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## THE INNOVATIVENESS OF POLISH MINING SECTOR COMPARED WITH OTHER INDUSTRIAL SECTORS

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### **1. Introduction**

Mining is this sector of industry, which involves mining the deposits, which are later processed in enrichment processes, that is in the processes of lowering the level of impurities; to be used in various other sectors of industry — for further processing or for sale and direct utilisation.

Apart from changes in the micro- and macro-economic conditions, the functioning of the mining industry is significantly influenced by the mining — geological conditions and changes in those conditions. Every enterprise has to constantly tune to the environment in which it operates, which enforces specific limitations or creates certain opportunities; yet the mining enterprises are more than others, compelled to introduce changes, because of the dynamic character of the conditions in which the production process is realised.

This requires more than average ability to introduce purposeful changes. If those changes contain the elements of newness, and it is enough, that those elements are new to the enterprise, then, they can be qualified as innovations, and the sole ability or inclination to introduce changes is the innovativeness, the level of which in the Polish mining industry was subjected to an analysis in this paper.

### **2. Changes in the percentage of enterprises introducing various types of innovations; both in the mining industry and in other sectors of industry**

In accordance to the Oslo methodological textbook [8], innovative enterprise is the enterprise, which implemented at least one innovative solution during the analysed period

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of time. In accordance to the definition, contained in the afore textbook — devised by the OECD experts — innovative solution shall be considered to be the implementation of a new or significantly improved product or process, a new marketing method or a new organisational method in the economic practice, organisation of the workplace or relations with the environment. The minimum requirement is that those products or processes were new to the enterprise; they do not have to be new on the market in which this enterprise operates, they can be adapted from other enterprises. This approach applies to measuring innovativeness in enterprises and EU Member States, as well as represents the OECD approach to the innovativeness.

Despite the commonly accepted attitude, that implementation of innovative solutions is a necessity, in order to achieve and maintain effectiveness and competitiveness, the innovativeness analyses of enterprises, conducted in a 2 — year cycle by the Central Statistical Office (GUS), showed that percentage of innovative enterprises, among enterprises operating in the general industry, is falling in the years following 2002 (Tab. 1) [2–5]. The same tendency was observed in enterprises, classified — according to the Polish Classification of Activities (PKD) — as „Górnictwo” (Section of NACE: „Mining”).

TABLE 1  
**Innovative enterprises in industry during 2002–2010**

Specification	2004	2006	2008	2010
	%	%	%	%
Industrial enterprises	45.6	23.2	21.3	17.1
Enterprises section of NACE „Mining”	30.5 <sup>*)</sup>	21.3	17.5	13.8

\*) more than 49 employees.

Source: Own preparation on the basis of [2–5]

The NACE „Mining” section contains — according to the applicable since 1 January 2008 — Polish Classification of Activities 2007 [9] groups such as:

- Hard coal mining;
- Brown coal (lignite) mining;
- Crude oil mining;
- Natural gas mining;
- Iron ore mining;
- Non – ferrous metal ores mining;
- Stone, sand and clay mining and quarrying;
- Mining and quarrying not classified elsewhere;
- Servicing activities, supporting the exploitation of crude oil and natural gas deposits;
- Servicing activities, supporting other mining and quarrying sectors.

The relation of the number of innovative enterprises, as compared to the total number of enterprises classified in the NACE „Mining” section, is lower than the similar relation determined for the enterprises operating in the general industry; and after 2006, the fall of the percentage of innovative enterprises operating in the NACE „Mining” section was higher than in enterprises operating in the general industry. However it has to be noted that the enterprise can be classified as innovative due to the simultaneous implementation of one or several types of innovative solutions. Depending on the scope of undertaken activities, four types of innovativeness can be distinguished [8]:

- Innovative solutions pertaining to products: that is the introduction of a product or service, which are new or significantly improved — within the scope of their properties or applications;
- Innovative solutions pertaining to processes: that is the implementation of a new or significantly improved production or delivery method;
- Innovative solutions pertaining to marketing: that is the implementation of a new marketing method, involving significant changes in the project/construction of the product or in packaging, distribution, promotion or price strategy;
- Innovative solutions pertaining to organisation: that is the implementation of a new organisational method in the adopted by the enterprise procedures and actions, in the workplace organisation or in relations to the outside environment.

