

ECONOMIC DEVELOPMENT AND VIABILITY FIRMS IN EUROPEAN MINING REGIONSBERUMEN, Sergio A. ¹

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Abstract

This work has the aim of knowing the situation in which the regions and the coal firms are in Europe – a very relevant issue since on December 31, 2018, all the EU and State mining aids will be suppressed. Specifically, it proposes a socioeconomic rank of the regions, and it also builds a rank which identifies: i) the will of the firms to start processes of industrial reconversion; ii) the internationalization of at least one part of the processes; and iii), to know which are the regions that, given the circumstances, are most likely destined to disappear.

JEL Codes: C38, L16, L72, O57.

Keywords: Mining sector; coal regions; economic development; viability firms; European Unión.

1. Introduction

In recent years the interest in studying the mining regions from different angles has increased spectacularly. Regarding the field of economics, research has focused in the development of the coal regions, in the problems caused by the lack of competitiveness of firms, and in the impact that generated the European and State grants and subsidies. In the first group of researchers we find Zanin (2007), Reeson *et al.* (2012), Guisan and Aguayo (2013) and Berumen (2014), among others. The second group includes the work of Berumen (2006^{a, b}), Kemfert and Diekmann (2006), Berumen and Llamazares Redondo (2007), Haftendorn and Holz (2008), Tavoni and Van der Zwaan (2009), Berumen and Hegemann (2007, 2014^{a, b}), Taeyoon *et al.* (2011), Metaxas (2011) and Kaplan (2012), among others. Finally, in the third group are those of Frondel *et al.* (2006), Gruian (2010) and Burke and Resosudarmo (2012), among others.

We can affirm that the coal industry in Europe is facing a difficult situation because over the last 30 years it has been unable to cope with the challenges posed by the current model of globalization, and it seems that things will not improve. The European

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Commission has established that aids will come to an end on December 31, 2018, which actually means the “death” for some coal regions. For the above reasons, the present article will meet two issues. First, it will develop a socioeconomic ranking of mining regions in Germany, Belgium, Czech Republic, Spain, France, Hungary, Poland and United Kingdom. And second, it will build a specific ranking to identify: i) the willingness of firms to undertake industrial restructuring; ii) that firms have to internationalize at least a part of the processes; and iii), the list of firms that are most likely to disappear (and obviously, all this is expected to negatively impact both, socioeconomic and competitiveness indicators of the regions and firms). Table 1 shows the regions that were studied.

Table 1: Firms/ mining regions studied

Country	Regions
Belgium	Mons–Charleroi (Wallone)
Czech Republic	Northern Bohemia / Sokolov
France	Nord-Pas de Calais
Germany	Dortmund (North Rihne-Westfalia <i>land</i>)
Hungary	Salgotarjan / Tatabany / Pecs
Poland	Śląsk
Romania	Petroșani / Lupeni (Târgu Jiu)
Spain	Castilla y León / Asturias
United Kingdom	Blaenau Gwent (Wales)

Source: Own elaboration.

Mining regions of Austria, Finland, Italy and Sweden were excluded because they specialize in exploiting wulfenite, chromium, copper, zinc, granite and iron, but not coal. In the case of Croatia, a member of the European Union (EU) since July 1, 2013, and indeed it has a relatively large coal sector, but it was not considered because data is not yet collected. The other EU countries, Bulgaria, Cyprus, Denmark, Slovakia, Slovenia, Estonia, Greece, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands and Portugal do not have strong mining sectors and, therefore, the exploitation of mineral has not allowed a development of representative companies. Companies and regions studied are part of Euromines (*European Association of Mining Industries, Metal Ores & Industrial Minerals*), which is an institution that operates under *Regenerating Coalfield Europe's Regions* of the EU program.

