FACTORS AFFECTING A QUARRY’S PROFIT

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Factors affecting a quarry’s profit

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The business profits are affected by natural and technological circumstances, as well as factors implied in human activities as such. These factors and circumstances differ with different industries. This paper investigates natural factors influencing profitability of the quarry extraction of raw materials for building industries. The file under analysis comprises 70 profitable and loss making quarry enterprises operating in 2008, and 50 of them operating in 2009. The quarries are located in seven countries of Central and Eastern Europe, and they are in the ownership of a major international company. The method of discriminate analysis was used for classifying these enterprises as profit or loss making. As input values for the analysis, eight standard company procedure monitoring parameters were used plus two parameters acquired by special inquiries. The causes of erroneous classification have been analyzed. It has been concluded from the evidence of the results that profitability is primarily affected by human factors (organization and management of quarry operations) paralleled by tenure period, i.e. the time for which the enterprise under analysis has been in tenure of the company. Natural factors play a secondary role concerning sales revenue per one ton of production.

**Key words**: quarries, profit, natural factors, discriminate analysis

1. Introduction

Profitability of business operations is an inherent demand of any industrial enterprise. Such profitability is influenced by many factors. Generally, it is about natural factors, (i), e.g. quality of soil for agriculture; technological factors, (ii), e.g. specific technology and equipment for production; human factor, (iii), e.g. strategies of business management.

The natural factors are important, as they are given by natural conditions that are difficult to change, for example irrigation in agriculture. Taking into account the economic results of business operations, they are of major effect, which is especially true for mining industries (geological conditions of extraction, metal content in ore, overburden thickness, etc.)

Vis-à-vis economic results, the effects of natural factors are usually subject of specific interest, especially in agriculture. Concerning differences of agriculture productivity in the Slovak Republic, Chrastinová (2008) takes natural conditions for decisive factors of agriculture efficiency, namely soil quality and its granularity, terrain topography, climatic conditions, and sea-level altitude. Legal form of farming activities, area concentration, organisation, and management strategies are all of minor importance. Regarding specific condition of agriculture in Turkey, Tatlidil at al. (2005) considers natural circumstances (frost, deluge before harvest) as decisive factors of harvest failures. Jasinevicius (2008) qualifies natural factors (for example global warming) as primary causes of conifer forest decreases in Lithuania. Forest farming economies are placed second, as well as emergency situation occurrences, e.g. hurricane – actually natural factors of influence again. Kimmins (1996)

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relates sustainability of Canadian forest management strategies to availability of tree nutrients related to soil temperatures, decomposition of dead tree tissue, forest soil overall character, and groundwater flows. Investigating specifically Dutch conditions, Wolff (2000) maintains that development of oyster population is influenced by natural circumstances, especially winter temperatures, and heavy seas. It is obvious that ecological system productivity influences economic results of businesses operating within the system. Papers and communications of the International Labour Organisation, ILO, 1994, take into account relationships between soil productivity and natural factors (weather, precipitation distribution, topography, soil quality).

From the point of view of theory, Biswanger (1998) calls our attention to the fact that taking nature as a production function constituent is of primary importance.

In other national industry branches, only some attention is paid to natural factors. Alabavera et al. (2001) takes Chile to exemplify that competitiveness of mining industries relates directly to natural circumstances like accessibility, quality, and metal content of ores; type of ore minerals and geographic location. It is only obvious, that natural factors primarily decide about starting of extraction activities and their subsequent economic results.

This assumption is also valid for quarries producing building materials. The sort and quality of the raw material/mineral, its overburden thickness, topography, hydro-geological conditions, all these belong to major factors of extraction profitability. Nevertheless, technological and human factors are almost of tantamount importance. Developments in the Czech Republic, as well as in other East European countries since the nineties of the past century, have attested to the validity of the claim. All former state run enterprises of building mineral extraction were privatised. The new proprietors wanted to maximise their profits, which often implied mismanagement and extraction of only the most profitable parts of the deposit. Many of these new owners refused or were not able to provide for renewal of the technical equipment of extraction. These quarries were either closed or became subject of acquisition by major extraction companies.