Analyses of the innovative activities of enterprises, conducted by the GUS [3–5] investigated the percentage of enterprises implementing each of the afore types of innovativeness separately (Tab. 2).

TABLE 2  
**Innovative enterprises by type of innovations during 2004–2010**

Type of innovation	Industrial enterprises, (in % of total enterprises)			Enterprises section of NACE „Mining”, (in % of total enterprises)		
	2004–2006	2006–2008	2008–2010	2004–2006	2006–2008	2008–2010
Product innovations	15.7	15.5	12.1	12.2	9.6	6.4
Process innovation	19.4	17.0	12.9	17.4	15.5	11.3
Organisational innovations	23.4	13.3	13.0	27.2	14.0	12.3
Marketing innovations	18.4	13.5	13.5	13.2	9.4	12.5

Source: Own preparation on the basis of [3–5]

Those analyses showed, that the predominant type of innovative solutions implemented by the enterprise changes. In years 2004–2006 the majority of enterprises operating in the general industry declared the implementation of organisational innovations (23.4%).

In the next analysis, covering the years 2006–2008, the general fall in the percentage of enterprises implementing innovations occurred; the highest fall was registered exactly among the organisational innovations. Thus this type of innovations was no longer prevailing, and it was surpassed by the process innovations (17.0%). During the last analysis of enterprise innovativeness, conducted in years 2008–2010 [5], a further fall in the percentage of innovative enterprises was registered. Within the scope of the implementation of organisational innovations, this fall was down to 13.0%.

The same level as in years 2006–2008 was maintained only among enterprises implementing marketing innovations, which became the major type of innovations. Product innovations were not — in any of the afore analyses conducted by GUS — the prevailing type of innovations. As with other types of innovations, the percentage of enterprises operating in the general industry, implementing product innovations fell from 15.7% in years 2004–2006, through 15.5% in years 2006–2008, down to 12.1% in years 2008–2010.

Similar changes to the prevailing type of innovation, implemented in the consecutive years also occurred in the mining industry. In years 2004–2006, the percentage of enterprises classified in the NACE „Mining” section, implementing innovative solutions was higher than the percentage of innovative enterprises operating in the general industry; it reached 27.2% of enterprises operating in this NACE section. However the results of the successive analyses conducted by GUS in years 2006–2008 [4], showed the fall of this percentage by half — to 14%; yet, it was still higher than in enterprises operating in the general industry. GUS analyses covering years 2008–2010 [5] showed further fall of the percentage of enterprises classified in the NACE „Mining” section, implementing innovative solutions: to the level of 12.5%, which is slightly lower than the percentage of innovative enterprises operating in the general industry. Organisational innovations seem to be recorded parallel with all other types of innovations; thus they can decide of the success of those other types of innovations [1].

The level of the prevailing type of innovations, implemented in the mining industry in the years 2006–2008, that is the process innovations, was by 1.5 percentage point lower than in enterprises operating in the general industry, and it reached 15.5%. Marketing innovations, which were the slightly prevailing type of innovations in the years 2008–2010, were implemented in the mining industry by 12.5% of enterprises, that is by 1% enterprises less than in enterprises operating in the general industry.

In the mining industry, the percentage of enterprises implementing this type of innovations, which for enterprises operating in general industry, after a fall from 18.4% (2004–2006) to 13.5% (2006–2008), was maintained at the same level of 13.5% (2008–2010), was much lower, and this fall from the level of 13.2% (2004–2006) to 9.4% (2006–2008) was difficult to interpret. Currently this percentage rose to 12.5% (2008–2010).

