VAIC and ICE which, in turn, highlights the significance of this capital in the formation of the company's added value. Nevertheless, human capital and structural capital exert very strong impact on the level of VAIC and thus, it is necessary to highlight the importance of such capitals and the necessity of developing them in order to increase the company's added value.

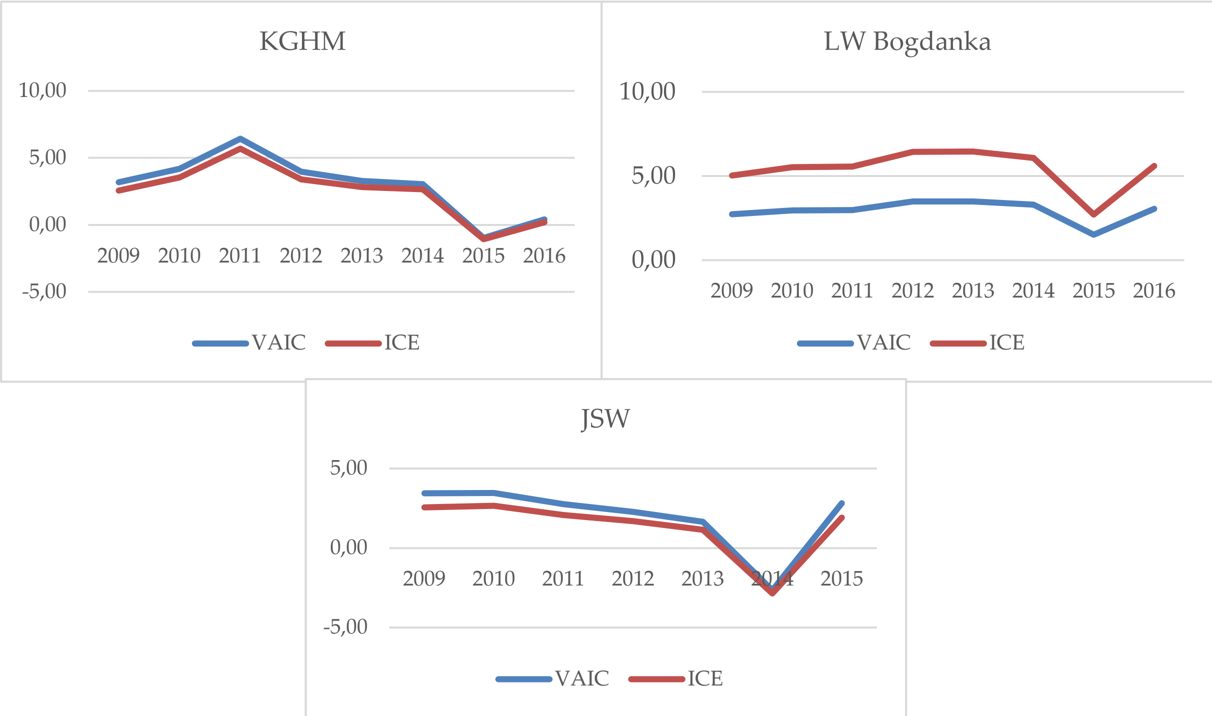

Figure 4. Level of VAIC and ICE for examined companies

Source: own study.

15.4. Analysis of relations among IC, CSR and company's Market Value

By comparing the intellectual capital with CSR reporting and, more precisely, with the search for effects that these two aspects may contribute to the improvement of a company's operation, it is necessary to use the information about the market value of examined companies. The assumption is that more positive information offered to all groups of stakeholders about a company, its care for the environment, employees and the local community improves the image of the brand and the company, and should also contribute to the growth of company's the market value.

The analysis covered three companies from the mining sector listed on the Warsaw Stock Exchange, namely KGHM Polska Miedź S.A., JSW S.A., and LW Bogdanka S.A. Each of these companies entered the stock exchange and started to implement CSR reporting at a different time, thence in the breakdown presented in fig. No. 4, the moment in time from which a given company has been performing CSR reporting is marked with an arrow;

furthermore, in the case of JSW S.A., the period of analysis is shorter on account of later date of entering the stock exchange.

The first conclusion refers to the diagram illustrating MV/BV, i.e. the relation of the market value and the book value and VAIC: the CSR reporting does not seem to influence the formation of these values with respect to the examined companies. Lack of CSR reports, e.g. in the case of KGHM the period from 2009 to 2011, did not pose a problem and the efficiency of intellectual capital determined by VAIC had a growing tendency in line with the book value, which was also growing at that time. What is more, the example of LW Bogdanka S.A. shows one more important aspect: the market value had a growing tendency between 2009 and 2012; in 2012, i.e. at the start of CSR reporting, the market value dropped until 2015. The value of intellectual capital efficiency determined by VAIC for LW Bogdanka S.A. shows an increase until 2013 and then a drop until 2015, similarly to the market value of this company. Another example taken into account in this analysis referred to JSW S.A. The image of this company is strongly related to the situation of the Polish mining sector and the drop in the market value between 2012 and 2015. In parallel to the drop in the market value, the intellectual capital efficiency diminished and the material standing of the company aggravated, which is illustrated by the reduced book value in the above-mentioned period. Combining this information with the data about CSR reporting did not improve the company's listing, which could have been expected assuming the premises adopted in this chapter.

Summing up the entire analysis performed for the selected mining companies illustrated in Figure 5, it may be concluded that there is no inter-dependence between the market value and the fact whether a company reports CSR or not. However, such inter-dependence is noticeable between the intellectual capital, its efficiency presented with the use of VAIC and the market value; this takes place in line with the most simple definition of intellectual capital, which stipulates that such capital constitutes a difference between the market value and the book value of a given company.

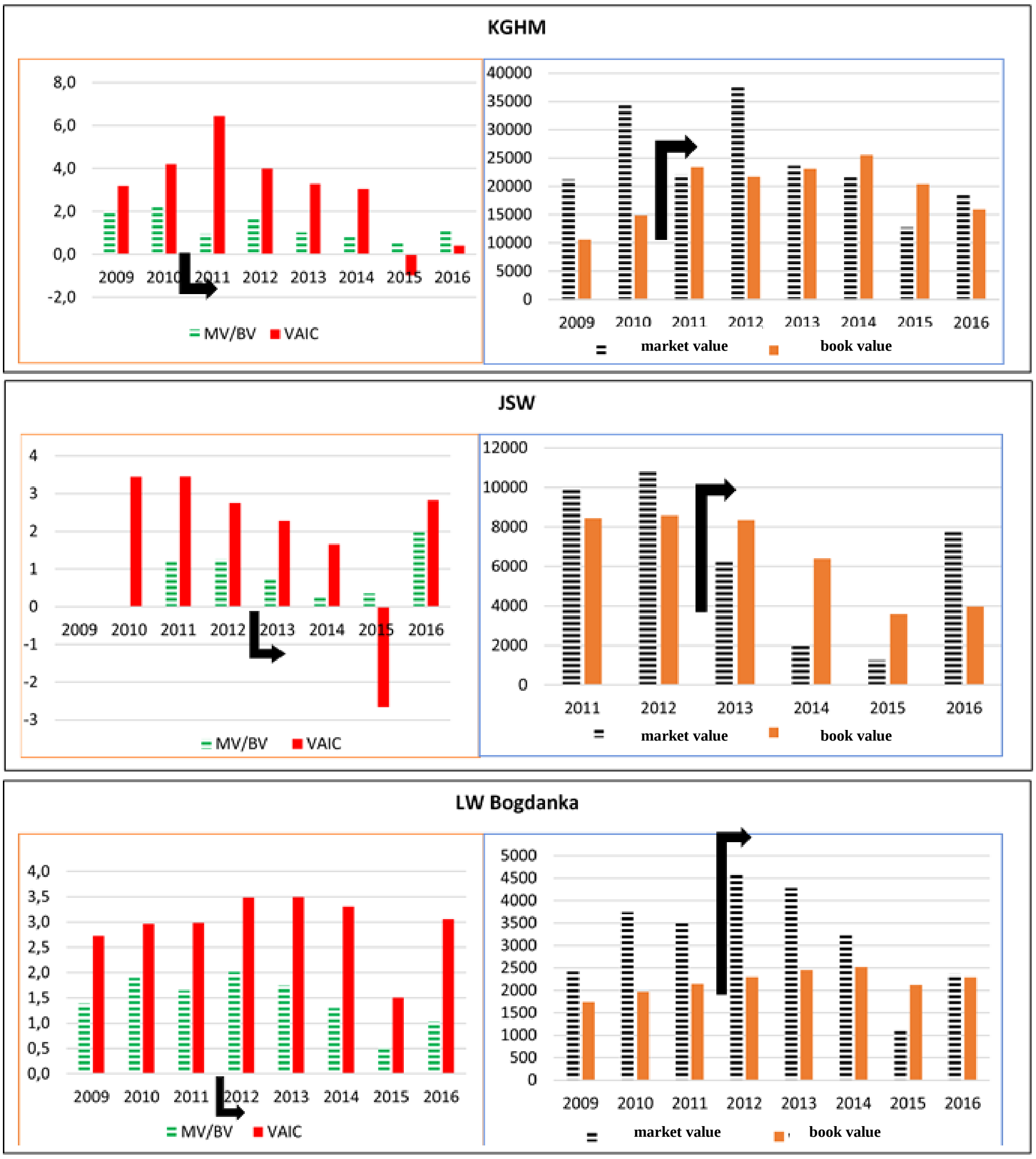

Figure 5. Relation between intellectual capital and CRS reporting

Source: own study.

15.5.Conclusions

It is important to highlight the co-existence of reporting about intellectual capital and CSR in the aspect of non-financial reporting. It seems to be correct to acknowledge that well-performed corporate social responsibility reporting and intellectual value reporting allow for preparing a report actually referring to the company's non-financial operation.

The conducted studies do not show a dependence between the intellectual capital efficiency or the market value of a company and the fact that such company performs CSR reporting. In spite of it, the positive aspect of the performed analysis is indication of the area that needs improvement. A CSR report, supplemented by important information from the point of view of the level of intellectual capital, may become a better tool in the aspect of building a company's value. CSR reporting is to be treated as an opportunity for intellectual capital in the sense that certain non-financial (social) activities have already been noticed and it is necessary to report them. The non-financial sphere which is difficult to quantify, to unify and to present stands a chance of becoming more "material" and "tangible" thanks to such reporting. Thus, a postulate may be put forward that indicates the possibility of cooperation with respect to these two intangible aspects in the context of creating a company's value. Combining these two areas, i.e. CSR and intellectual capital, may offer an actual increase in the market value of a company, which will definitely make the shareholders and the management of the company very satisfied.

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References

Altuner, D., Celik, S., Gulec, T. (2015). The linkages among intellectual capital, corporate governance and corporate social responsibility Corporate Governance. *The International Journal Of Business In Society,* 15 (4), 491-507.

Aras, G., Aybars, A. Kutlu , O. (2011). The interaction between corporate social responsibility and value added intellectual capital: Empirical evidence from Turkey. *Social Responsibility Journal*, 7(4), 622-637.

Bogacz, P. (2016). Environmental management reporting in Polish mining companies in the context of World CSR trends. E3S Web of Conferences.

Branwijck, D., (2012). Corporate Social Responsibility plus Intellectual Capital. Integrated Reporting? 4th European Conference on Intellectual Capital (ECIC) Finland, Proceedings of the 4th European conference on intellectual capital, 75-85.

Dietz, J. , Sherman, H., Halevi, J. (1977). Reviewed Work: *The Intellectual Capital of Michal Kalecki* by George R. Feiwel. *Journal of Economic Issues,* 11 (1), 133-144.

Fijałkowska, J. (2013). VAIC™ jako metoda pomiaru dokonań przedsiębiorstw. *Zarządzanie i Finanse* 11 (2).

Luthan, E., Yohana, A.D. (2016). A Correlation of CSR and Intellectual Capital, its Implication toward Company's Value Creation. *International Journal of Business and Management Invention,* 5 (11).

Pulic, A. (2000). VAIC™ - an accounting tool for IC management. *International Journal of Technology Management,* 20 (5-7).

Priyanka, J., Vyas, V., Ankur, R. (2017). Exploring the mediating role of intellectual capital and competitive advantage on the relation between CSR and financial performance in SMEs. *Social Responsibility Journal,* 13 (1), 1-23.

Razafindrambinina, D., Kariodimedjo, D. (2010). Intellectual Capital and Its Impacts on Corporate Social Responsibility: Findings from Indonesia. *Business Transformation Through Innovation And Knowledge Management: An Academic Perspective,* 1-2, 496.

Sułkowski, Ł, Fijałkowska, J. (2013). Corporate social responsibility and intellectual capital interaction and voluntary disclosure. *Studia Ekonomiczne*, yadda.icm.edu.pl.

Ustawa z 15 grudnia 2016 r. o zmianie ustawy o rachunkowości, Dz. U z 2017 r., poz. 61.