Each of these acquisitions was paralleled by the question of profitability concerning continued operation of the quarry. This question can be only answered if factors of profitability influence are known, as these can provide for qualified assessment of enterprise future performance.

We have tried to find solution to the problem, investigating it within structures of a major construction company operating in several countries of Central and Eastern Europe. Such is the sensitivity of the information, and such tense competition in the field that we have taken it for imprudent to specify the name of the company or even location of specific quarries involved in our investigation.

2. Selection of factors affecting a quarry’s profit

It is classifying of a quarry operations as profit or loss making, which answers the question about the acquisition suitability. The classification can be founded on specific knowledge or qualified assessment of parameters that characterize a quarry’s performance, and also on the knowledge of the classification criterion. The latter can be determined taking into account the income files of loss and profit-making units. Each unit (a quarry) is characterised by the same parameters. The criterion calculation method is standardized. Concerning categories of either loss or profit-making units, a pilot classification of all original input file quarries provides for a measure of classification accuracy. This accuracy can be qualified in percentages of successfully classified units in each category of loss or profit-making quarries.

As such, providing for selection of economically characteristic parameters is a basic task to be accomplished. An economic result can be defined as a difference between revenues and costs. The total revenues of a quarry can be expressed as the result of multiplying aggregate total sales together with the specific revenue per one ton of the aggregate sold. The specific revenue is influenced by the sort and quality of the aggregate produced. The costs are the sum of fixed and variable costs. The total variable costs can be expressed as the product of the aggregate total sales and variable costs per one ton of the aggregate sold.

It is obvious that revenues, fixed or variable costs are subject of influence by many factors implied in the production technology, natural conditions, and human factors. But only standard
information provided on operation of all units should be used for qualifying individual quarries as profit or loss-making. It is especially the case if larger files are processed.

The company of our investigation owns quarries in 7 Central and Eastern European countries. They produce building materials for their own use, and also sell them to external customers. The managing of the quarries is based on cost accounting of which the method is identical for all units. Each quarry provides for its individual financial statements that inform on their revenue and costs of operation. The costs that are not inherent to individual quarry activities are taken account of by means of overhead expenses. Such overhead expenses are determined as percentages of aggregate sales to external customers. Total costs include both external and internal costs. As such, the difference between sales and costs differs from the economic result that is established on base of generally accepted rules. The company uses the term, operative economic result. The EURO currency unit is used for accounting in all the countries in which the company operates.

We have used 10 parameters to characterise the individual quarries as loss or profit-making. Eight of these parameters are subject of financial statements of all the quarries investigated; two of them are result of specific research. The following parameters have been used:

- Proportion of fixed costs in total costs: The fixed costs comprise depreciations of production equipment, fixed components of wages (80% as based on the firm’s methodology of accounting), salaries of technical and managerial staff, interests, insurance, taxes, fees, and charges for aggregate quality testing, and other fixed costs. This parameter reflects a basic structure of costs vis-à-vis production volumes.
- Proportion of personal costs in total costs: This parameter reflects effects of human and technological factors – staff total, technological equipment, work productivity.
- Proportion of area costs in total costs: Extraction of raw materials starts with the acquisition of land, where the minerals exists. This land acquisition costs are divided by the volume of raw materials that can be extracted. This ratio multiplied by extraction volumes per certain period debts the variable costs account. This parameter reflects natural conditions of extraction, and finances needed for the acquisition of the necessary land.
- Proportion of subcontracting costs in total costs: Some work is outsourced to be delivered by subcontractors – drilling and blasting, loading of blasted rock and transport to sites of aggregate processing, transport of final aggregate products. This parameter reflects technological factors of production, especially investments to technical equipment, inclusive its utilisation.
- Proportion of industrial estate costs in total costs: These costs comprise depreciations, maintenance and rents of buildings, lending rents of third party estate with raw materials reserves or without them (used only as storage grounds). The parameter reflects technological factors of production – fixed assets wealth of a quarry.
- Sales per one ton aggregate produced: Aggregate product prices reflect costs of the aggregate itself and its transport. If the customer realizes transport by his own means, the transport costs can be deducted from the product price. Aggregate sales are increased by other receipts (for example fixed asset lease earnings). We receive the parameter of the sales per one ton of aggregate product if we divide total sales by total production in tons. This parameter is influenced by natural condition of production (sort and quality of the rock extracted), and the market position of the quarry (competition, quarry location).
- Aggregate sales: Sales of aggregate in tons per period reflect market demand, natural conditions (sort and quality of the rock mineral), quarry productivity.
- Proportion of variable costs in 1 ton of aggregate: Variables include costs of overburden removal, drilling and blasting costs, energy costs, partial of the worker wages (20% on the company methodology of accounting), and other costs varying in proportion to production volumes. The parameter is influenced by natural conditions (rock quality as related to consumption of explosives, overburden thickness, etc.), as well as by human factors (specific consumption of material and energy as related to processes of organisation and management).
- Los Angeles Test: The test determines percentage losses of aggregate material crushed by steel ball milling per a definite time. The parameter determines quality of the rock mineral, and it is entirely defined by natural conditions.
• Quarry tenure period: The parameter determines number of years in which the company operated the quarry.