The implementation of product innovations in enterprises, classified in the NACE „Mining” section is difficult, due to the specificity of this branch of industry. The product is

obtained from the nature, not manufactured, thus the possibilities of introducing changes to the product are very limited. In years 2004–2006 the percentage of mining industries implementing product innovations reached 12.2%, that is in was by 3.5 percentage points lower than in enterprises operating in the general industry. In further years, the fall of this percentage was registered, and this fall was greater than in enterprises operating in general industry. This led to widening the gap between the mining enterprises and enterprises operating in general industry. In years 2006–2008 this gap was 5.9 percentage point. In years 2008–2010 a further fall in the percentage of mining enterprises implementing product innovations was registered, and this percentage reached only 6.4% of the total enterprises classified in this section. The gap between enterprises operating in general industry and mining enterprises, implementing product innovations fell to 5.7 percentage point, due to a general fall of the innovativeness level of enterprises.

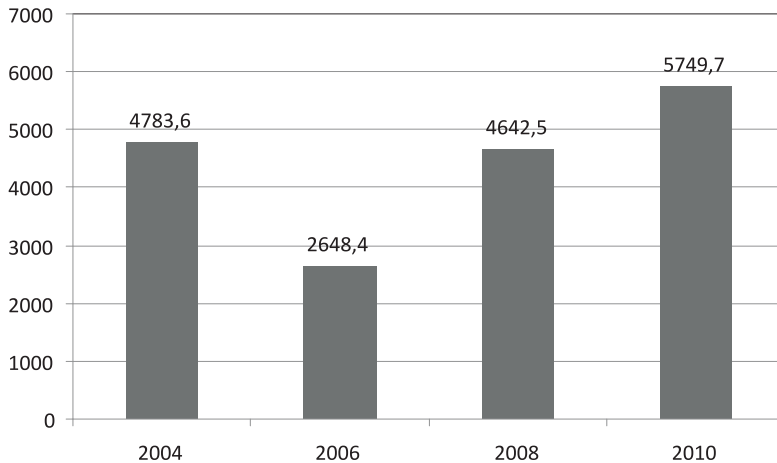
### **3. Changes in the structure of outlays on innovative activities in the mining industry and in enterprises operating in general industry**

The factor determining the level of innovativeness can be, apart from the number of enterprises implementing innovative solutions pertaining to products, processes, marketing and organisation, the level of outlays on innovative activities and solutions. At the same time, it can be said that the fall in the level of outlays for innovative activities can be the reason for the fall in the number of enterprises implementing innovative solutions.

However the analyses conducted by GUS did not support this thesis. Admittedly, analyses covering years 2004–2006 [3] showed the fall in outlays for innovative solutions, per one enterprise implementing such innovations — as compared to years 2002–2004 — but in the following years, 2006–2008 and 2008–2010, a rise in the level of outlays for innovative solutions, per one enterprise implementing such innovations, was registered (Fig. 1), while at the same time, the percentage of enterprises implementing innovative solutions was falling (Tab. 1).

Outlays for innovative activities, per one enterprises classified in the NACE „Mining” section, implementing innovative solutions in years 2008–2010 were PLN 13092.5 thousand, that is they were over twice as high than in case of the enterprise operating in general industry, where such outlays equalled PLN 5749.7 thousand/enterprise. This can be interpreted as definitely above average engagement in innovative activities. Higher outlays for the implementation of innovative solutions per one enterprise were recorded only in enterprises operating in the following PKD groups (NACE sections):

- Manufacture of tobacco products;
- Manufacture of coke, refined petroleum products and nuclear fuel;
- Manufacture of motor vehicles, trailers and semi-trailers, excluding motorcycles;
- Sewage and refuse disposal, sanitation and similar activities.