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Chapter 16

MANAGEMENT OF SOCIAL INFRASTRUCTURE OBJECTS OF THE MINING COMPANIES ON NEWLY-DEVELOPED TERRITORIES

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Abstract

In the Russian Federation, the extraction and production of mineral resources, particularly, hydrocarbons are transferred to the northern regions with severe climatic conditions and underdeveloped infrastructure. Therefore, the development of these regions considerably depends on the business of large companies, such as Gazprom, who are becoming responsible for the formation and development of social infrastructure. At the same time, the maintenance of social infrastructure facilities entails significant costs for the company, thus, provoking contradictions between the company's social obligations and its financial capabilities. However, the reduction of social infrastructure without regard to the need for these facilities can lead to a decrease in the quality of life of the population of the region, and also affect the state of the company's human resources. This circumstance requires more objective research of the objects of the social infrastructure of the company, their structure, condition, possible use. Purpose of the article is to develop the recommendations for the management of social infrastructure facilities of a large mining company. Methodology includes the analysis of the structure of social infrastructure facilities (based on the example of Russian gas producing company), analysis of the factors influencing the use and application of social infrastructure facilities. This report is a synthesis of the research on the topic "Methodological recommendations for ensuring effective asset management of a gas company". The study is dedicated to resolving the practical problem concerning the use of social infrastructure facilities under the context of a particular company - the subsidiary of Gazprom. Thus, the main sources of empirical data are the materials provided by the company. We have developed the classification of social infrastructure facilities. We have also provided the proposals concerning the use and reorganization of social infrastructure facilities of a gas producing company, taking into account commercial and social significance of the facilities.

Keywords: corporate social responsibility, management, social infrastructure facilities.

16.1. Introduction

In Russia the extraction of mineral resources (particularly fuel and energy resources) is carried out in the regions with severe natural and climatic conditions and underdeveloped infrastructure. For example, more than 50% of natural gas is produced at the extraction sites located in the Yamalo-Nenets Autonomous Region (http://www.mnr.gov.ru/docs). This region is characterized by severe arctic climate (during the winter temperature can drop to - 50 degrees Celsius), as well as by the lack of well-developed infrastructure and low density of population. The harsh climate has a significant impact on the working conditions and health of personnel involved in the production of natural gas (Marinina and Nevskaya, 2017). About 45% of region population live in five cities. At the same time, the economic development of the region is closely linked with the extraction of minerals, especially natural gas. Therefore, companies have certain social obligations to employees and the population.

The research problem discussed in this study incorporates social responsibility of a mining company to the local population of the regions of presence, responsibility to the shareholders of the mining company as well as the need to ensure social welfare and development of human capital of the mining company.

The objective of this research is to develop the recommendations for improving the management of social infrastructure facilities of the Subsidiary of Gazprom.

Gazprom is the world's biggest gas company operating the world's richest reserves of natural gas: The Company's share of world's gas reserves is 17% and the share of Russian reserves - 72%. Gazprom accounts for 11% of the world's gas production as well as for 66% of Russian gas production (*Gosudarstvenny …*, 2016). Currently the company is actively implementing large-scale projects on the Yamal peninsula, development of gas resources of the Arctic shelf, Eastern Siberia and the Far East. For example, the biggest gas project of the last decade is the "Megaproject Yamal" which includes the development of 32 gas deposits of the Yamal peninsula that accounts for 26.5 trillion of cubic meters of gas. The total number of Company's employees is around 500 thousand people (*Godovoj …*, 2017). Gazprom has agreements with many constituent entities of the Russian Federation determining mutual obligations in the field of tax, price and social policy. All Company's subsidiaries are regional enterprises that usually are the main employers of the towns where they are operating. Therefore, they are focused on the complex socio-economic development of the regions of presence.

Hence, the research problem that is being discussed in this study incorporates social responsibility of mining company to the local population of the regions of presence, responsibility to the shareholders of the mining company as well as the need to ensure social welfare and development of human capital of a mining company.

Social responsibility and social welfare are the components of the corporate social policy of large Russian companies. The Russian Federation had its own path of social development under the terms of planned economy (Soviet Union), when all the issues of social development and social welfare were assumed by the state.

The main subject of this research is the management of social infrastructure facilities of a subsidiary of Gazprom that operates in the Yamalo-Nenets Autonomous Region. The main source of information is the reporting data from Gazprom.

16.2. Literature study

Large companies operating in the Russian Federation are facing the growing demands from various groups of stakeholders – shareholders, employees, local population of the regions of presence, etc. The interests of different stakeholders usually vary and in order to manage various stakeholder relationships the companies are having internal and external "vectors of social responsibility", where the internal vector is associated with the development of human capital, social security of employees and their families, enhancement of the level and quality of life, and so on (Blechzin, 2017).

The idea of corporate social responsibility (Husted, 2006, Lee, 2008), which implies the development of human capital, generating additional benefits for the company (Baron, 2001; Webb, 2004; Carroll and Buchholtz, 2012; Chen and Roberts, 2008), is widely accepted within the Russian mining companies (Ponomarenko et al., 2016). At the same time, the economic basis of CSR is established by the social infrastructure that entails significant extra costs of its creation and maintenance. One of the specificities of a large company is the independent implementation of institutional functions.

The term “social infrastructure” was introduced by Toshchenko (1980). Various aspects and levels of social infrastructure were considered in the works of Jochimsen (1966), Nurkse (1993) and other authors. For example, the state of the social welfare system is defined as one of the parameters determining the quality of life of the population (Riecen and Yavas, 2001). In more modern publications, the social infrastructure is considered mainly in the regional aspect as a form of institutionalization and a criterion determining the level of modernization of the region (Koch, 2015), as well as "a set of institutions and conditions that ensure the fulfilled human life" (Dzhafarova, 2012). In a narrower sense, social infrastructure is a subset of the infrastructure facilities that includes assets dedicated to social services (Kotyrlo, 2012).

According to any approach it is recognized that social infrastructure includes various elements including healthcare, education, housing and domestic services, transport, cultural development and many others, while its operation involves the use of various real assets - social facilities (or social infrastructure facilities). At the same time, the management of social infrastructure facilities of large companies needs to be developed. Management of social infrastructure facilities of large companies incorporates at least two key objectives: to fulfill company's obligations towards stakeholders and to use the opportunity to generate additional revenues by these facilities (Maksimova and Chuzhbovski, 2017).

Meanwhile, one cannot but agree with the position of Maksimova and Chuzhbovski that strong profit-orientation of the use of social facilities does not enable the analysis of other ways how social infrastructure facilities may indirectly influence the development of the company's human capital. Moreover, in the Northern Regions, the value and importance of social infrastructure is much higher (Kotyrlo, 2012).

Social problems of the northern regions of Russia associated with social infrastructure are considered in many publications of Russian scientists. In particular, it is said that the need for state support is essential in solving these problems. At the same time, in Gazprom the state is a major shareholder interested in obtaining economic benefits (Agarkov, 2018). Therefore, the issues of managing the objects of social infrastructure of Gazprom, where the state is a major shareholder, need to be considered in more detail.

Hence follow the research questions:

1. How can social infrastructure facilities be classified by their function and profitability?
2. What factors and conditions of activity influence the management of social infrastructure?
3. What options for managing social infrastructure facilities are possible for a large mining company?

16.3. Methods of the study

The methodological framework of this research includes:

1. Analysis of the factors influencing the management of social infrastructure facilities.

2. Grouping and analysis of the social infrastructure facilities in terms of particular parameters.
3. Elaboration of the recommendations on the management of social infrastructure facilities.

It is important to emphasize that:

1. Social infrastructure facilities are assets used for life support and social development.
2. The state policy regarding social infrastructure facilities and non-production assets is focused on their transfer to municipalities.
3. The policy of Gazprom is optimization of costs for the maintenance of social infrastructure facilities.

16.4. Research results

The study identified two groups of factors: external and internal (Tab. 1).

We have also included the management policy of parent company to the group of external factors, distinguishing three key dimensions of corporate management – asset management, HR management and CSR management. The fact that Gazprom is a corporation with state participation determines the key objective of the management of social infrastructure facilities – to decrease the costs of its maintenance.

The principle objective of HR management is to attract and retain young specialists by providing high level of salary and promising career opportunities. CSR management is principally focused on employees' development, corporate philanthropy and co-financing of socially important projects (support of children's sport, healthy lifestyle, support to the veterans and poor people).

At the same time the Subsidiary is fulfilling several social functions, such as creating decent working conditions for the employees who are working on a rotational schedule, building facilities for preventive treatment and medical aid to employees and to the local population as well as creating facilities for the rehabilitation of employees and their families (that implies changing climatic conditions by going to more comfortable climate). One of the popular places for rehabilitation and recreation is corporate health resort located on the shores of the Sea of Azov (Gelendjik). All above mentioned supplement the basic social security determined by the Code of labor of Russian federation and ensured by the state.

Table 1. Factors influencing the management of social infrastructure facilities

EXTERNAL Factors		**INTERNAL Factors**		
1.The state policy is focused on the transfer of social infrastructure facilities of state companies to municipalities		Special social functions of subsidiaries in the region of presence		
2.Policies of Gazprom				
Type of policy	**Guidelines**	**Functions**	**Particular terms**	**Social infrastructure facilities**
Asset management	Cost optimizations in terms of the maintenance of social infrastructure facilities. A unified approach to the management of social infrastructure facilities in subsidiaries. Transfer of residential properties to municipalities and managing companies.	Organization of production activities	Rotational schedule	Infrastructure objects of shift camps, dormitories, consumer services facilities
HR Management	Material incentives (high wages) Creation of the environment for attracting and retaining staff	Medical preventive maintenance and medical aid to employees and the population	The remoteness of production facilities (140-700 km) from urban and rural settlements	Medical facilities
CSR Management	Physical and cultural development of human capital Charity, sponsorship, co-financing of social programs	Rehabilitation of workers	The need for long rest, climate change	Resorts, health resorts, tourist centers

Source: compiled by the authors.

In order to better establish the choice of managerial tools applied within the management of social infrastructure facilities we have developed several criteria for its classification such as its principal purpose, functions, types of facilities and its profitability.

We suggested the following criteria for its classification: its principal purpose, functions, types of facilities and its profitability. We have singled out two groups of facilities according to its principal purpose – life support facilities and social development facilities (Fig. 1).

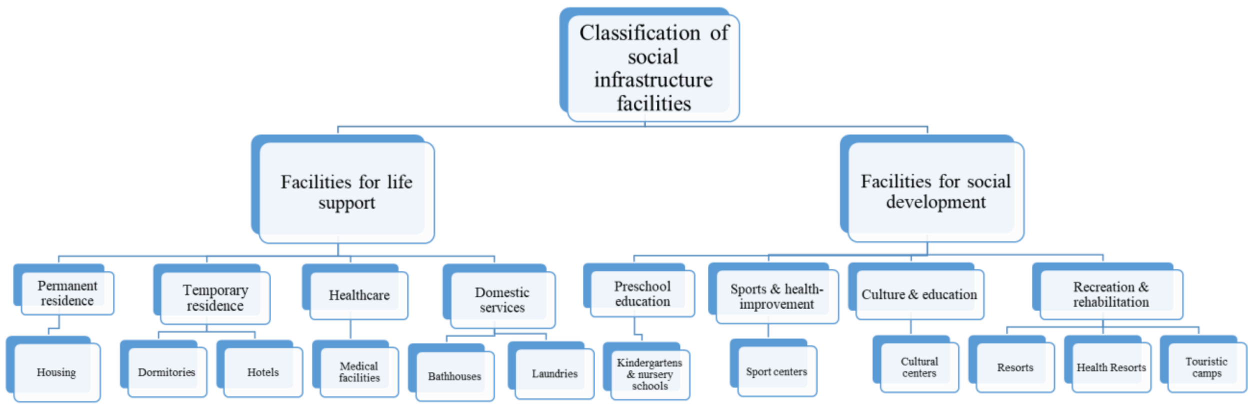

Figure 1. The groups of social infrastructure objects

Source: compiled by the authors.

At the level of functional criterion, the group of life support facilities includes the facilities for permanent residence, temporary residence, healthcare and domestic services, while the group of social development facilities includes the facilities for pre-school education, sports and health-improvement, culture and education as well as recreation and rehabilitation.

The analysis of social infrastructure in terms of their purpose, functions and types showed that: 66% are the facilities for life support. In the structure of life support facilities: 60% account for housing, 30% - for temporary residence; medical facilities - 7%, facilities of domestic services - 3% (Fig. 2). In the structure of facilities for social development, about 48% are cultural centers, 33% - sports centers, about 18% - recreation and rehabilitation facilities; facilities of preschool education account for less than 1% (Fig. 3).

