Annals of Optimization Theory and Practice

Volume 2, Number 1, 27-39
April 2019

DOI: 10.22121/aotp.2019.92102

A strategic approach for improving iron mines in Iran based on a hybrid method

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(Received: March 17, 2019 / Accepted: April 27, 2019)

Abstract Iron mines are already a sizable segment of the Iranian economy, but it has huge potential for development and can be the driver of further growth. This paper presents a strategic approach with hybrid Grey Relational Analysis (GRA) and Interpretive Structural Modeling (ISM) methodology for improving iron mines in Iran. At first these studies are established strategies and after that presented hybrid GRA and ISM analyses. The result shows the strategic of priorities improvement iron mines are arranged in four levels in Iran: First, an innovative mining and minerals industry with an excellent knowledge base, second, dialogue and cooperation to promote innovation and growth, third, Framework conditions and infrastructure for competitiveness and growth, forth level, a mining and minerals industry in harmony with the environment, culture and other industries and an internationally renowned, active and attractive mining and minerals industry.

Keywords Strategy; Mining; Hybrid approach

1. Introduction

The development of a process to turn raw earth into steel merits a high spot on a list of mankind's most ingenious achievements. The metal provides the backbone of skyscrapers, bridges and motorways, and the carapace and internal organs of cars, fridges and washing machines. Given steel's ubiquity—it makes up 95% of global metal production—iron ore, the raw material from which it is made, attracts strangely little attention www.economist.com.

Iran has 68 types of minerals, including gold, coal, iron ore, copper, lead, zinc, chromium, barite, salt, gypsum, molybdenum and rare-earth elements. Iran is especially rich in key industrial metals, such as iron ore, copper, zinc and gold, for which it has been placed among the top 10 reserve holders globally, in both reserves and production

volumes Mining in Iran – Country Mine. Iran ranks ninth and 12th in terms of global reserves for copper and iron, respectively. It also has the world's largest combined lead and zinc reserves, with 11 million tons of proven zinc and potentially 222 million tons of lead and zinc. Iran is also a major producer of iron ore, steel, copper and zinc. However, Iran's major resources are largely underdeveloped, including copper (reserves to production 137 years), gold (reserves to production 83 years), zinc (reserves to production 73 years), and iron ore (reserves to production 56 years) Archived from the original on 24 November 2011 and Archived from the original on 21 October 2008.

Although Mining in Iran is underdeveloped, yet the country is one of the most important mineral iron producers in the world. The most important mines in Iran include coal, metallic minerals, sand and gravel, chemical minerals and salt. Khorasan has the most operating mines in Iran. Other large deposits which mostly remain underdeveloped are zinc (world's largest), copper (world's ninth largest reserves in 2011, according to the managing director of National Iranian Copper Industries Company), iron (world's 12th largest in 2013 according to the US Geological Survey), uranium (world's tenth largest) and lead (world's eleventh largest) www.earthstonegroup.com and Shiau and Hsu (2003). Iran with roughly 1% of the world's population holds more than 7% of the world's total mineral reserves www.adlittle.com.

Mining, coupled with base metals and non-metal minerals, already exceeds 6 percent of the country's GDP. More than 20 out of the top-100 Iranian companies come from metals & mining and the broader IG space. Moreover, metals & mining accounts for 21 percent of overall market capitalization on the Tehran Stock Exchange Archived from the original on 21 October 2008.

Therefore, this paper has surveyed iron mines and used of strategic analyses for improvement iron mines in Iran.

2. Irons and Iranian strategies

Iran discovered huge reserves of high-quality iron ore in the country's Central Lut desert lately. Iran ranks third in Asia and 11th in the world in terms of iron reserves and Iran is among the 15 major mineral-rich countries and exports its industrial and mineral products to 159 countries, including Iraq, China, the United Arab Emirates, India and Afghanistan www.iran-daily.com.