The last two parameters were acquired by a special investigation; the others were adopted, regarding the company’s information system.

3. Method of classifying quarries as profit or loss-making

The ten parameters given above have been used to characterize 35 profitable and 35 loss making quarries that operate in seven countries of Central and Eastern Europe. In 2008, a classification criterion was established using the values of the mentioned parameters for the necessary calculations. This criterion provided for a pilot classification of all 70 quarries as profitable or loss-making enterprises. As such, measure of accuracy for this classification was determined.

In 2009, the same file of quarries was subjected to classification procedure based on the same set of parameter values. In the interim one year period, 6 originally successful quarries moved in the red, and 10 former enterprises operating at a loss could improve and transferred to the group of profitable businesses. In the same year, 2009, in order to keep the number of both classes equal, the original file from 2008 was reduced to 50 units so that both the group of profitable and loss-making quarries consisted of 25 units. Average values of individual parameters are given by Table 1. The average value of tenure means that quarries of longer tenure periods have been deleted from the original file. In 2009, again both for profitable and loss making quarries, another criterion of classification was calculated. A pilot classification of all 50 units was made as regards their profitable or loss-making operations. Again, the rate of successful classification was established.

Classifying quarries as belonging either to the group of profitable businesses or rather to those enterprises that were operating in the red, the method of discriminate analysis was used.

3.1. Discriminate analysis applications and results

The method of discriminate analysis belongs among multidimensional statistical methods that provide for classification of objects into two or more classes. Each object is described by a group of independent variables, \( m \), the so called discriminators, and by a single qualitative dependent variable. In the simplest case of a two-group classification, the latter can be only a binary variable.

The classic discriminate analysis provides for prediction models that enable ranking of objects into classes.

If linear discriminate function is applied for determining of two classes, the objects in these classes are characterized by discriminator values, \( m \). It is appropriate that both classes have the same number of objects, \( n \).

Sample averages, \( \overline{X}_1 \) a \( \overline{X}_2 \) (these are vectors of which individual constituents are calculated as average values of discriminators), are calculated for individual classes, as well as a common covariance matrix,

\[
S = \frac{1}{n-2} S_1 + \frac{1}{n-2} S_2.
\]  

(1)

where \( S_1, S_2 \) are covariance matrixes of individual classes.

Assuming normality, we can determine a vector,

\[
a = S^{-1} \overline{X}_1 - \overline{X}_2.
\]  

(2)

of which individual constituents are the coefficents the linear discriminate function,

\[
f = a_1 x_{i1} + a_2 x_{i2} + \cdots + a_m x_{im}
\]  

(3)

If we apply vectors of average values for class I and class II, we can calculate the values of the averages, \( \overline{X}_1 \) a \( \overline{X}_2 \).
An optimum threshold point value, C, which determines the place of unclassified objects as belonging to class I or class II, can be established by

\[ C = \frac{\mu_1 + \mu_2}{2} \]  

(4)

An unclassified object of which the discriminate function value exceeds the optimum threshold point value, C, can be ranked as belonging to class I. If the discriminate function value is smaller than the value, C, the object is ranked as belonging to class II. As such, the optimum threshold point value, C, is the measure of ranking individual quarries as profit or loss-making units. The classification is an outcome of comparing values, C, with discriminate function values, f. For a specific quarry of our own investigation, the latter is determined by multiplication of 10 parameters (discriminators) and the linear discriminate function coefficient values. The linear discriminate function coefficients are given by Table 2.