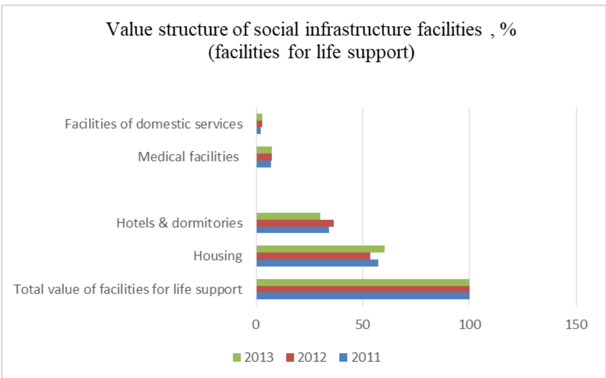

Figure 2. Value structure of facilities for support

Source: compiled by the authors on the basis of internal company reporting data.

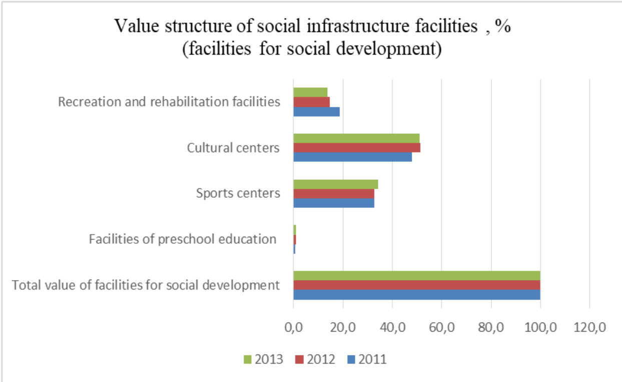

Figure 3. Value structure of facilities for social development

Source: compiled by the authors on the basis of internal company reporting data.

The main argument for the transfer of social infrastructure facilities to the municipalities is high level of maintenance costs.

Indeed, the recreation and rehabilitation facilities are the only profitable type of social infrastructure facilities while the rest of social infrastructure facilities are unprofitable for the Subsidiary. The profitability of social infrastructure facilities is less than 100%, with the exception of recreation and rehabilitation facilities (Fig. 4)

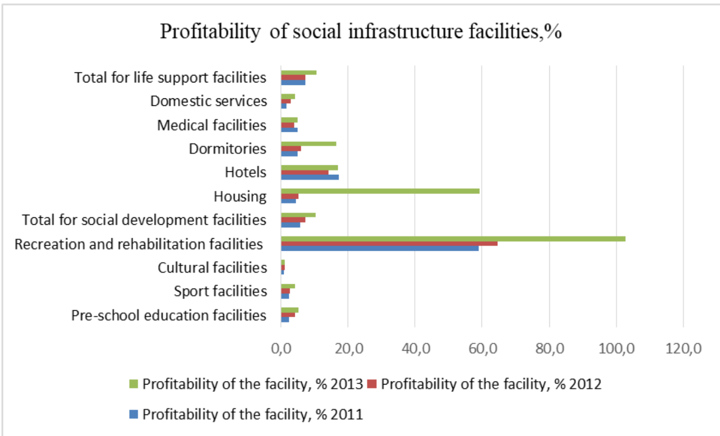

Figure 4. The profitability of social infrastructure facilities

Source: compiled by the authors on the basis of internal company reporting data.

Within the life support facilities, the largest share in the structure of costs & income is provided by the facilities for temporary residence (hotels and dormitories). The share of income coming from housing facilities is less than 10%, the share of costs is about 20% (Fig. 5).

Among the recreation and rehabilitation facilities more than 40% of the costs are given by pre-school education facilities, sports and cultural centers. The income coming from recreation and rehabilitation facilities is more than 60% (Fig. 6).

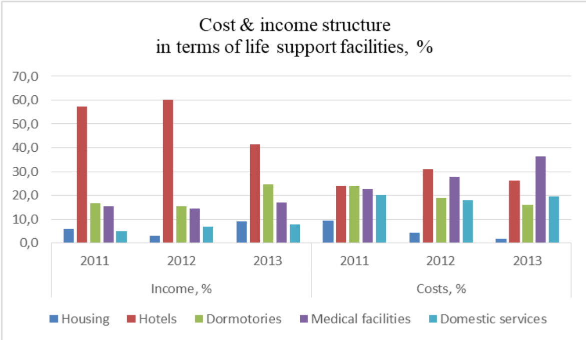

Figure 5. Costs & income structure in terms of life support facilities

Source: compiled by the authors on the basis of internal company reporting data.

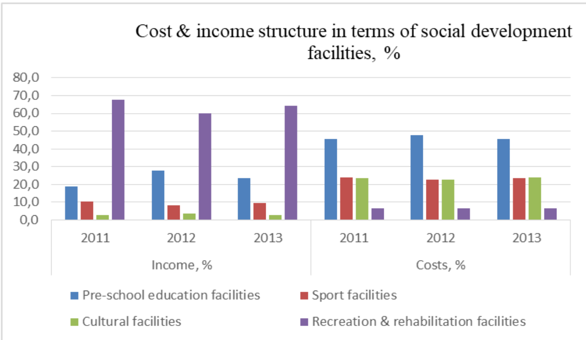

Figure 6. Costs & income structure in terms of social development facilities

Source: compiled by the authors on the basis of internal company reporting data.

As you can see from the analysis of the objects structure, some facilities (healthcare, pre-school education, culture and sport centers) do not have the potential for revenue growth, therefore, it is proposed to increase income by leasing unused facilities. In this way, it is possible to distinguish two dimensions of management of the facilities, they are facilities' restructuring and decrease in loss ratio of their usage (Fig. 7).

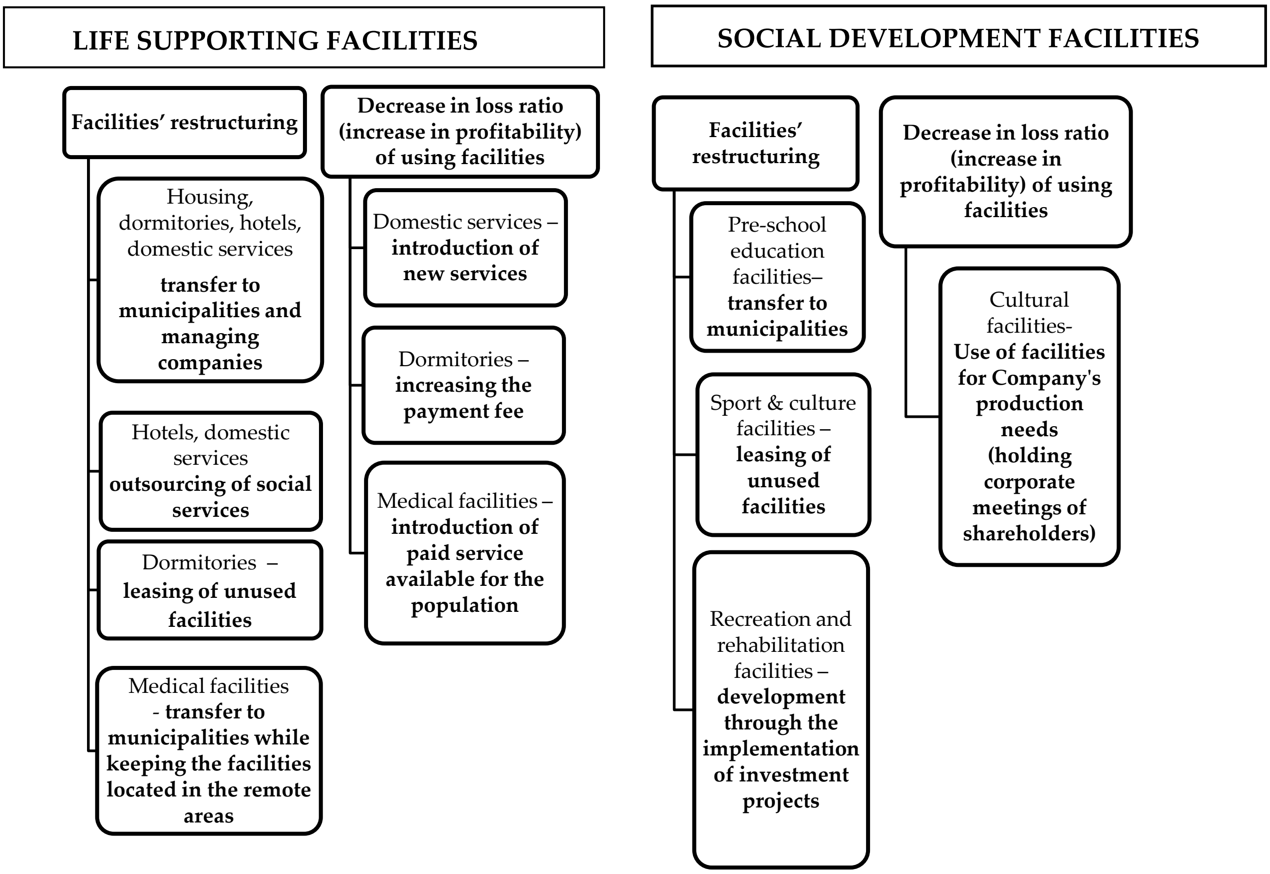

Figure 7. Options of the management of social infrastructure facilities of the Subsidiary of Gazprom

Source: compiled by the authors.

16.5. Conclusions

1. The social infrastructure of the gas company is a complex of facilities necessary for the life support and social development of the company's human capital.
2. The structure of social infrastructure facilities depends on the external and internal factors of the gas company's business activities as well as on the operational conditions in the region of presence.
3. The effectiveness of management of social infrastructure facilities under the context of Gazprom is determined by the management policy applied by the state towards the companies with state participation, by the property policy of Gazprom and by the current needs of social welfare and development of human resources in the region of the company's presence.
4. Management of social infrastructure facilities should involve: transfer of the facilities of domestic services to the municipalities and managing companies; limited transfer of medical facilities to the municipalities in remote areas; leasing of

unused facilities; development through the implementation of investment projects; outsourcing of social services; introduction of additional paid services available for the population; increasing the payment fee.

Reference

Agarkov, S.A., Kozlov, A.V., Fedoseev, S.V., Teslya, A.B. (2018). Osnovnye napravleniya povysheniya ehffektivnosti hozyajstvennoj deyatel'nosti v Arkticheskoj zone Rossijskoj Federacii. *Zapiski Gornogo instituta* 230, 209-216. DOI: http://pmi.spmi.ru/index.php/pmi/article/view/6415/7862

Baron, D. (2001). Private Politics, Corporate Social Responsibility and Integrated Strategy. *Journal of Economics and Management Strategy*, 10 (1), 7–45.

Blechzin, I.Y (2017). The strategy of social-oriented development of a global energy company. *Izvestiya Sankt-Peterburgskogo gosudarstvennogo ehkonomicheskogo universiteta,* 1(103), 115-125.

Carroll, A.B. and Buchholtz, A.K. (2012). Business and Society: Ethics, Sustainability and Stakeholder Management. 8th Edition, Mason, OH: South-Western Cengage Learning.

Chen, J.C. and Roberts, R. (2008). Corporate Charitable Contributions: A Corporate Social Performance or Legitimacy Strategy? *Journal of Business Ethics*, 131-144. doi: http://dx.doi.org/10.1007/s10551-007-9567-1

Godovoj otchet PAO «Gazprom neft'» za 2016 g. (2017). https://csr2016.gazprom-neft.ru/#safe-development

Gosudarstvennyj doklad «O sostoyanii i ispol'zovanii mineral'no-syr'evyh resursov Rossijskoj Federacii v 2015 godu» (2016). http://www.mnr.gov.ru/docs/o_sostoyanii_i_ispolzovanii_mineralno_syrevykh_resursov_rossiyskoy_federatsii/

Dzhafarova, S.A. (2012). Teoreticheskie aspekty ponyatiya "social'naya infrastruktura". *Ekonomicheskie nauki* 8 (93), 68-70. DOI: http://ecsn.ru/articles/index/201208

Husted, B. de Jesus Salazar J. (2006). Taking Friedman Seriously: Maximizing Profits and Social Performance. *Journal of Management Studies,* 43 (1), 75–91. doi: http://dx.doi.org/10.1111/j.1467-6486.2006.00583.x

Jochimsen, R. (1966) *Theorie der Infrastruktur.* Tubingen: Mohr (Siebeck).