2. Analysis Methodology

It becomes increasingly necessary to utilize methodologies that allow achieving higher levels of competitiveness within the productive sectors and improving socioeconomic indicators of the regions. Some of the most frequently used methods are of overrating, originally developed in the late sixties by Roy (1968), but also an alternative approach is the proposed by Saaty (1980, 1986, 1990 and 1994^a, ^b and ^c), known as *Analytic Hierarchy Process* (AHP). The AHP method is a logical-and-structured method that optimizes complex decision-making processes when multiple

criteria is possible by decomposing the problem into a hierarchical structure. This allows subdividing a complex attribute into a set of simple attributes and determining how they influence the object of study.

When the number of items for which comparisons are made exceeds (7 ± 2) , which is the magic number of Miller (1956), the AHP model relies on the use of absolute measures (*ratings*), although this restriction can be removed if we divide alternatives into groups with a lower cardinal number than Miller's magic number. Multiple Attribute Decision Making works with a finite number (which is usually small) of alternatives, $A = \{A_1, A_2, \dots, A_m\}$, whose attributes are known, $X_1, X_2, \dots, X_n$, as long as they are quantitative or qualitative. This is represented by the so-called decision matrix (Table 2).

Table 2: Decision Matrix

	X_1	X_2	...	X_j	...	X_n
A_1	x_{11}	x_{12}	...	x_{1j}	...	x_{1n}
A_2	x_{21}	x_{22}	...	x_{2j}	...	x_{2n}
...	...	...	...	...	...	...
A_i	x_{i1}	x_{i2}	...	x_{ij}	...	x_{in}
...	...	...	...	...	...	...
A_m	x_{m1}	x_{m2}	...	x_{mj}	...	x_{mn}

Source: Llamazares Redondo and Berumen, 2011.

By using this matrix can be expressed x_{ij} as the result achieved by the alternative A_i , $j = 1, \dots, n$. Also, from the selected values (for each attribute) an optimal alternative can be formed. One of the most relevant parts of the AHP is the hierarchical structuring of the problem visually. At this stage, the researcher must break down the problem and its main components in parts. The steps to obtain the structure of the hierarchical model are: i) definition of the target; ii) identification of criteria; iii) identification of sub-criteria; and iv), identification of alternatives.

Based on these elements it is possible to set priorities according to the AHP method. The most useful feature of the method proposed by Saaty (1980) is that it grants numerical values to a given judgment. To perform comparisons ratio scales in terms of preference, importance or probability (based on a numerical scale ranging from 1 to 9) are used.

The AHP method works directly with ordered pairs of priority importance, preference or likelihood of an attribute. Therefore, we may assume that this is the natural way that people follows to make decisions. The information request is a square matrix containing paired comparisons of alternatives or criteria, as set in Table 3. In this case, A is an $n \times n$ matrix, where a_{ij} is a subjective measure of the relative importance of the criteria i versus j , according to a normalized scale of 1 (the same value) to 9 (absolutely most important).

Table 3: Saaty Scale

Numerical Scale	Verbal Scale
1	• Both criteria or elements are of equal importance.
3	• Weak or moderate importance of one over the other.
5	• Essential or strong importance of one over the other.
7	• Demonstrated importance of criteria over another.
9	• Absolute importance of criteria over another.
2,4,6,8	• Mean values between two adjacent trials, which are used when a mean term is needed between two of the above intensities.
2	• Between equal or moderately preferred.
4	• Between moderately preferred and strongly preferred.
6	• Between strongly preferred and extremely preferred.
8	• Between very strongly and extremely preferred.

Source: Saaty, 1994^b.

The paired comparisons matrix is a tool that contains alternatives or criteria comparisons. If we assume a matrix A of dimension $n \times n$, with relative judgements about the attributes or criteria, and a_{ij} is the element (i, j) of A , for $i = 1, 2, \dots, n$, and $j = 1, 2, \dots, n$, then it can be said that A is a matrix of paired comparisons of n parameters, if a_{ij} is a measure of the preference criteria in row i when it is compared to the criteria of column j . When $i = j$, the value of a_{ij} is equal to 1, then the criterion is being compared with itself.

$$A = \begin{pmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{pmatrix} \text{ holds that: } a_{ij} \cdot a_{ji} = 1: A = \begin{pmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{pmatrix}$$