**Fig. 1.** Average expenditures for one enterprise with innovation activity during 2004–2010 [thous. Zł].  
Source: Own preparation on the basis of [2– 5]

However, in [7] it was determined, on the basis of the GUS data from 2007, pertaining the enterprises from the Śląskie Voivodeship and on the basis of the conducted calculation that enterprises involved in mining of hard and brown coal, classified in the NACE „Mining” section were characterised by the worst innovation effectiveness, determined as a relation between outlays for innovative activities and income from the sale of new or significantly improved products.

Thus the analysis of the outlays themselves is not enough, as such outlays can be ineffective. According to the author, considering the measure of the effect from the incurred expenditures for the innovation activities to be the income from the new or significantly improved products makes sense only in case if innovations pertaining to the product, as realised innovations pertaining to processes, organisation and marketing do not generate income from the sale of new or significantly improved products, but they lead to lowering costs or — through better customer service — to the rise of the income in general; in the quoted paper, those factors were dismissed from the analysis.

The structure of outlays for innovative solutions in the mining enterprises in years 2004–2008 was discussed in other paper by the author [6]. There, it was brought to attention that in the structure of outlays for the implementation of innovative solutions, the dominating position was held by outlays for the purchase of machines and technical devices, next place was taken by the outlays for buildings and structures and the third by the outlays for research and development activities. This structure was maintained for the last dozen or so years, and the latest analyses of innovative activities conducted in years 2008–2010 [5] (Tab. 3).

However it has to be noted that total outlays for the implementation of innovative solutions in years 2008–2010, as compared to the previous period, that is years 2006–2008, fell in both the NACE „Mining” section and in enterprises operating in the general industry (Tab. 3 and 4).

TABLE 3  
Expenditures on innovation activity in enterprises by section of NACE „Mining“ during 2004–2010

Specification	2004		2006		2008		2010	
	thous. Zl	%	thous. Zl	%	thous. Zl	%	thous. Zl	%
Total	432.0	100.00	460.4	100.00	672.9	100.00	536.8	100.00
R&D	16.7	3.87	17.9	3.89	16.1	2.39	25.5	4.75
Acquisition of complete technology in the form of documentation and rights	3.0	0.69	2.8	0.61	0.5	0.07	0.0	0.00
Acquisition of software	0.0	0.00	4.2	0.91	7.5	1.11	13.4	2.50
Capital expenditure	107.4	24.86	buildings, constructions and land	102.9	145.7	21.65	98.2	18.29
			machinery and technical equipment of which import	327.3	71.09	364.5	54.17	389.4
Personnel training connected with innovation activity	38.5	8.91	27.8	6.04	71.7	10.66	27.1	5.05
Marketing for new and significantly improved products	8.4	1.94	0.3	0.07	0.5	0.07	1.1	0.20
	0.1	0.02	0.1	0.02	0.2	0.03	0.1	0.02

Source: Own preparation on the basis of [2–5]

TABLE 4  
Expenditures on innovation activity in industrial enterprises during 2004–2010

Specification	2004		2006		2008		2010	
	thous. ZI	%	thous. ZI	%	thous. ZI	%	thous. ZI	%
Total	15628.1	100.00	17841.2	100.00	25367.2	100.00	23757.8	100.00
R&D	1172.7	7.50	1592.8	8.93	2068.9	8.16	3351.2	14.11
Acquisition of complete technology in the form of documentation and rights	438.9	2.81	352.5	1.98	275.7	1.09	918.8	3.87
Acquisition of software		0.00	504.5	2.83	389.7	1.54	490	2.06
buildings, constructions and land	3630.5	23.23	4029.7	22.59	6956.9	27.42	5408	22.76
machinery and technical equipment	9351.1	59.84	10632.7	59.60	14471.8	57.05	12491.7	52.58
of which import	3885.9	24.86	4446.9	24.92	5745.9	22.65	4935.2	20.77
Personnel training connected with innovation activity	40.5	0.26	51.5	0.29	234.8	0.93	105.7	0.44
Marketing for new and significantly improved products	409.5	2.62	480.6	2.69	625.2	2.46	457.6	1.93

Source: Own preparation on the basis of [2–5]



In the NACE „Mining” section this fall was by 20%, whereas in enterprises operating in the general industry this fall was by around 6%.