Koh, I. A. (2015). Social'naya infrastruktura kak forma institucializacii processov modernizacii. *Vestnik Omskogo universiteta. Seriya: ehkonomika* 3, 213-219. DOI: http://journal.omeco.ru/ru/archive/doc/2015_03.pdf

Kotyrlo, E. (2016). Contemporary Issues in the Circumpolar North: The Economy of the Circumpolar North University of the Arctic. *Module 9: Northern Social Infrastructure* DOI: https://members.uarctic.org/media/1596801/cs-331-1-elana-kotyrlo-basic-economic-concepts-as-applied-to-the-circumpolar-north.pdf

Lee, M.P. (2008). A review of the theories of corporate social responsibility: its evolutionary path and the road ahead. *International Journal of Management Reviews* 10, 53–73. doi: http://dx.doi.org/10.1111/j.1468-2370.2007.00226.x

Maksimova, T.G, CHuzhbovskij, K.L. (2017). *Povyshenie ehffektivnosti ispol'zovaniya neprofiltnyh aktivov predpriyatiya: problemy i puti ih resheniya* DOI: https://doi.org/10.24158/pep.2017.1.12

Marinina, O.A. and Nevskaya, M.A. (2017). Specific nature of labour management in the oil and gas sector in the Russian Far North. *International Journal of Applied Business and Economic Research* 15 (8), 177-185 . doi: https://www.researchgate.net/publication/317745811

Nurkse, R. (1953). Problems of Capital Formation in Underdeveloped Countries. Oxford University Press: Oxford.

Ponomarenko, T.V., Vol'nik, R., Marinina O. A. (2016). Korporativnaya social'naya otvetstvennost' ugol'noj otrasli (praktika rossijskih i evropejskih kompanij). *Zapiski Gornogo Instituta,* 222, 882-891. doi: http://dx.doi.org/10.18454/pmi.2016.6.882.

Riecen, G., Yavas, U. (2001). Improving Quality of Life in a Region: A Survey of Area Residents and Public Sector Implications. *International Journal of Public Sector Management* 14 (7), 556-568 doi: https://www.researchgate.net/publication/247615968

Toshchenko, Z.H. T. (1980). *Social'naya infrastruktura: sushchnost' i puti razvitiya*. M.: Mysl'.

Webb, K., ed. (2004). *Voluntary Codes: Private Governance, the Public Interest, and Innovation.* Carleton Research Unit for Innovation, Science and Environment: Ottawa.

Chapter 17

THE ISSUES RELATED TO OCCUPATIONAL HEALTH AND SAFETY CULTURE IN THE MINING INDUSTRY

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Abstract

The mining business is one of the branches of industry with the highest work-related accident rates. In terms of the occupational health and safety culture, it is crucial to make every effort to minimise or, preferably, eliminate the work accidents. This paper is an attempt at diagnosing the issues related to the occupational health and safety culture, using surveys. The key aspect is the broadly defined shaping of the OHS (occupational health and safety) culture among the employees. The anonymous surveys enabled the employees to subjectively assess the weaknesses of the OHS policy and provide directions for the employers and management.

Key words: organisational culture, occupational health and safety, mining industry.

17.1. The importance of the occupational health and safety culture in the mining industry

Culture is defined as a comprehensive set of rules, conditions and methods of human activity, the products of human labour and artistic activity constituting a collective attainment of a community. Culture is built on the specific human biological and social properties, and the living conditions, and undergoes historical development and transformation. The relation between the rate of accidents and near-misses in an organisation, and the occupational health and safety culture, has been studies and analysed a number of times (Lee and Harrison, 2000). The aspect of the culture pertaining to occupational risk and safety is defined as the safety culture of an organisation. The culture is formed by the set of standards, values and beliefs characteristic for the given organisation which the employees adhere to and which determine the conduct and behaviour of individuals and groups within the organisation (McKenna and Beech, 1999).

One of the crucial factors shaping the safety culture is employee education and training. A high safety culture is a sign of high safety level in the organisation (Mearns et al., 1998). Therefore, it can be said that the companies which have taken care to provide their employees with high level of education based on current training methods have a high safety culture. The occupational health and safety management system, which is one of the elements of the organisation management system, includes: the organisational structure, planning, accountability, the rules of conduct, the procedures, processes and resources necessary to develop, implement, enforce, review and maintain the occupational health and safety policy. Particular focus is given to the appropriate design and implementation of the following elements to facilitate the growth and reinforcement of the safety culture:

- determining the occupational health and safety goals,
- engaging the management in the OHS (occupational health and safety) policy,
- competence and training,
- motivation,
- communication,
- monitoring.

The proper functioning of the elements listed above largely determines the shaping of the employees' conduct and behaviour towards the occupational health and safety.

In the mining industry, line employees are exposed to accident and health hazards. The process of implementing and shaping the culture among the employees is long-term and should take into account a number of internal and external conditions specific to the given mine. Figure 1 provides a diagram of selected factors impacting the development of the occupational health and safety in a mining company (Kapusta et al., 2016).

Figure 11. Factors impacting the safety culture level in a company

Source: own study.

17.2. Key safety culture factors identification areas

In the Authors' opinion, the occupational health and safety culture should be identified and diagnosed in the following areas:

- vision and goals;
- occupational risk assessment;
- identification of hazards;
- safety controls and control of management behaviour;
- training and compliance with OHS regulations;
- accidents and near-misses.

In each of the aforementioned areas, the company should assess the employee awareness of the issue, and should also work towards continuous maintenance and improvement of the quality of those factors. Employee training is an important block in building the organisation's safety culture (Bąk et al., 2016; Sukiennik et al., 2016; Sukiennik and Bąk, 2017). The necessity of training arises directly from the applicable law and also from the requirements to which the occupational health and safety management systems must conform to. All employees of the organisation must be competent in their functions in the company. The documented competences of the employees should conform to the requirements of the company. In the case of the occupational health and safety management system, the employees should have the appropriate knowledge and awareness of how to perform their duties in a manner ensuring their own safety and the safety of their co-workers (*Prawo geologiczne i górnicze …*).

Identifying the key occupational safety areas determines the employees' approach to and conduct in the work environment. The safety culture is shaped first and foremost by education, beginning with the knowledge acquired in school, through workplace training, all forms of work safety-related education in the media (TV, radio, press), to initiatives popularising the safety culture (Nahrgang et al., 2011). By shaping the employees' awareness and providing them with appropriate competences, we are conditioning the employees to behave and act in the desired way. Those activities will succeed if the employee becomes aware of the purpose and meaning of their activities, and the consequences of their actions for everyone around them. The applicable laws obligate the supervisory institutions and companies to train the workforce in the occupational health and safety rules (Kapusta et al., 2017; Kapusta, 2017). The organisation should put in place and maintain the appropriate procedures to make their employees aware of:

- the types of hazards across the organisation and on individual positions, and the related occupational risk,
- the benefits for the employees and the organisation arising from the elimination of hazards and the reduction of occupational risk,
- their tasks and responsibilities in ensuring the compliance with the occupational health and safety policy, and the procedures and requirements of the occupational health and safety management system, along with the requirements concerning the readiness and response to work accidents and serious breakdowns,
- the potential consequences of non-compliance with the procedures in place.

Engagement of the employees in the occupational health and safety management processes make it possible to achieve both the general and the specific goals.

17.3. Methodology of the study

The issues related to the occupational health and safety culture in the mining industry was diagnosed using a survey of a sample group.

The results of the survey allowed the Authors to determine those elements among the key factors which will contribute to the shaping of the OHS culture in the mining companies.

The survey took the form of a pilot study and was conducted on a sample group of persons professionally related to the mining industry. The analysis of the respondents according to job seniority (Fig. 2) shows that more than half of the sample group are young employees with short tenure (1 to 5 years). This might suggest knowledge gaps both with respect to the company itself and the guidelines on the knowledge of the OHS rules in the given position.

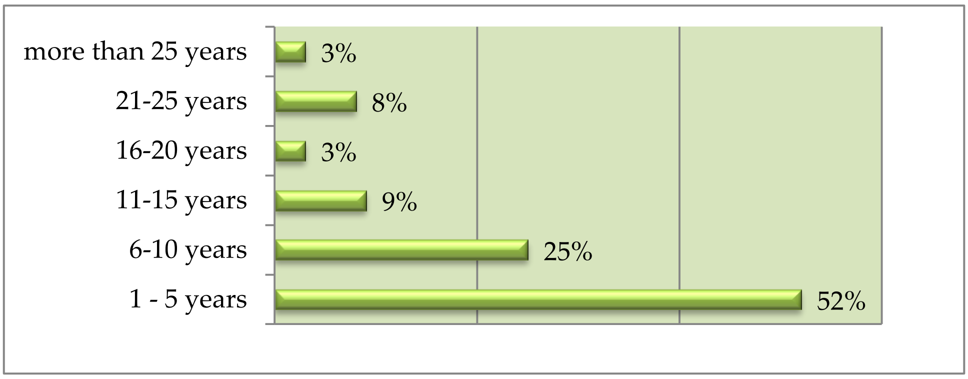

Figure 12. respondents according to job seniority

Source: own study.

The survey on the job satisfaction level (Fig. 3) is positive, with the clear majority of the respondent satisfied with their job, which might translated into work commitment.

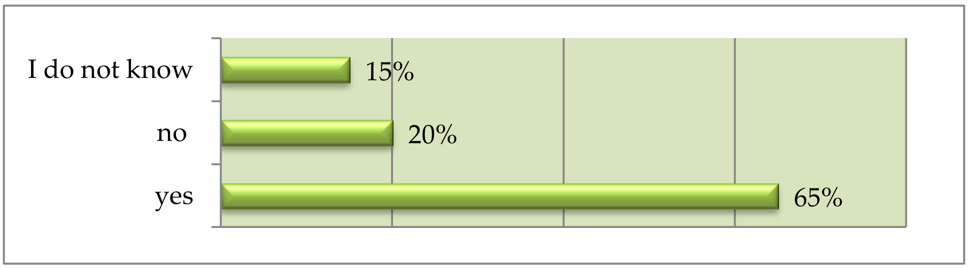

Figure 13. Job satisfaction analysis

Source: own study

The survey on the safety certificates possessed by the employers of the sample group (Fig. 4) shows than nearly half of the respondents know and are convinced that their company has the relevant safety certificates. However, the fact that nearly 20% of the respondents had no knowledge on the matter is a reason for concern. This suggests that either the company management has failed to communicate the relevant information, or that the employees themselves are not interested in the matter. Both reasons are a cause for concern and steps should be taken to ensure that every employee has a broad knowledge on the certification of their company.

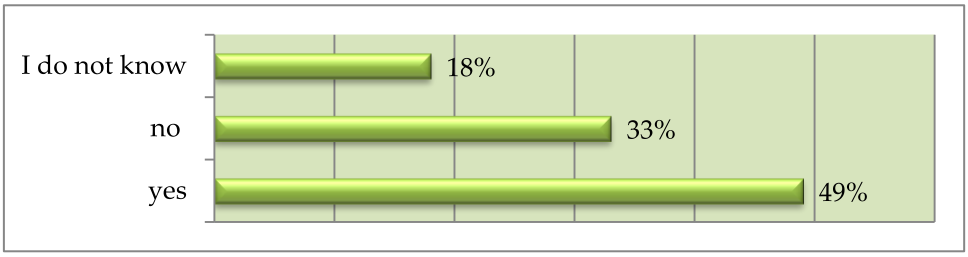

Figure 14. Analysis of the certification of employers

Source: own study.

The pilot studies comprised a questionnaire of fourteen closed-ended thematic questions. The surveyed issues related mainly to the position and role of the OHS rules in the company's culture. The questions were closed-ended and scored on the scale from 1 to 7. This methodology makes it possible to identify the degree of the respondents' familiarity with the given issue. The purpose of the scoring system was to encourage the persons responding to the survey to precisely grade each question. However, for the further analysis of the results, the Authors adopted specific premises. The scores of 5÷7 were considered positive answers, while the scores of 1÷3 were interpreted as negative. The answers scored 4 were considered neutral.

17.4. The analysis of the survey results in terms of the scope of identification of the key aspects of the OH&S culture in the companies

Analysing the answers to the question: "Please grade your knowledge of the vision and goals of the company you are employed in", one can notice that 21% of the respondents either do not know or have only rudimental knowledge of the vision and goals of their company (Fig. 5). This is not a majority group but it is a cause for concern, as it shows that a sizable group of employees have no interest in the company they are working for. This does not contribute to the improvement of the organisational culture in those companies; furthermore, in some cases it can even deteriorate it. The companies should pay more attention to foster and reinforce their relationship with their employees.

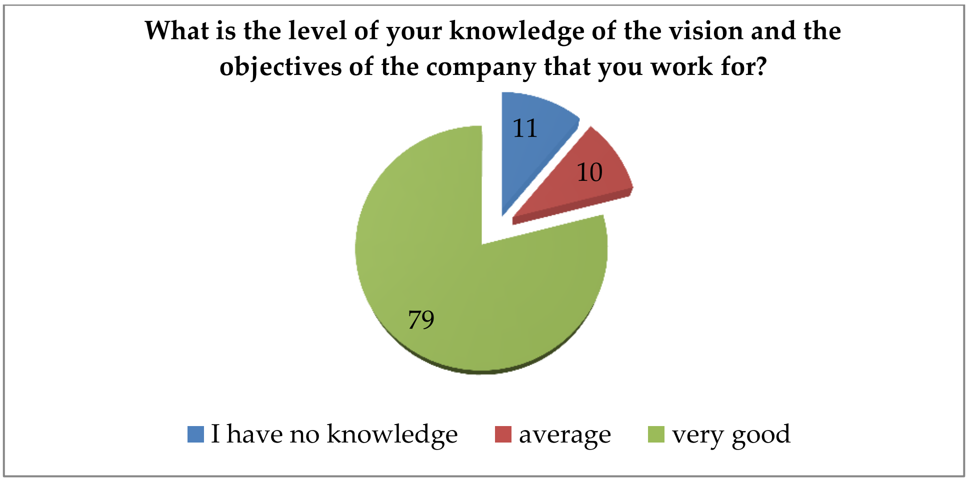

Figure 15. The percentages of answers on the knowledge of the vision and goals of the company

Source: own study.