The knowledge of three factors, namely the linear discriminate function coefficients, optimum threshold point values, and the individual quarry parameter values in both years, enables pilot classifications of the original 70 quarries in 2008 and the reduced number of 50 units in 2009, as belonging to profitable or loss-making enterprises. The proportion of successfully ranked quarries to the original number of the file (35 in 2008 and 25 in 2009) determines percentage of successful ranking. The results of successful rankings are given by Table 3.

4. Discussion

Our primary interest focused on the question; why was it that between 2008 and 2009 sixteen quarries changed their ranking from loss-making to profitable businesses or vice versa? Having had analysed accounting documentation, we could establish the following:

Transfer of loss-making quarries into the class of profitable units:
- Seven units could increase aggregate sales between 44 – 122%,
- Two units increased their earnings per one ton of aggregate by 9 – 53%,
- One unit decreased proportion of fixed assets to total assets by 13%.

Changes of other economic indices could not be clearly identified. Nevertheless they indicated increased sales or decreased costs, which resulted in profitable operations.

Transfer of profitable units into the class of in the red operating units:
- Aggregate sales of all units decreased by 24 – 58%.

Obvious changes of other economic quantitative factors could not be identified but primarily increases of variable specific costs led to increases of overall costs, which, along with decreased sales of aggregate and total revenue reduction, meant operation in the red. As such, it can be assumed that category transfers were primarily caused by unexpected fall of demand as regards specific aggregate production of affected quarries. The demand setback was initiated by financial and economic crisis of the latest period. The marked increases of sales were concurrent to realisation of a major building project close to the area of quarries’ operations.

Another problem to solve was the rate of success with which individual quarries were classified as loss or profit-making units in 2008 and 2009. The objective was to identify causes of erroneous classification in these two years. The classification of individual quarries is based on comparison of the optimum threshold point (criterion of classification), C, and the linear discriminate function value, f. The same linear discriminate coefficient values are used for calculations of the value of the optimum threshold point, and the linear discriminate function. Calculating the value, C, average values of discriminators are used for the whole file comprising both profitable and in the red operating units. For calculations of the value, f, discriminator values for a specific quarry are used. From purely mathematical point of view, the relation between f and C is defined by differences between discriminator average values for each class of units and the value for a specific quarry in the class. This difference product for individual discriminator value and the value of the linear function
coefficient indicates influence of the given discriminator on classifying units as profitable or loss-making. Taking into account a negative or positive sign of the product, it is possible to determine, which discriminator is the most influential one:

- Negatively signed product: the relevant discriminator contributed to erroneous ranking of the quarry as a loss-making unit, which in fact is in the class of profitably run businesses.
- Positively signed product: the relevant discriminator contributed to positive classification of the unit, which in fact operated in the red.

Year 2008: The method specified above was applied for 4 profitable quarries that had been classified erroneously as loss-making units, and for 5 in the red operating quarries that had been wrongly ranked as profitable. These were the most prominent discriminators:

**Profitable units wrongly classified as loss-making:**
Operation of all 4 erroneously ranked quarries was influenced most negatively by the period of tenure. These quarries were in the ownership of the company for about three times shorter period than it was the average for all profitably run units.

**Loss-making units wrongly classified as profitable:**
- Tenure period was the most prominent discriminator that positively influenced operations of 3 of the erroneously ranked quarries. The company owned these quarries for about four times longer than it was the average for all in the red operating units.
- Earnings per one ton of aggregate represented the most dominant positively acting factor in the case of one quarry. They were two times higher in relation to averages for all loss-making units.
- Operations of another single unit were the most positively influenced by the ratio of fixed assets to total assets that was one quarter of the average for all loss-making quarries.