In matrix A all elements are positive and satisfy the following properties:

1. Reciprocity: If A is matrix of paired comparisons it can be stated that: $a_{ij} = 1/a_{ji}$, for all $i, j = 1, 2, \dots, n$
2. Consistency: $a_{ij} = a_{ik} / a_{jk}$ for all $i, j, k = 1, 2, \dots, n$

To each cell of the matrix it will correspond one of the values of the Saaty scale. Comparisons located to the left of the diagonal formed by the value 1 have a reverse preference to those located on the right side of the diagonal. Moreover, the priorities are located on the right side of the matrix and are computed by the specialized software, incorporating the reciprocal element in the correspond cell of the matrix. Additionally, the AHP method shows inconsistencies resulting from judgements and the value that would improve them. If the degree of inconsistency is unacceptable, it should be reconsidered and revised the judgments on the paired comparisons to continue with the analysis.

Once paired comparisons matrix is obtained, we may proceed to make a synthesis of priorities drawn from every step of the study in order to obtain general priorities and management alternatives. For this purpose, AHP allows to combine all judgements or opinions, so alternatives are organized from best to worst.

To apply the AHP method is not necessary to have quantitative information on the result achieved by each alternative in each of the criteria considered, but only the value judgements given by the researcher. To carry out the process the following steps must be met: i) add up the values of each column of the paired comparisons matrix; ii) divide each element of the matrix by the total of its column; and iii), calculate the average of the elements in each line of priorities.

Thus, given the matrix of comparisons $A = \begin{pmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{pmatrix}$, elements of

each column must be summed up, obtaining values $v_1, v_2, \dots, v_n = \sum_{i=1}^n a_{i \cdot}$.

Having gained the sum of each column, each element of the array is divided by the above sum, obtaining:

$$A_{\text{standardized}} = \begin{pmatrix} \frac{1}{v_1} & \frac{a_{12}}{v_2} & \dots & \frac{a_{1n}}{v_n} \\ \frac{a_{21}}{v_1} & \frac{1}{v_2} & \dots & \frac{a_{2n}}{v_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{a_{n1}}{v_1} & \frac{a_{n2}}{v_2} & \dots & \frac{1}{v_n} \end{pmatrix}$$

which is named standardized comparisons matrix.

The next step is to obtain the priorities of the comparison matrix from the standardized matrix, for which the column vector is calculated,

$$P = \begin{pmatrix} \frac{1}{n} \sum_{j=1}^n a_{1j} \\ \frac{1}{n} \sum_{j=1}^n a_{2j} \\ \vdots \\ \frac{1}{n} \sum_{j=1}^n a_{nj} \end{pmatrix}$$

which contains the averages of the rows, which gives the priority vector of the criteria

$$P = \begin{pmatrix} p_{c11} \\ p_{c12} \\ \vdots \\ p_{c1n} \end{pmatrix}.$$

The sum of the elements of the vector priorities should be equal to 1.

The result of the priorities of the alternatives is obtained by constructing arrays containing the priorities of the alternatives on the criteria and sub-criteria:

	Criterion 1	Criterion 2		Criterion m
Alternative 1	p_{11}	p_{12}	$\dots$	p_{1m}
	p_{21}	p_{22}	$\dots$	p_{2m}
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
Alternative 2	p_{n1}	p_{n2}	$\dots$	p_{nm}

Then the arrays obtained are multiplied by the arrays of vectors priorities of sub-criteria of the criterion of higher rank.

$$\begin{pmatrix} p_{11} & p_{12} & \dots & p_{1m} \\ p_{21} & p_{22} & \dots & p_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ p_{n1} & p_{n2} & \dots & p_{nm} \end{pmatrix} \begin{pmatrix} p_{c11} \\ p_{c12} \\ \vdots \\ p_{c1n} \end{pmatrix} = \begin{pmatrix} p'_{11} \\ p'_{12} \\ \vdots \\ p'_{1n} \end{pmatrix}$$

Thus, the process is repeated until all comparisons of model elements (criteria, sub-criteria and alternatives) are made. One advantage of AHP is that it requires no cardinal transitivity in judgements, which allows the researcher to issue them some inconsistency (see Wedley *et al.*, 1993). However, the AHP itself provides a method for measuring the degree of consistency between the paired reviews: if the degree of consistency is acceptable the process can continue, but otherwise we should modify the judgements before proceeding with the research.