In terms of the analysis of the occupational risk, 30% of the respondents had no knowledge of the occupational risk assessment in their company (Fig. 6). This is a considerably large percentage which clearly shows that the issue must be addressed appropriately. The purpose of the occupational risk assessment is to prevent the harmful consequences of the work environment hazards. The assessment consists in analysing the work aspects to determine which hazards in the work environment might cause injuries or affect the employee's health, and whether those hazards can be eliminated. If the hazards cannot be eliminated, the risk assessment highlights the actions to be taken to reduce the occupational risk related to those hazards. In the case in question, 20% of the respondents answering that such risk assessment was not conducted is a major issue.

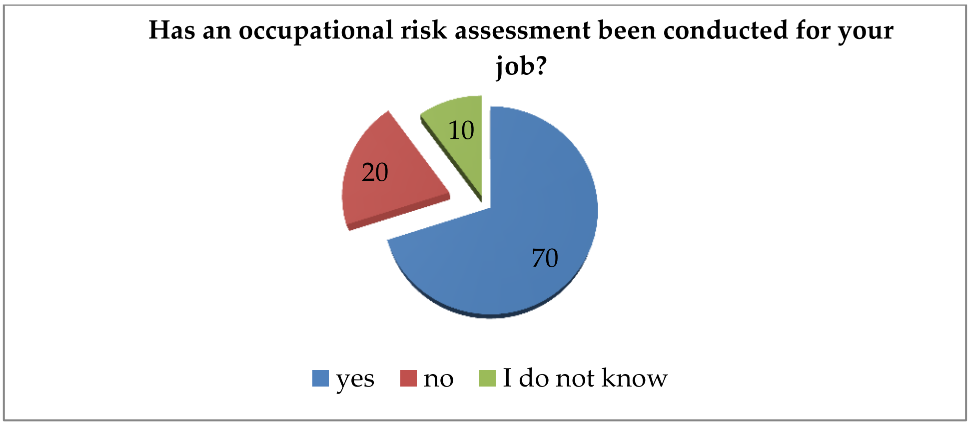

Figure 16. The percentages of answers to the questions on the knowledge of the occupational risk assessment by the employees

Source: own study.

Hazards identification is another crucial element shaping the OHS culture in the companies. In this respect, particular focus is given on the respondents' subjective assessment of their own level of awareness of the potential hazards in their workplace. The results are quite optimistic, with 86% of the respondents grading their knowledge level as high, and only 11% reporting very low knowledge level, or no knowledge at all (Fig. 7).

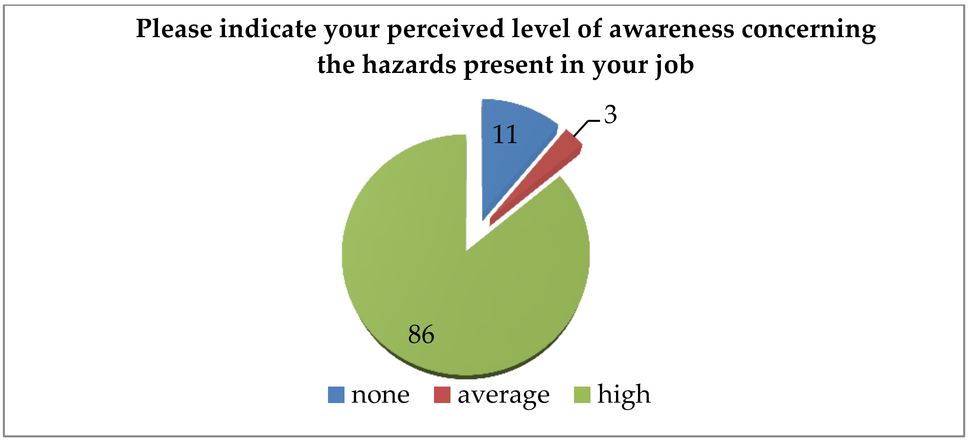

Figure 17. The percentages of answers to the question on the knowledge of workplace hazards

Source: own study.

One of the most important areas of the study involved the supervision by the employer and the management over the employees' compliance with the OHS rules. Unfortunately, 28% of the respondents gave a negative assessment of their immediate supervisors (Fig. 8). Moreover, a further 18% were unable to clearly determine whether their supervisors' actions in terms of work safety were appropriate or not. This is undoubtedly caused by high employee turnover and frequent changes of persons directly supervising the employees. In the case of younger supervisors, a frequently cited argument was their inexperience caused by short tenure in the company. On the other hand, in the case of senior employees, their prestige and experience are offset by the comments on routine and tendency for taking and accepting excess risk related to their work.

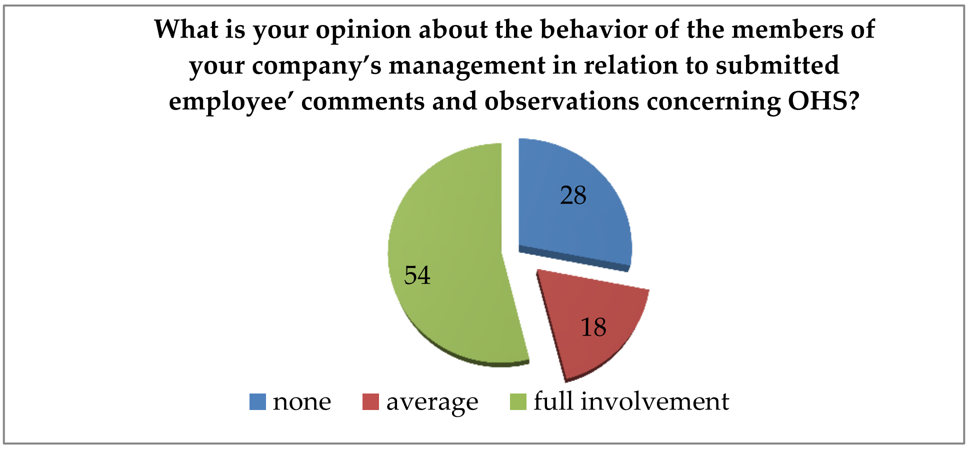

Figure 18. The percentages of answers to the question on the compliance with the safety regulations by the management

Source: own study.

The attitudes and behaviours of the employees are heavily influenced by training and their perceived need to comply with the OHS rules. The results of the survey show a high correlation with the area of responsibility of the management staff. 27% of the respondents gave a negative assessment and 22% considered it to be "neutral" (Fig. 9). In this case, the result may be considered "disappointing", as frequent training is characteristic for the mining industry. The line employees attend periodical training not less than once a year. Frequently, individual solutions are adopted in the mining plants, e.g. weekly OHS training given by the supervisory staff. Furthermore, the employer often provides financial incentives for the employees by holding OHS knowledge contests.

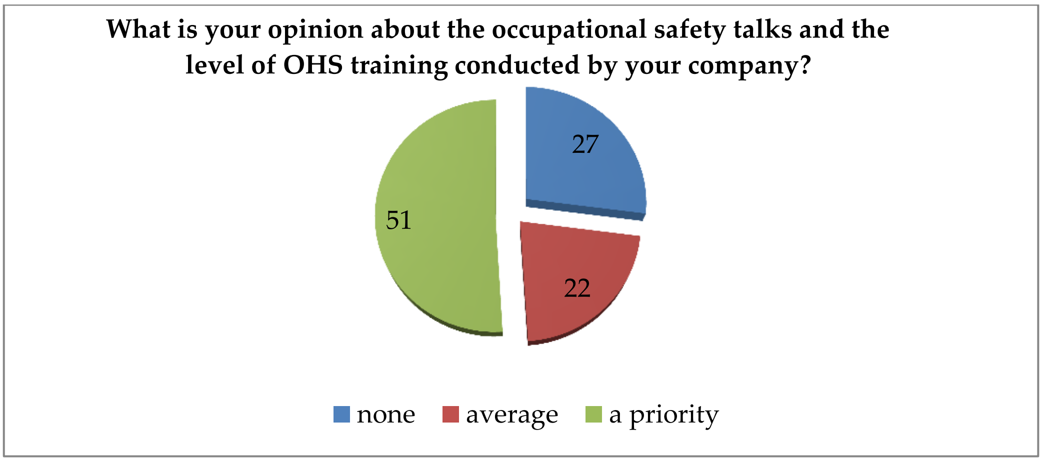

Figure 19. The percentages of answers to the question on training and compliance with the safety regulations

Source: own study.

The final area of the study concerned the accidents and the identification of near-misses. This is a particularly sensitive area for every company, since misguided policy and wrong decisions might directly endanger the life and health of the employees. Compared to other branches of the economy, the mining industry still has a high accident rate. Therefore, it is important for the employees themselves to be convinced and aware that the employer is making every effort to ensure safe working conditions for them. Unfortunately, 31% of the respondents gave negative assessments of the implementation of preventive measures and post-accident recommendations in their company (Fig. 10). In this case, 57% of positive answers is a decidedly unsatisfactory result. A frequently cited argument is that that the companies employ the piece work system and that the financial results are closely related to the production volume. This approach results in frequent hazardous situations and the pressure on the employees forces them to take risks.

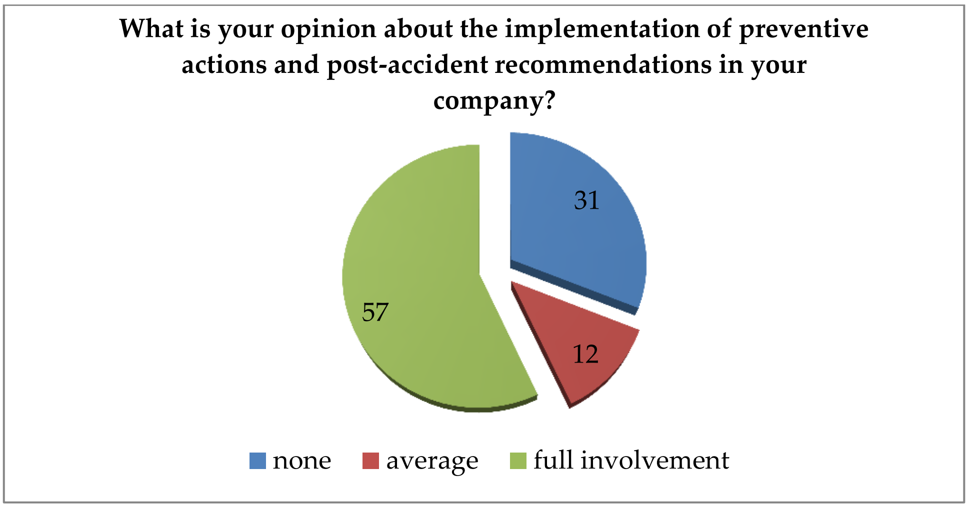

Figure 20. The percentages of answers to the question on accidents and near-misses

Source: own study.

17.5. Conclusions

The mining business is one of the branches of industry with the highest work-related accident rates. On the basis of the conducted surveys, it can be concluded that there is room for improvement of the work safety conditions in a number of identified areas. The key aspect is the broadly defined shaping of the OHS culture among the employees. The anonymous surveys enabled the employees to subjectively assess the weaknesses of the OHS policy and provide directions for the employers and management.

It can also be concluded that the employees are familiar with the vision and goals of their companies, are satisfied with their work. Also, most employees are able to identify the workplace hazards and the occupational risk. A clear cause for concern is the fact that around 30% of the respondents identify a deliberate disregard for the OHS rules both by the employees and their immediate supervisors. A similar percentage of the respondents clearly identify the issues related to the quality of training, and the prevention and reporting of near-misses.

References

Bąk, P., Sukiennik, M., Kowal, B., (2016). Corporateculture in terms of management processes in the Polish mining companies. *Inżynieria Mineralna – Journal of the Polish Mineral Engineering Society*, 17 (2).

Kapusta, M., Bąk, P., Sukiennik, M. (2016). Rola kultury bezpieczeństwa i higieny pracy w przedsiębiorstwie wydobywczym. *Przegląd Górniczy*, 72 (8).