Year 2009: The method specified was applied for 2 profitable quarries that had been classified erroneously as loss-making units, and for 1 loss-making quarry that had been erroneously classified as profitable. These were the most prominent discriminators:

**Profitable units wrongly classified as loss-making:**
In both cases, the most prominent factor of negative influence was the tenure period. The quarries were owned only for a third and seventh of the period average for all profitably run units.

**Loss-making units wrongly classified as profitable:**
Again, the most influential factor was the tenure period. This was in average four times longer in comparison to the average of in the red operating units.

We have observed that wrong classifications for both years were usually caused by differences of tenure periods. Erroneously ranked loss-making units were owned by the company for periods that markedly differed as compared to averages of the quarries that were classified as loss-making. Profitable businesses wrongly classified as loss-making were in the tenure of the company for too short periods of time in comparison to averages of the units operating with profit. Nevertheless, periods of tenure per se do not determine profitable or loss-making operations. It can be assumed that units operating in the red for longer periods of time should be closed or subject of profitability restructuring. In practice, anticipated demand related to building activities nearby (for example a new motorway) or anticipated market change can influence the related decision making process. In contrast to this, successful operation of a quarry owned for a short period of time attests to successful acquisition.

The question is: What are the parameters (discriminators) that are of decisive influence, classifying quarries as profitable or loss-making units. The answer may be in the relative importance of individual discriminators. The discriminate analysis method states (Meloun and Militky 2004) that relative importance of discriminators can be assessed by standardized discriminate coefficients. These can be established if discriminate function coefficients are multiplied by standard deviations of corresponding discriminators. The discriminators characterized by major standard discriminate coefficients are of stronger influence, when quarries are classified as profitable or loss-making units. Whether a quarry is classified as profitable or loss-making, this is specified by a negative or positive sign of the discriminate function coefficient. The discriminate function standard coefficients are given
by Table 4. Whether some quarry is ranked as profitable or loss-making, this is decided by the following positively signed values of the standardized discriminate function coefficients:

- Period of tenure,
- Earnings per one ton of aggregate.

5. Conclusion

From the point of view of the factors that are decisive for profitable operations of a quarry, we can conclude that

- The period of ownership reflects primarily the impact of human factors – organisation and management methods applied. As based on practical operations (Zapletalová – by word of mouth), it takes 2 – 3 years before operations of a newly acquisitioned quarry can be structured so that it yields profit. But it is also known from experience that natural factors of influence are active in the process, primarily quality of the raw aggregate product, volume of reserves, quarry location, etc. These factors can lead to profitability of units in tenure for short periods of time or inversely to protractedly loss-making operations even if the unit has been in the ownership of the company for longer time periods. The latter usually concerns expectations for its chance, which may materialise with the realisation of a major construction project in the area. Otherwise, there would be little reason for continued operation of the unit.
- Earnings per one ton of aggregate product relate directly to natural factors. It is primarily about the raw material quality measured by the Los Angeles Test. Rocks of the highest strength rates earn much more per one ton of production than it would be the case for softer or less firm rocks. As such, it is of major importance for new acquisitions, to assess thoroughly sort, quality, and quantity of the rock produced by the quarry, which is to be bought. The application of the discriminate analysis method can provide for assessment and knowledge of other parameters of future economic development of the enterprise.

References

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### Table 1. Parameter Averages for both Classes of Quarries

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<tr>
<td>1. Proportion of fixed costs in total costs</td>
<td>0.436</td>
<td>0.491</td>
<td>0.457</td>
<td>0.530</td>
<td></td>
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<tr>
<td>2. Proportion of personal costs in total costs</td>
<td>0.169</td>
<td>0.167</td>
<td>0.164</td>
<td>0.149</td>
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<tr>
<td>3. Proportion of area costs in total costs</td>
<td>0.024</td>
<td>0.087</td>
<td>0.019</td>
<td>0.108</td>
<td></td>
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<td>4. Proportion of subcontracting costs in total costs</td>
<td>0.153</td>
<td>0.161</td>
<td>0.132</td>
<td>0.132</td>
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<tr>
<td>5. Proportion of industrial estate costs in total costs</td>
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<tr>
<td>6. Earnings per 1 ton of aggregate [€/1 t]</td>
<td>6.997</td>
<td>5.807</td>
<td>6.884</td>
<td>5.274</td>
<td></td>
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<tr>
<td>8. Proportion of variable costs in 1 ton of aggregate [€/1 t]</td>
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<tr>
<td>9. Los Angeles testing [%]</td>
<td>18.916</td>
<td>37.557</td>
<td>18.806</td>
<td>34.520</td>
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### Table 2. Linear Discriminate Function Coefficients