On the other hand, consistency has two simultaneous properties. The first is on the transitivity of preferences, indicating that judgements must respect the conditions of transitivity that arise when comparing more than two elements. That is, if w_1 is better than w_2 , and w_2 is better than w_3 then is expected w_1 to be better than w_3 . The second property

concerns to the proportionality of preferences, i.e. the entirely consistent judgments, besides the transitivity property, involve the proportionality between them. This means that if w_1 is three times better than w_2 , and w_2 is twice better than w_3 , then w_1 is expected to be six times better than w_3 . According to the above, we can conclude that a matrix (A) is consistent even when paired comparisons are based on accurate measurements. That is, when the values $W_1, \dots, W_n$ are known and $a_{ij} = w_i/w_j$ is obtained.

According to Saaty (1980), the consistency of the judgements is the verification of the result $a_{ik} = a_{ij}a_{jk}$ for all i, j, k of the matrix of pairwise comparisons. Thus, if the researcher's judgements have been exact the equation will be fulfilled and that means that the comparison matrix (A) is consistent.

If the pairwise comparisons between alternatives are presented in the matrix

$$(A) = \begin{pmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{pmatrix}^t$$

that means element a_{12} represents the importance between alternative 1 and alternative 2.

By analogy of values, and assuming that alternative "1" worth w_1 and alternative "2" worth w_2 , it should be stated that: $a_{12} = w_1/w_2$. If in the matrix (A) each element a_{ij} is replaced by the ratio w_i/w_j , the following matrix (A) is obtained:

$$\begin{pmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{pmatrix}.$$

Considering the "i" row of judgments' array: $a_{i1}, a_{i2}, \dots, a_{ij}, \dots, a_{in}$ and, in the optimal case, the elements of the row $w_1, w_2, \dots, w_n$, would be multiplied: $\frac{w_i}{w_1} \cdot w_1 = w_i$
 $\frac{w_i}{w_2} \cdot w_2 = w_i \dots \frac{w_i}{w_j} \cdot w_j = w_i \dots \frac{w_i}{w_n} \cdot w_n = w_i.$

If we proceed in the same way with the actual judgements then we get a *line vector*, whose elements represent a statistical dispersion of the judgement given on the w_i value. Therefore, the average value can be used as an estimate of w_i . So:

Optimal state of affairs: $w_i = a_{ij} \cdot w_j$ (for $i, j = 1, 2, \dots, n$)

State of affairs of a real case: $w_i = \frac{1}{n} \cdot \sum_{j=1}^n a_{ij} \cdot w_j$

Thus, in a matrix (A) containing the ideal or fully accurate judgements, and other matrix (A') which also collects deviations or errors occurring in a real case, the next will happen: to determine whether the level of consistency is or not acceptable depending on the existence of a column vector (w) of values w_j ($j = 1, 2, \dots, n$), where:

$$w_i / w_j = a_{ij} \text{ and that } (A) \cdot (w) = n \cdot (w)$$

According to matrix theory, given that $\sum \lambda_i = \sum a_{ii} = n$, and considering loss of consistency of the matrix (A), a new matrix (A') is generated, and that it will be fulfilled:

$$(A') \cdot (w') = \lambda_{\max} \cdot (w') \text{ and } \lambda_{\max} \geq n$$

$$\text{If there is consistency: } \lambda_{\max} = n = \sum_{i=1}^n \lambda_i \text{ y si } \lambda_i = \lambda_{\max} \Rightarrow \sum \lambda_i + \lambda_j \Leftrightarrow \sum_{i \neq j} \lambda_i$$

$$\text{If there is not consistency: } \sum_{i \neq j} \lambda_i \neq 0$$

Besides, the more similar is $\lambda_{\max}$ to the number of alternatives being analyzed (n), a more consistent value judgement will be made.