Kapusta, M., Sukiennik, M, Bąk, P. (2018). Effectiveness of Occupational Health and Safety Rules in Shaping Organizational Culture. *Inżynieria Mineralna – Journal of the Polish Mineral Engineering Society*, 1.

Kapusta, M. (2017). Wpływ osób dozoru górniczego na poprawę warunków bhp, [The influence of mining supervision personnel on the improvement of health and safety conditions], *Inżynieria Mineralna - Journal of the Polish Mineral Engineering Society,* 2(40).

Lee, T., Harrison, K. (2000). Assessing safety culture in nuclear powerstation. *Safety Science,* 34.

McKenna, E., Beech, N. (1999). Zarządzanie zasobami ludzkimi, Felberg SJA: Warszawa.

Mearns, K., Flin, R., Gordon, R. (1998). Measuring safety climate on offshoring installations. *Work &Stress*, 45 (2).

Nahrgang, J.D., Morgeson, F.P., Hofman, D.A. (2011). Safety at work: A meta-analityc investigation of the link between job resources, burnout, engagement, and safety outcomes. *Journal of Applied Psychology*, 96(1), 71-94. doi: http://dx.doi.org/10.1037/a0021484

Ustawa z dnia 9 czerwca 2011 r. Prawo geologiczne i górnicze, Dz.U. Nr 163. Poz. 981.

Sukiennik, M., Bąk, P., Kapusta, M. (2016). Kultura korporacyjna a czynnik ludzki w polskich przedsiębiorstwach wydobywczych. *Inżynieria Mineralna – Journal of the PolishMineral Engineering Society,* 2.

Sukiennik, M., Bąk, P. (2017). Corporate culture versus Corporate Social Responsibility in Polish companies of the energy sector, [in:] *SEED, 2nd International Conference On The Sustainable Energy And Environment Development*, Kraków.

Chapter 18

SURVEY OF STAFFING NEEDS TO IMPLEMENT PROJECTS ON THE ARCTIC SHELF

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Abstract

Theoretical aspects of strategic management of the oil and gas complex have a different degree of development. However, the conceptual and methodological problems of managing the development of marine Arctic oil and gas fields are not generalized and are practically not reflected in the works of domestic and foreign scientists. This article addresses the issues of staffing support for offshore projects in the context of strategic management of the oil and gas complex in the development of Arctic hydrocarbon resources on the shelf. Methodology includes methods and tools of system, situational, strategic analysis, expert assessments, methods of multicriteria choice of strategic alternatives, economic-mathematical and simulation modeling, methodology of project management, methods for evaluating investment projects were applied in the work. The proposed model can be used in forecasting and planning the number of personnel of a certain skill in implementing projects on the Arctic shelf. The existing potential of personnel of this qualification and the need for workers of this qualification. The authors propose a toolkit of forecasting and planning the number of personnel of a certain qualification for the development of hydrocarbon fields in the Arctic zone, which can be employed for a comprehensive analysis of the needs for support of the existing and promising projects in the Arctic.

Keywords: strategic management, staffing support, shelf, human resources, hydrocarbon resources, the Arctic region.

18.1. Introduction

Currently, the rate of growth of oil production in the world exceeds the growth rate of its consumption. Nevertheless, the issue of maintaining the levels of oil and gas production to meet the future needs of the world and Russian economy continues to be relevant. In this regard, the role of the Arctic region and the Northern Sea Route for the national security of the Russian Federation is increasingly growing.

Today, the Arctic shelf of Russia is treated as a large region, which industrial development will balance the decline in oil and gas production in the existing oil and gas producing centers of the country (Toskunina, 2007). It has a significant hydrocarbon potential, which is able to satisfy a significant part of this country's energy needs and provide great economic benefits. The area of the deposits on the shelf promising for the development is 4-6 million km^2; the shelf hydrocarbon reserves that have been already explored amount to about 100 billion tons (Shishkin et al., 2016). However, this potential fulfillment requires addressing complex regulatory, legal, technical and technological, economic and environmental issues (Kasantsev, 2006; Ananiev, 2010).

Successful development of the Arctic region is inextricably associated with providing the projects being implemented with high-end professionals. It is human resources that constitute the key component to success in taking strategic solutions, solving the most complicated engineering and technical and economic problems the country faces today when handling the issues of development of the Arctic shelf (Fadeev, 2010).

It should be mentioned that a number of experts put the development of the shelf on a par with space exploration, nanotechnology and electronics. Implementation of future projects on the shelf will require the science and industry to develop and produce a large number of complex technical means: from vessels and drilling platforms to equipment and instruments for geophysical, navigation and other purposes (Ilyinsky et al., 2006). The process of development of oil and gas fields on the shelf is characterized by high capital intensity of projects, the need to use advanced marine technologies, and a high investment risk (Fadeev, 2012, Marinina and Nevskaya, 2017).

It should be noted that oil is a product of a fairly uniform quality. In this aspect, oil can be compared with coal, which is currently one of the challengers to oil, and has a much greater heterogeneity in quality (Vasilyev, 2015). Standardized quality of oil grades allows for their trading on the commodity exchanges. Building of a system for exchange trading of hydrocarbon resources of the Russian Federation has been carried out since 2009 (Vasilyev, 2012).

It stands to mention that the projects implemented in the Arctic zone, even today, annually need dozens of thousands of additional high-end professionals (Rogozin, 2015). These figures are also confirmed by state officials. Thus, the ex-Minister of Education and Science of the Russian Federation D. Livanov said that the average annual staffing need for specialists with secondary vocational education to implement projects in the Arctic zone is about 25 thousand per year (Livanov, 2015).

We are talking about complex training of experts, that is, about training of specialists in geology and geophysics, prospecting and exploration of oil and gas fields on the shelf of the northern seas, professionals in drilling and completion of offshore drill wells, development of offshore fields, their development and operation, specialists in maritime transport of hydrocarbons (including boatmasters, ship mechanics and other specialized personnel), construction and operation of offshore facilities and facilities for the liquefaction of natural gas and storage of hydrocarbons and their products, management of complex offshore oil and gas projects, risk assessment and decision-making specialists, integrated marine (including international) projects, etc. (Fadeev et al., 2010).

As to the shelf of the northern seas, then specialists with unique qualifications should work there, since liquefied gas and oil cannot be transported in the ice anywhere else in the world. Transportation of liquefied gas needs almost space technologies, cryogenic equipment required (gas is transported by vessel at minus 162°C). Handling this technique implies a very high educational level. Boatmasters also should have high professional skills, since responsibility for gas transportation is extremely high. Also, experts, candidates and doctors of sciences to conduct a qualified examination will be required.

18.2. Literature studies

Analysis of composition of the educational institutions located in the Arctic zone made it possible to identify the following. To date, there are 42 educational institutions than rank among higher education organizations. For example, there are two institutions in the Chukotka Autonomous District, six in Krasnoyarsk Territory, twelve in Yamalo-Nenets Autonomous District (YNAO), one in Komi Republic, fourteen in Murmansk Region, and seven in Arkhangelsk Region.

In speaking of secondary education, the number of organizations of higher professional education that implement programs of secondary vocational education is as follows: YNAO – 2, Murmansk Region – 4, Arkhangelsk Region – 5, Krasnoyarsk Territory – 1.

Finally, educational organizations of secondary vocational education located in the Arctic zone are represented as follows: YNAO – 10, Komi Republic – 5, Arkhangelsk Region – 20, Murmansk Region – 27, Chukotka Autonomous District – 4, Sakha Republic – 1.

At present, including with the support of the state, work is being done to increase the network interaction between universities located in the Arctic zone. Some universities are united in large federal universities, as well as educational consortia.

It is noteworthy that the total number of students studying at the Arctic universities is about 40 thousand people (Leksin et al., 2000). There are also training centers for oil and gas corporations, where vocational training and retraining of personnel is conducted.

Despite rather significant total number of students at the Arctic universities, the number of students being prepared specifically for the development of the Arctic shelf is still insufficient.

Currently, training of such specialists is carried out mainly by the following educational institutions: the RSU of oil and gas named after I. M. Gubkin; Murmansk State Technical University (MSTU); Northern (Arctic) Federal University; St. Petersburg Mining University.

The proposed toolkit for estimating the demand for personnel depending on the volume of hydrocarbons produced is a methodical basis for identifying the need for personnel in the development of the Arctic shelf.

It must be stressed that when implementing any projects on the shelf, there is a growing need not only for highly qualified personnel engaged directly in the production of hydrocarbons, but also for supporting personnel. Development of exchange trade determines the need for specialist knowledge in the field of marketing, exchange trading, and the use of financial instruments (spot contracts, futures, risk hedging, etc.) (Vasilyev, 2012; Tsvetkova, 2013; Nevskaya and Marinina, 2017).

The above question "Who will come to the World Ocean?" immediately sets the task of the own personnel, capable, first, of exploring and developing new offshore oil and gas and ocean (resource) technologies, and second, of operating the existing technical devices ensuring the necessary level of reliability and the safety of all work at sea, including environmental safety.

The potential of available labor resources for the implementation of projects in many ways predetermines the staffing of the projects being implemented. The concept of "human resources" of the company-operator implementing offshore projects means the maximum number of employees with combined knowledge and skills, as well as psycho-physiological and socio-cultural opportunities in the context of specific socio-economic and scientific and technical information. Following this logic, human resources of the oil and gas company is formed from the professional qualities of individuals who can put into practice their knowledge, skills and experience when implementing projects on the Arctic shelf.

As previously noted, the tasks related to the development of the shelf require high-end professionals with higher professional education, as well as a whole range of working specialties. In addition, such employees should have qualifications to work in the Far North, and be able to withstand increased psycho-physiological loads, which should be confirmed by the conclusion of a special medical examination board (Fadeev, 2012).

18.3. Research results

Human resources of oil and gas companies implementing projects on the Arctic shelf are formed of the following sources: inhabitants of the Arctic zone where the project is being implemented; employees attracted from other regions of the country, as well as citizens of foreign states.

In order to identify the conformity of the qualitative and quantitative characteristics of human resources to emerging needs in the implementation of projects on the shelf, we suggest that the model of the static balance between the available human resources and demanded resources be employed, expressed by a system of equations:

$$\begin{cases} \sum_{j=0}^{j}\left(\sum_{i=0}^{i}(ai\cdot Aji)+\sum_{n=0}^{n}(bn\cdot Ajn)+\sum_{k=0}^{k}(ck\cdot Ajk)+\sum_{m=0}^{m}(dm\cdot Ajm)\right)=\lambda(Aj); \\ \sum_{x=0}^{x}\left(\sum_{i=0}^{i}(ai\cdot Bxi)+\sum_{n=0}^{n}(bn\cdot Bxn)+\sum_{k=0}^{k}(ck\cdot Bxk)+\sum_{m=0}^{m}(dm\cdot Bxm)\right)=\lambda(Bx); \\ \sum_{y=0}^{y}\left(\sum_{i=0}^{i}(ai\cdot Cyi)+\sum_{n=0}^{n}(bn\cdot Cyn)+\sum_{k=0}^{k}(ck\cdot Cyk)+\sum_{m=0}^{m}(dm\cdot Cym)\right)=\lambda(Cy); \\ \sum_{z=0}^{z}\left(\sum_{i=0}^{i}(ai\cdot Dzi)+\sum_{n=0}^{n}(bn\cdot Dzn)+\sum_{k=0}^{k}(ck\cdot Dzk)+\sum_{m=0}^{m}(ai\cdot Dzi)\right)=\lambda(Dz), \end{cases} \tag{1}$$

where:

A – higher education professionals;

B – secondary vocational education professionals;

C – auxiliary workers;

D – maintenance workers;

a – knowledge;

b – skills;

c – socio-cultural competencies;

d – psycho-physiological possibilities;

i, n, m – types of knowledge, skills and psycho-physiological possibilities, respectively.