In the NACE „Mining” section this fall was caused mainly by lowering the level of investment outlays for buildings, structures, civil and water engineering objects and land associated with innovative activities. At the same time the rise in the level of outlays for machines and technical devices was recorded, what led to a situation, when the percentage of such outlays in total outlays for innovative activities reached as much as 72.5% in years 2008–2010. This leads to repeating the reservation mentioned in [6] and based on analyses covering the earlier years, whether all investment outlays, listed in the outlays for innovative solutions for the purchase of machines and devices were associated with the implementation of new or significantly improved products or processes and were they really necessary for the implementation of those products and processes.

In case of enterprises operating in the general industry, with an exception of outlays for research and development activities, all other types of outlays for innovative solutions in years 2008–2010 fell. When we consider the largest positions, we will notice, that also in this group of enterprises, a significant fall — by 22% of investments for buildings, structures, civil and water engineering objects and land associated with innovative activities — occurred. Investment outlays for machines and devices fell by 13%.

In the general number of enterprises operating in the industry, those modifications led to positive changes in the structure of outlays for the implementation of innovative solutions, as the percentage of outlays for research and development activities rose to 14.1% and the percentage of outlays for the purchase of readymade technologies rose to 3.87%. The mining industry also dedicated more to the research and development activities, but this percentage was only 4.75% of the total outlays for innovative activities. Outlays for the purchase of readymade technologies fell to zero. It can be said that innovative activities — implementation of changes — in the mining industry was reduced to the purchase of machines and technical devices; or that the developed solutions require each time significant investment outlays, what can cause ineffectiveness of such innovative activities.

#### **4. Summary**

Percentage of innovative enterprises classified in the NACE „Mining” section, as compared to the general number of enterprises classified in this section is lower than the percentage of innovative enterprises operating in the general industry, compared to the total number of enterprises operating in the general industry. Since 2002 the percentage of innovative enterprises, as compared to the total number of enterprises operating in the industry is systematically falling. In case of mining enterprises, it has to be noted that the rise of this fall was much higher since 2006.

A detailed analysis, specifying four different types of innovation activities, allows to notice that up to 2008, organisational innovations were implemented by a higher percentage of mining enterprises than in case of enterprises operating in the general industry.

In latest analyses conducted by GUS, covering years 2008–2010, this percentage is — in case of mining enterprises — lower by 0.7 percentage point. The worst result was achieved by the mining enterprises in the field of the implementation of product innovations. This is justified by the specificity of the economic activity, as the product is not manufactured but mined from natural deposits, thus the possibilities of implementing changes and improvements are limited. According to the latest analyses, covering years 2008–2010, product innovations were introduced by only 6.4% of mining enterprises. Possibly, the reasons of the neglect in this field was the fact that the customers do not put pressure on the mining sector to develop innovative products.

One can highlight a weak relation between the total level of outlays for innovative activities and the percentage of innovative enterprises as compared to the total number of enterprises; as this percentage of innovative enterprises falls steadily since 2002 and the total outlays fell for the first time in 2010. This fall was mainly associated with lowering the level of investment outlays for buildings, structures, civil and water engineering objects and land associated with innovative activities.

In the structure of outlays for innovative activities, the dominating position is held by outlays for the purchase of machines and technical devices, next place is taken by the outlays for buildings and structures and the third by the outlays for research and development activities. In recent years, in case of enterprises operating in general industry, the level of outlays for research and development rose, whereas in the mining industry, the percentage of investment outlays for the purchase of machines and devices rose to 72.5%.

The specification of outlays for innovative activities, per one enterprise operating in general industry and per one enterprise operating in the NACE „Mining” section shows that the financial involvement of mining enterprises is more twice as high as enterprises operating in general industry, but this can lead to ineffectiveness of the conducted innovative activities.

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