The deviation of consistency is represented by the Consistency Index (CI), $CI = \frac{\lambda_{\max} - n}{(n-1)}$, which measures the dispersion of the judgments of the researcher in the matrix (A). The AHP method calculates consistency as the ratio of CI (A) and Random CI or (AI), taking into account Consistency Relation $CR = \frac{CI}{AI}$.

AI is the random consistency index of matrix (A), whilst the consistency index of a matrix of pairwise comparisons is when pairwise comparisons are generated randomly. It is even possible to generate random arrays of type (A) that are strictly reciprocal and of different sizes and it is catalogued as Random Consistency Index (RCI) or Random Index (RI).

3. Analysis of results

Once analysis methodology is explained, the results of the research will be shown. Therefore, the research was interested in developing a socioeconomic ranking of the coal regions, and secondly, to establish a rank to: i) identify the companies' leaning to undertake industrial restructuring; ii) internationalize at least part of the processes; and

iii), know what firms are doomed to disappear. In all cases we used the AHP Hipre program to determine the ranking for each of the variables (high to low by virtue of its attributes and factors) of the regions studied.

Table 4: Socioeconomic profile by region

Regions / Countries	Local population density	Local birth rate	Local unemployed population	Local disposable income per capita	Local budget by citizen	Number of local companies related to the sector
Belgium	88,61	3,3	16,87	29.916	1.322	32
Czech Republic	32,84	3,9	14,57	10.831	596	36
France	50,43	2,6	14,98	24.117	1.835	28
Germany	73,46	2,9	12,15	31.650	1.504	59
Hungary	25,35	3,7	7,71	10.980	883	34
Poland	62,07	4,5	9,04	11.187	907	17
Romania	52,16	5,8	14,79	6.797	384	21
Spain	36,99	1,8	29,63	19.223	1.138	22
United Kingdom	71,31	2,1	11,20	25.870	1.371	48

Source: Euromines, 2012.

Table 5: Criteria links

Criteria	Description
Population density	It provides information about rural or urban character of the region. Population/Surface for Km ² .
Birth rate	It provides information on the likely quantitative evolution of the population to promote and guide the development and qualitative transformation of a society in the future.
Disposable income per capita	Gross disposable income by households per capita (€).
Local budget	Average local budget by citizen (€).
Unemployment rate	Unemployed / Total population (%).
Number of firms	Firms related to the mining sector with more than 250 workers.

Source: Self devised, based on Euromines, 2012.

In the Table 6 we show the evolution of the regions according to the criteria considered and their comparison.

Table 6: Paired comparison and results

	Local population density	Local birth rate	% Local unemployed population	Local disposable income per capita	Local budget by citizen	Number of local companies related to the sector	Results from paired comparison
Population density	1,00	0,33	0,50	1,00	1,00	0,50	0,102
Birth Rate	3,00	1,00	1,00	2,00	2,00	2,00	0,259
Unemployment rate /Total population	2,00	1,00	1,00	2,00	2,00	1,00	0,218
Disposable income per capita	1,00	0,50	0,50	1,00	3,00	2,00	0,175
Local budget by citizen	1,00	0,50	0,50	0,33	1,00	0,50	0,090
Number of firms related to the sector	2,00	0,50	1,00	0,50	2,00	1,00	0,155

Source: Own elaboration.

In the next step, the factor "preference" through peer comparison of the selected criteria is incorporated. Square arrays $A = (a_{ij})$ reflect the relative dominance of one element over another with regard to a common attribute, therefore, a_{ij} represents the dominance of alternative i over j . Once the resulting vector is obtained, Table 7 shows: i) paired comparisons between the nine regions (vector); and ii), the ranking for each of the criteria considered.