φ (Aj) – actual human resources of higher education professionals, corresponding to the expression:

$$\sum_{j=0}^{j}\left(\sum_{i=0}^{i}(ai\cdot Aji)+\sum_{n=0}^{n}(bn\cdot Ajn)+\sum_{k=0}^{k}(ck\cdot Ajk)+\sum_{m=0}^{m}(dm\cdot Ajm)\right)=\varphi(Aj); \tag{2}$$

φ (Bx) – actual human resources of secondary vocational education professionals, corresponding to the expression:

$$\sum_{x=0}^{x}\left(\sum_{i=0}^{i}(ai\cdot Bxi)+\sum_{n=0}^{n}(bn\cdot Bxn)+\sum_{k=0}^{k}(ck\cdot Bxk)+\sum_{m=0}^{m}(dm\cdot Bxm)\right)=\varphi(Bx); \tag{3}$$

φ (Cy) – actual human resources of auxiliary workers, corresponding to expression:

$$\sum_{y=0}^{y}\left(\sum_{i=0}^{i}(ai\cdot Cyi)+\sum_{n=0}^{n}(bn\cdot Cyn)+\sum_{k=0}^{k}(ck\cdot Cyk)+\sum_{m=0}^{m}(dm\cdot Cym)\right)=\varphi(Cy); \tag{4}$$

φ (Dz) – actual human resources of the maintenance workers, corresponding to the expression:

$$\sum_{z=0}^{z}\left(\sum_{i=0}^{i}(ai\cdot Dzi)+\sum_{n=0}^{n}(bn\cdot Dzn)+\sum_{k=0}^{k}(ck\cdot Dzk)+\sum_{m=0}^{m}(ai\cdot Dzi)\right)=\varphi(Dz); \tag{5}$$

λ (Aj) – regulatory human resources of higher education professionals;

λ (Bx) – regulatory human resources of secondary vocational education professionals;

λ (Cy) – regulatory human resources of auxiliary workers;

λ (Dz) – regulatory human resources of maintenance workers;

$$\begin{gathered} A \in [0;i],\ A \in N; \\ B \in [0;i],\ B \in N; \\ C \in [0;i],\ C \in N; \\ D \in [0;i],\ D \in N; \end{gathered} \tag{6}$$

Aji – the j^{th} employee with higher education, possessing the i^{th} knowledge;

Ajn – the j^{th} employee with higher education, possessing the n^{th} skill;

Ajk – the j^{th} employee with higher education, possessing the k^{th} socio-cultural competence;

Ajm – the j^{th} employee with higher education, possessing the m^{th} psycho-physiological capability;

Bxi – the x^{th} employee with secondary vocational education, possessing the i^{th} knowledge;

Bxn – the x^{th} employee with secondary vocational education, possessing the n^{th} skill;

Bxk – the x^{th} employee with secondary vocational education, possessing the k^{th} socio-cultural competence;

Bxm – the x^{th} employee with secondary vocational education, possessing the m^{th} psycho-physiological capability;

Cyi – the y^{th} auxiliary worker possessing the i^{th} knowledge;

Cyn – the y^{th} auxiliary worker possessing the n^{th} skill;

Cyk – the y^{th} auxiliary worker possessing the k^{th} socio-cultural competence;

Cym – the y^{th} auxiliary worker possessing the m^{th} psycho-physiological capability;

Dzi – the z^{th} maintenance worker possessing the i^{th} knowledge;

Dzn – the z^{th} maintenance worker possessing the n^{th} skill;

Dzk – the z^{th} maintenance worker possessing the k^{th} socio-cultural competence;

Dzm – the z^{th} maintenance worker possessing the m^{th} psycho-physiological opportunity.

To assess the companies' demand for personnel of various skill levels for implementing projects on the Arctic shelf, let us denote the higher education employees by λ (Aj), secondary vocational education employees by λ (Bx); auxiliary workers by λ (Cy); and maintenance workers by λ (Dz).

Thus, there are three alternatives of the relationship between the human resources of these workers and the need for employees of certain qualification. Let us consider the following example of employees with higher education.

Case 1: λ (Aj) < φ (Aj)

The available human resources of this qualification are greater than the need for workers with higher education. In this case, the need is fully provided by the resources available, with a certain additional human resource formed.

Case 2: λ (Aj) = φ (Aj)

The available human resources of this qualification are equal to the need for workers with higher education. Obviously, in this case, the need is fully provided by the resources available. However, in case of development of production, additional investments, aimed at professional retraining and training of personnel, is likely to be required.

Case 3: λ (Aj) > φ (Aj)

The available human resources of this qualification are less than the need for higher education professionals. In this case, in order to ensure implementation of projects, qualified training and professional retraining of personnel is required.

This model is a formalized description of the balance between the human resources (available capacity of employees of different categories) and the need for qualified personnel, taking into account the prospects for the development of exploration, production and transportation of hydrocarbon raw materials. This model can be used for forecasting and planning the number of personnel of a certain skill in the implementation of projects on the Arctic shelf.

The static model developed by A.M. Fadeev is exemplified by shuttle tankers operating at the Varandey field. He considers the transport component of the Varandey field exploitation process.

First, the available potential of the North-West region of the Russian Federation was determined in terms of the number of people who acquired professions under curriculum of institutions of higher vocational education (HVE), secondary vocational education (SVE), and in terms of the number of workers. As estimated, the potential of employees with HVE is 28,070, those with SVE – 21,140, workers – 18,200, and supporting employees – 7,560 man*competencies.

Then, according to the proposed static model, A.M. Fadeev established a need for personnel of the transport component of the process of exploitation of the Varandey field. The below data were obtained: the demand for employees with HVE – 660, for SVE employees – 836, for workers – 715, and for supporting employees - 88 man*competencies.

Thus, actual demand for personnel in the transport component of the exploitation process is less than the available potential of the region, therefore, it can be employed without outsourcing additional labor.

18.4. Conclusions

Training of in-house specialists for offshore operations should become an integral part of the country's sustainable development and a guarantee of its energy and technological independence.

The developed toolkit for forecasting and planning the number of personnel of a certain qualification for the development of hydrocarbon fields in the Arctic zone can be used in a comprehensive analysis of the needs for the provision of existing and promising projects in the Arctic region.

Along with the technical training of future engineers for the development of marine hydrocarbon deposits, an important role in the development of the shelf is played by the need for training personnel in the field of economics and management, as well as a range of working specialties necessary for the safe and efficient development of marine hydrocarbon deposits in the Arctic.

For the state, training and subsequent rational use of young specialists is an important task: this will determine further effective social and economic development of the country. In modern conditions, it is necessary to create a system of training and retraining high-end professionals for the oil and gas industry immediately in the region, which allows taking into account the features of innovative trends in the development.

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References

Ananiev, V. (2010). To the Arctic shelf in Russia "hands do not reach". *Oil & Gas Journal*, 38.

Dodin, D.A. (2007). Mineral resources of the Russian Arctic (state, prospects, directions of research), 129.

Fadeev, A.M., Cherepovitsyn, A.E., Larichkin, F.D., Egorov, O.I. (2010). Economic features of the projects development of offshore hydrocarbon fields. *Economic and social changes: facts, trends, forecast* 3 (11), 61-74.

Fadeev, A.M., Cherepovitsyn, A.E., Larichkin, F.D. (2011). Peculiarities of personnel training for development of offshore hydrocarbon fields in the Arctic. *Problems of development of mineral-raw and fuel and energy complexes of Russia. Proceedings of the Mining Institute* 194, 332-338.

Fadeev, A.M. Efficient development of the Arctic territories // Website of the Russian Council on international Affairs [Electronic resource]. – Mode of access: http://russiancouncil.ru/inner/index.php?id_4=1328#top

Fadeev, A.M. (2012). Improvement of economic approaches to management of development of marine hydrocarbon deposits of the Arctic. Apatity: publishing house of Kola science centre RAS.

If Russia does not prepare personnel, then Asians will work on the development of the Northern shelf: an interview with the Director of the Arkhangelsk branch of the Maritime Academy. Mode of access: http://www.regnum.ru/news/720683.html#ixzz1F9ESL0Cc

Ilyinsky, A.A., Mnatsakanyan, O.S., Cherepovitsyn, A.E. (2006). Oil and gas complex of North-West Russia. Strategic analysis and development concepts.

Kasantsev, V. (2006). While the state is sleeping. *Oil of Russia* 6, 94-97.

Katysheva, E., Tsvetkova, A. (2017). The future of oil and gas fields development on the Arctic shelf of Russia. [in:] International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 17, Ecology, Economics, Education and Legalizationp, 935-940.

Leksin, V., Shvetsov, A. (2000). Regional programs in the latest reformation situation. *Russian Economic Journal* 8, 23-25.

Livanov, D. (2015). Arctic-info. www.arctic-info.ru (15.12 2015).

Rogozin, D. (2015). Arctic-info. www.arctic-info.ru (15.12 2015).

Shishkin, A.I. (2016). Continental shelf of the Russian Federation and its importance. [in:] Modern problems of natural resources management and development of social and economic systems. Proceedings of the XII international scientific conference. Moscow state University S.Yu. Witte: Moscow, 93-98.

Marinina, O.A., Nevskaya, M.A. (2017). Specific nature of labour management in the oil and gas sector in the Russian Far North. *International Journal of Applied Business and Economic Research* 15(8), 177-185.

Nevskaya, M.A., Marinina, O.A (2017). Challenges and opportunities of state regulation of the innovation process in the Russian mineral resources sector. *Academy of Strategic Management Journal* 1(16), 149 – 159.

Toskunina, V.E. (2007). Program-functional approach to development of oil and gas resources of new regions: autoref. dis. ... Doc. Econ. Sciences: 08.00.05.

Tsvetkova, A.Yu. (2013). Principal of information innovation in the energy and mineral resource complexes. *Zapiski of the Mining Institute* 201, 247-252.

Vasilyev, Yu. (2015). Estimation of variation of product quality coal mining companies of the Russian Federation. *Mining information-analytical Bulletin (scientific and technical journal)* 40, 3-11.

Vasilyev, Yu. (2012). The use of tools for procurement in product sales fuel and energy complex: Monograph. 148 p.

Chapter 19

PERCEPTION OF ENVIRONMENTAL RESPONSIBILITY AND RISKS IN OIL AND GAS INDUSTRY IN RUSSIA

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Abstract

In the 21st century such issues as environmental sustainability, the preservation of natural resources, and a focus on climate change are not mere words but an internationally growing concern. Due treatment of above-mentioned issues requires a mature level of environmental responsibility demonstrated by different groups of actors. Hence, analysis of lessons learned from catastrophes can be an effective way of assessing environmental responsibility of a country. Nowadays more authors tend to perceive risks in such a way. The purpose of the article is to analyze the perception of environmental responsibility in Russia by assessing the attitude to the oil spill accident in the Mexican Gulf in 2010. The attitude of Russian actors such as government, researchers, environmental organizations as well as business representatives has been considered. Methodology includes study of literature on the issues of perception of risks in oil and gas industry; analysis of experts' interviews. Use of primary sources – interviews of representatives of actors' groups on the issue of risks in oil and gas industry – adds value to the outcomes of this research. This research can be used on the classes of the English language when studying the theme 'Environmental problems in industry': students can analyze the positions of different actors and make conclusions about their level of environmental responsibility. Opinions of different actors' groups could be useful for managers of enterprises since they demonstrate if actors stick to awareness of the problem, or they are ready to take measures of mitigation. Anyway, reasoning of every actor's opinion should be carefully considered. However, the article does not thoroughly study cooperation between actors mentioned though it is considered to be a prospective trend for a separate research. Findings of the research presuppose that attitude of actors to risks shows their level of environmental responsibility. Actors tend to provide debate on the necessity of lessons learned from the catastrophe such as the one happened in the Mexican Gulf in 2010 (researchers, environmental organizations) as well as take concrete measures (introduction of the law on prevention of the sea pollution by the government, initiating environmental regulations by business)., environmental organizations as well as business representatives has been considered.

Key words: environmental responsibility; environmental risk, gas industry.

19.1. Introduction

Demonstration of environmental responsibility can be a principle of a country's international position, a characteristic of a company's reputation as well as a trait of a person's character. Possible approach to environmental responsibility presupposes indicating of environmental awareness as well as commitment to continuous improvements. It is possible to analyze the level of environmental responsibility of different actors by assessing their level of awareness of the problem as well as readiness to take actions.

The aim of the article is to analyze the perception of environmental responsibility in Russia with the help of assessing the attitude to the oil spill demonstrated by Russian actors. The article analyzes the response of government, petroleum companies, environmental organizations as well as researchers to the catastrophe in the Mexican Gulf that took place in April, 2010.

Perception of risks by different actors was taken as an example of environmental responsibility; opinions of actors have been gathered from semi-structured interviews on the issues of research.

The position of a country is comprised of the attitudes of different actors. By the term 'actor' we mean a person, a company, a government body who take an active part in international processes, can express the position on the issue. Accordingly, international actors can be any organizations, groups and individuals that can change the environment by means of their activities.

Though environmental catastrophes present a challenge for society scientists recognize their necessity in order to introduce transformations. The function of the crises is to shock, focus attention, and generate decision-making. Learning lessons from the accidents is considered to be a basis of risk management nowadays as it gives information for realizing an accident modeling approach (Samia, 2018). The Deepwater Horizon oil spill in April, 2010 surely served as a crisis of perception, expectations and undermined trust in the capability of oil and gas industry to ensure offshore operations safety. However, it also resulted in actions taken to overcome further accidents.

19.2. Literature studies

The oil spill in the Mexican Gulf generated a great amount of research and projects aimed at analyzing the actions of responsible actors, the preparedness of industry for offshore activities. The analysis of response can be organized in several stages: immediate one that took place after the accident and before the final report was released by the company *Beyond Petroleum* in September, 2010. The longer response can be bound to the catastrophes that took place after the one in the Mexican Gulf and in a way 'distracted' attention from it, for example, the accident at Fukushima.