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<thead>
<tr>
<th>Parameters (Discriminators)</th>
<th>2008</th>
<th>2009</th>
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<tbody>
<tr>
<td>1. Proportion of fixed costs in total costs</td>
<td>a_1 = -5.213</td>
<td>a_1 = 3.460</td>
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<tr>
<td>2. Proportion of personal costs in total costs</td>
<td>a_2 = 2.850</td>
<td>a_2 = 11.394</td>
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<tr>
<td>3. Proportion of area costs in total costs</td>
<td>a_3 = -13.648</td>
<td>a_3 = -28.481</td>
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<td>4. Proportion of subcontracting costs in total costs</td>
<td>a_4 = -1.688</td>
<td>a_4 = 4.925</td>
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<td>5. Proportion of industrial estate costs in total costs</td>
<td>a_5 = 0.711</td>
<td>a_5 = -26.647</td>
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<tr>
<td>6. Earnings per 1 ton of aggregate [€/1 t]</td>
<td>a_6 = 0.312</td>
<td>a_6 = 0.935</td>
</tr>
<tr>
<td>7. Sale of aggregate [thousands of tons]</td>
<td>a_7 = 0.002</td>
<td>a_7 = 0.003</td>
</tr>
<tr>
<td>8. Proportion of variable costs in 1 ton of aggregate [€/1 t]</td>
<td>a_8 = -0.378</td>
<td>a_8 = -0.985</td>
</tr>
<tr>
<td>9. Los Angeles testing [%]</td>
<td>a_9 = -0.016</td>
<td>a_9 = -0.006</td>
</tr>
<tr>
<td>10. Quarry tenure period [years]</td>
<td>a_{10} = 0.236</td>
<td>a_{10} = 0.390</td>
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<tr>
<td>11. Threshold Point Optimum Value</td>
<td>C = 0.133726</td>
<td>C = 8.239106</td>
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Table 3. Rate of Successful Classifications for Quarries

<table>
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<td>Successful classification [%]</td>
<td>88.57</td>
<td>85.71</td>
<td>92.00</td>
<td>96.00</td>
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<tr>
<td>Failed classification [%]</td>
<td>11.43</td>
<td>14.29</td>
<td>8.00</td>
<td>4.00</td>
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Table 4. Discriminate Function Standard Coefficients

<table>
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<th>Parameters (Discriminator)</th>
<th>Coefficient</th>
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<tr>
<td>Proportion of fixed costs in total costs</td>
<td>+ 0.5567</td>
</tr>
<tr>
<td>Proportion of personal costs in total costs</td>
<td>+ 0.9985</td>
</tr>
<tr>
<td>Proportion of area costs in total costs</td>
<td>- 2.2730</td>
</tr>
<tr>
<td>Proportion of subcontracting costs in total costs</td>
<td>+0.6810</td>
</tr>
<tr>
<td>Proportion of industrial estate costs in total costs</td>
<td>-1.0513</td>
</tr>
<tr>
<td>Earnings per 1 ton of aggregate [€/1 t]</td>
<td>+1.9004</td>
</tr>
<tr>
<td>Sale of aggregate [thousands of tons]</td>
<td>+1.4578</td>
</tr>
<tr>
<td>Proportion of variable costs in 1 ton of aggregate [€/1 t]</td>
<td>-1.9684</td>
</tr>
<tr>
<td>Los Angeles testing [%]</td>
<td>-0.1263</td>
</tr>
<tr>
<td>Quarry tenure period [years]</td>
<td>+2.7895</td>
</tr>
</tbody>
</table>