Table 7: Paired comparison and socioeconomic ranking

Regions / Countries	Local population density	Local birth rate	% Unemployed / total population	Local disposable income per capita	Local budget per citizen	empresas locales relacionadas con el sector	Vector	Ranking
Germany	0,029	0,073	0,013	0,008	0,011	0,014	0,147	1
France	0,002	0,005	0,075	0,039	0,002	0,022	0,144	2
United Kingdom	0,003	0,014	0,022	0,008	0,021	0,042	0,111	3
Belgium	0,012	0,053	0,011	0,018	0,003	0,012	0,109	4
Poland	0,003	0,014	0,036	0,022	0,010	0,009	0,094	5
Hungary	0,022	0,025	0,008	0,013	0,009	0,010	0,085	6
Czech Republic	0,003	0,019	0,010	0,037	0,003	0,010	0,083	7
Spain	0,013	0,028	0,015	0,012	0,004	0,010	0,081	8
Romania	0,011	0,016	0,013	0,012	0,010	0,012	0,074	9

Source: Own elaboration.

To achieve the second objective we use the same procedure explained above in order to develop a specific ranking to identify the companies' leaning to: i) undertake industrial restructuring; ii) internationalize at least part of the processes; and iii), know what firms are most likely to disappear.

Table 8: Paired comparison and competitiveness ranking

Regions / Countries	Industrial reconversion processes	Internationalization of at least one part of the process	Firms doomed to disappear	Vector	Ranking
Germany	0,071	0,094	0,008	0,361	1
United Kingdom	0,059	0,062	0,016	0,294	2
France	0,062	0,059	0,014	0,287	3
Belgium	0,050	0,057	0,018	0,269	4
Hungary	0,032	0,043	0,059	0,156	5
Poland	0,027	0,038	0,073	0,124	6
Czech Republic	0,023	0,022	0,091	0,105	7
Spain	0,021	0,019	0,117	0,082	8
Romania	0,012	0,006	0,123	0,061	9

Source: Own elaboration.

The results from Table 8 show that firms with better competitive position are the German, followed by the British, the French and the Belgian (positions 1 to 4), because they are the ones that better meet the criteria considered. We found at a striking distance the Hungarian, Polish and Czech companies (positions 5 to 7), and an even greater distance the Spanish and Romanian companies (positions 8 and 9).

4. Conclusions

In an environment of continuous change it is extremely necessary to use methods that help to position regions and productive agents. As has been noted in this research, the AHP method is a useful tool to identify and prioritize the situation found in the mining regions and associated firms. Specific conclusions are the following:

- In light of the results, the regions with better socioeconomic position were, from higher to lower, German and French, at a greater distance the British and the Belgian, a little farther the Polish and the Hungarian, and in the tail we found the Czech, the Spanish and the Romanian. Regarding to the viability of companies, the German lead the ranking again, followed by the British, the French and the Belgian. To a very considerable distance we find the Hungarian and the Polish,

and much more far away are the Czech, the Spanish and the Romanian. In view of the above, the results indicate the vast overlap between the regions and the best-positioned companies, which are on the average and those at the tail.

- Second, the first four positions include companies that are better able to undertake their industrial restructuring and internationalize at least part of the process. On the opposite side, the results indicate that under the current circumstances the companies from regions 7 to 9 (Czech Republic, Spain and Romania) are most likely destined to disappear as soon as grants and subsidies to the coal industry are suspended in the European Union on December 31, 2018. So, the time has come for involved governments, firms, academics and other stakeholders to provide alternative solutions.

This research has been limited only to empirically explain the reality that data shows, but it is likely that the results obtained do not coincide with the view, and especially with the wishes, of the agents of the worst positioned regions. It would be a terrible mistake if the companies, government authorities, and the people living in the regions of Northern Bohemia and Sokolov, Castilla y León and Asturias, as well as from Petroșani and Lupeni remain hopeful, in the belief that the European Communities will continue with its aids to the coal industry, because it is highly probable that that will not happen and then it will be too late to change the course of events.

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