Oil and gas industry has always evoked interest of researchers who can give an overview of developing innovative business model related to offshore oil and gas projects (Legorburu, 2018), explore accidents resulted from natural factors (Zambrano, 2018) as well as pay attention to human factor risk (Zhou, 2017, Marinina, 2017).

As the issue of risks has also been widely studied in different fields of research, we can come across different approaches to studying risks: geopolitical (Antonakakis, 2017), psychosocial (Bergh, 2017) as well as cultural (McEvoy, 2017). Researchers also explore debate on risks taking place in different countries (Metcalfe, 2018). Some researches aim at filling the gap in studying corporate performance in which environmental responsibility is playing an important role (Peng, 2018).

The article does not cover the possibilities of cooperation between actors in one country as well internationally. Still, research in this direction is going on, for example, on the issue of researchers' cooperation, thus giving new prospects for further positive outcomes (Ochirbat, 2018, Ponomarenko, 2016).

19.3. Methodology

Methods used in this research include literature studies as well as analysis of semi-structured expert interviews as a primary source of information. Responses taken in four interviews have been used in this research, interviews were made during internship in Norwegian Institute of International affairs and also during the conference visit in Moscow. We use two interviews of researchers, Norwegian and Russian ones, the interview of the oil and gas company's representative as well as the interviews of an employee of a Russian environmental organization. We also used secondary source of data, the interview given by a former president of the Russian Federation as one of the groups of actors under study is government. Since it was not possible to make an interview with the government representative, we used material suggested by one of the leading journals where answers on questions of importance for this research have been answered by Dmitriy Medvedev.

Interviewees were asked the following questions:

What impact did catastrophe in the Mexican Gulf have on oil and gas industry?

Did the accident change perception of risks?

Did the accident have an impact on plans to manage Arctic resources?

The research problem within this study is formulated in the following way: how can we assess environmental responsibility of country? What is the possible role of risks' perception in assessing the level of environmental responsibility of country's actors?

The hypothesis of the research is formulated as follows: firstly, it is possible to assess the level of environmental responsibility of a country by looking at positions of its actors: government, business, researchers, environmental organizations, Secondly, attitude to risks in oil and gas industry by different actors – awareness of the issue and readiness to take effective measures – can show their level of environmental responsibility.

19.4. Research results

The results of the study are presented according to actors' opinions given. Petroleum companies' attitude is assessed based on two interviews.

Petroleum companies expressed concern that 'agony over the accident will hamper the development of petroleum and associated industries'. They took a sensible approach and demanded to determine the cause of the oil spill before they agree to draw lessons. Additional attention was focused on offshore projects in Russia though it has no proven and long term experience in this. The head of *Lukoil* stated that 'after the accident in the Mexican Gulf we are expecting strengthening of environmental regulations' (Alekperov, 2010, Nevskaya and Marinina, 2017).

One more response was that a training center for the personnel working on the shelf was established by *Lukoil*. It marked the necessity in further educating the personnel to work at offshore oil projects. Companies that tend to be considered 'international' demonstrated their adherence to stricter environmental norms in offshore projects; *Lukoil* is one of such companies.

Gazprom introduced proposals to improve the environmental policies of the Russian Federation and placed emphasis on the increase of environmental responsibility for the dissemination of information. The examples show that oil and gas companies look forward to changes of the old-fashioned Russian legislation regarding work on the continental shelf of the Russian Federation.

The catastrophe in the Mexican Gulf made an impact on the work of joint international groups that aim at making suitable safety standards for the Barents Sea, for instance, 'Barents 2020'. The participant of Barents 2020'and an oil and gas company's employee said the following:

'The accident in the Mexican Gulf made us think over the work we are doing within the commission. It is difficult to refer to concrete steps made in the light of the accident but in general what we do now regarding the Barents Sea is done having this catastrophe in mind, taking into account the consequences of the accident in the Mexican Gulf'.

As for the government's opinion on the risks in oil and gas industry, plans in the Arctic are perceived in a more responsible way and the idea that new oil and gas projects should be environmentally friendly prevails.

According to the opinion of the president of the Russian Federation the catastrophe in the Mexican Gulf could change the prevailing attitude to authority. The President is in favour of an international approach to risk security in the light of the Deepwater Horizon accident saying that 'such an accident can undermine anything, including the authority of government… we have to find a new way of distributing accountability regarding risk security… a new international approach has to be found. We shall consolidate our efforts in this respect' (Medvedev, 2010).

In October, 2010 the Committee for Natural Resources, Nature management and Environment organized parliamentary hearings on the 'Legislative Provision of Protecting Seas from Oil Pollution' where the issue of developing law projects was discussed with the aim of establishing a clear system of environmental risk assessment as well as requirements for industrial safety.

The law project was initiated in 2007 after the oil spill in the Kerch strait when more than 1,500 tons of oil products poured out into the Kerch Strait. The idea was to regulate the level of corporate environmental responsibility. Thus, it is possible to state that the accident in the Mexican Gulf was one more 'wake-up call'.

The next group of actors, Russian environmental organizations, has joined the discussion with a very sound argument. One of the respondents from WWF company gave a concrete example of how the accident could change the existing state of things:

'If we seek examples of the concrete steps taken in light of the accident, one of them is the draft law project 'On the Prevention of Sea Pollution by Oil' though it has not yet been accepted. The project is under discussion though a year has passed since the catastrophe in the Mexican Gulf'.

Environmentalists appeal for concrete actions. In response to the accident in the Mexican Gulf they wrote a letter to the Ministry of Foreign Affairs from several organizations before the meeting of the Arctic Council explaining the arguments and asking for the initiation of a moratorium on drilling in the Arctic:

'The oil spill in the Mexican Gulf reminded us once more of the serious risks involved in offshore drilling. We ask …to take the initiative at the coming meeting of the Arctic Council …and discuss the necessity to declare a moratorium on offshore drilling in this region…in the Arctic region warming takes place twice as fast as in other parts of our planet. No effective means of cleaning oil spills offshore can be applied especially in a region containing ice'.

They traditionally keep on appealing to petroleum companies for cooperation, taking more drastic measures to ensure nature conservation and radically stop activities in the Arctic.

Concrete steps need time to be taken. This opinion is proved by the words of one of the respondents – researcher:

'Measures in Russia are not adopted in a fast manner. This is perhaps due to financial difficulties. The financial side is a very important indicator of how important it is for the country'.

In general, environmentalists evaluate the Russian system of response to similar disasters as not satisfactory. For instance, one of the respondents remarked:

'Russia has no response mechanism to damage done to mammals in the Arctic as a result of an oil spill'.

Alternative response to the Deepwater Horizon accident was proposed by researchers who say one should not worry about deep-water drilling in Russia since there are no such deep projects as they have in the Mexican Gulf. The opinion of the representative of a research institute was the following: 'as for ecosystem damage oil is lighter substance than water, it is on the surface thus, fish and plankton are out of danger. Damage can occur in the places where oil reaches the shore, such contacts are of local, limited and solvable character as we can see in the accidents that took place so far'.

To sum up, higher level of environmental responsibility leads to more attentive approach to risks involved in offshore projects. It is necessary to pay more attention to the risks associated with the development phase that will increase the cost of the projects. Risks associated with the petroleum industry did not increase, the attention to them became more obvious after the accident in the Mexican Gulf. This catastrophe has implications for the offshore exploration and production industry that go well beyond the region.

19.5. Conclusions

The following conclusions have been made on the basis of literature and interviews' analysis:

Assessment of the attitude of actors to risks shows their level of environmental responsibility. Actors tend to take concrete measures (introduction of the law on prevention of the sea pollution by the government) as well as provide debate on the necessity of lessons learned from the catastrophe such as the one happened in the Mexican Gulf in 2010.

Environmental responsibility in a country can be measured by the attitude to the similar catastrophes (in this case, accident at Deepwater Horizon in April, 2010) and readiness to learn lessons.

In Russia the possibility to introduce the law 'On prevention of sea pollution by oil' initiated by environmental organizations is the example of increased environmental awareness. Claim on behalf of the government about more stringent approach to environmental management of Arctic projects; business initiative on legislative and environmental regulations are the ones as well.

The concept of environmental responsibility in respect to the catastrophe at Deepwater Horizon is still much manipulated by various actor groups, the reason being the wish to promote groups' self-interest, take initiative, improve reputation (petroleum companies), to appeal to further cooperation with business (environmental organizations).

The response of oil and gas companies to the Mexican Gulf was notable, though we see that only global players reveal their positions. The example of a typical response is to ask for changes and introduce proposals to the old-fashioned environmental laws regarding work on the continental shelf. Russia in this respect definitely needs to strengthen the institutions of accountability. Russia's possible contribution to the world's environmental well-being' can be reducing inefficient use of energy, protecting the clean water and forest resources.

Managers of enterprises could take into account opinions of all actors whose opinions are given in the article. It is advisable to analyse the reasoning given by actors in order to prove their viewpoint.

Opinions can be divided into the ones reflecting the level of awareness of the problem and the ones demonstrating mitigation in the situation of high risks.

References

Alekperov, V. Interview to 'Kommersant'. https://www.kommersant.ru/doc/1391120 (30.06.2018)

Antonakakis, N., Gupta, R., Kollias, C., & Papadamou, S. (2017). Geopolitical risks and the oil stock nexus over 1899-2016. *Finance Research Letters,* 23, 165-173. doi: http://dx.doi.org/10.1016/j.frl.2017.07.017

Bergh, L. I. V., Leka, S., Zwetsloot, G. (2018). Tailoring Psychosocial Risk Assessment in the Oil and Gas Industry by Exploring Specific and Common Psychosocial Risks. *Safety and Health at Work,* 9(1), 63-70. doi: http://dx.doi.org/10.1016/j.shaw.2017.05.001

Legorburu, I., Johnson, K. R., Kerr, S. A. (2018). Multi-use maritime platforms – North Sea oil and offshore wind: Opportunity and risk. *Ocean & Coastal Management,* 160, 75-85. doi: http://dx.doi.org/10.1016/j.ocecoaman.2018.03.044

McEvoy, J., Gilbertz, S. J., Anderson, M. B., Ormerod, K. J., Bergmann, N. T. (2017). Cultural theory of risk as a heuristic for understanding perceptions of oil and gas development in Eastern Montana, USA. *Extractive Industries and Society-an International Journal,* 4(4), 852-859. doi: http://dx.doi.org/10.1016/j.exis.2017.10.004

Medvedev, D. (2010). Interview to 'Wall Street Journal'. http://www.kremlin.ru/news/8082 (30.06.2018)

Metcalfe, J. (2018). Environmental pollution and the media, political discourses of risk and responsibility in Australia, China and Japan. *Jcom-Journal of Science Communication,* 17(2). doi: http://dx.doi.org/10.22323/2.17020702

Marinina, O.A., Nevskaya, M.A. (2017). Specific nature of labour management in the oil and gas sector in the Russian Far North. *International Journal of Applied Business and Economic Research,* 15 (8), 177-185 . doi: https://www.researchgate.net/publication/317745811

Nevskaya, M.A., Marinina, O.A (2017). Challenges and opportunities of state regulation of the innovation process in the Russian mineral resources sector. *Academy of Strategic Management Journal,* 1(16), 149 – 159.

Ochirbat, P., Chinzorig, B. (2018). On Enhancement of Cooperation Between Universities for Implementation of the Program «Sustainable Development – 2030». *Zapiski Gornogo Insituta,* 229, 27-30. doi: http://dx.doi.org/10.25515/PMI.2018.1.27

Peng, B. H., Tu, Y., Elahi, E., Wei, G. (2018). Extended Producer Responsibility and corporate performance: Effects of environmental regulation and environmental strategy. *Journal of Environmental Management,* 218, 181-189. doi: http://dx.doi.org/10.1016/j.jenvman.2018.04.068

Samia, C., Hamzi, R., Chebila, M. (2018). Contribution of the lessons learned from oil refining accidents to the industrial risks assessment. *Management of Environmental Quality,* 29 (4), 643-665. doi: http://dx.doi.org/10.1108/meq-07-2017-0067

Zambrano, J., Kovshov, S.V., Lyubin, E.A. (2018). Risk assessment of accidents due to natural factors at the Pascuales – Cuenca multiple-use pipeline (Ecuador). *Zapiski Gornogo Instituta,* 230, 190-196. doi: http://dx.doi.org/10.25515/PMI.2018.2.190

Ponomarenko, T.V., Vol'nik, R., Marinina O. A., (2016). Korporativnaya social'naya otvetstvennost' ugol'noj otrasli (praktika rossijskih i evropejskih kompanij). *Zapiski Gornogo Instituta,* 222, 882-891. doi: http://dx.doi.org/10.18454/pmi.2016.6.882.

Zhou, A. T., Wang, K., Zhang, H. (2017). Human factor risk control for oil and gas drilling industry. *Journal of Petroleum Science and Engineering*, 159, 581-587. doi: http://dx.doi.org/10.1016/j.petrol.2017.09.034