China continues to be the largest destination for Indian iron ore exports in 2017. It made up 82% or 16.23 million tons of total iron ore exported from India last year. Other major destinations were Japan with 2.62 million tons and South Korea with 610,000 tons, Steel Mint's data revealed.

Iranian iron ore miners experienced a good year in 2017, as they became the sixth largest supplier of the material to China by shipping about 22 million tons to the world's largest importer of iron ore. Top ore exporters to China in 2017 were Australia, Brazil, South Africa, India, Ukraine and Iran respectively, according to Chinese customs statistics Shipments to China make up about 91% of Iranian iron ore exports. Accounting for

nearly 70% of world's seaborne ore trade, China imported 1.07 billion tons of iron ore in 2017, up 8% YOY, Steel Mint reported www.financialtribune.com.

What has spurred iron ore demand is the industrial goliath's crackdown on pollution. The government is mandating steelmakers to use higher-grade ores to curb pollution, buoying imports from high-content ore producers.

In this paper, five strategies for improving Iranian iron mines have been selected from the literature primarily from and discussions with experts in the mine industry. These strategies are explained as follows references:

A mining and minerals industry in harmony with the environment, culture and other industries

Growth in the mining and minerals industry must take place with respect for and in harmony with environmental values, cultural environments and other industries. A long-term sustainable mining and minerals industry tackles the negative environmental effects it causes in a lifecycle perspective. This means that sustainable technologies are used for exploration and exploitation. Mining operations are efficient in terms of materials, energy and water use. This is achieved as a result of waste prevention, recycling, use of new and substitute materials and using chemical and biological enrichment methods that do not have a negative environmental impact Archived from the original (PDF) on 28 September 2011. Emissions are generally low and environmental impact is measured and managed.

Dialogue and cooperation to promote innovation and growth

Cooperation between central government, municipalities, regions, the business sector and interest groups creates the conditions needed to improve local and regional attractiveness and national growth. Good dialogue and clear distribution of responsibility among stakeholders provide an important basis for stimulating greater competitiveness, more jobs and growth in the mining and minerals industry as well as in the business sector as a whole in areas affected by large-scale initiatives. The matching on the labor market, higher costs for the individuals and businesses and poorer public services. These are examples of the challenges that have to be faced by the various actors if the potential of the mining and minerals industry is to be fully utilized. The expansion of the mining industry is of strategic importance for growth and employment on both the regional and the national level Iran world's 8th iron ore producer: report. The objective of regional growth policy is to create momentum for development in all parts of the country with strengthened local and regional competitiveness.

Framework conditions and infrastructure for competitiveness and growth

The government will consider various alternatives to satisfy the needs of the mining industry in cooperation with relevant stakeholders as part of the action planning Molybdenum Production by Country (Metric tons of contained molybdenum). The various alternatives will be highlighted based on a holistic perspective, where the total

benefit for all travel and transport needs, including those of the mining industry, will be taken into consideration. These alternatives shall present cost-benefit assessments as well as consider and describe other aspects and consequences, not least environmental impact, but also reloading requirements, effects on traffic safety, effects on the possibility of labor commuting and interregional accessibility, etc. In connection with the production of background documentation and decisions on the implementation of infrastructure projects, the Transport Administration will look into the scope for financing from different stakeholders.

An innovative mining and minerals industry with an excellent knowledge base

The Iran mining and minerals industry currently faces a number of challenges, to which the solutions can be found in research and innovation. The mining industry is very energy-demanding. Ore is mined at ever-greater depths and the process must be efficient to be profitable at the same time as new demands are being placed on safety measures and on knowledge of the bedrock's geology at greater depths. Mining and minerals field provide new knowledge that can be converted into new products and services as well as increase the industry's growth and competitiveness. To enable the mining and mineral industry to expand at the pace made possible by today's strong demand for metal and minerals, businesses must have access to a skilled workforce Steel Production Capacity at 20m Tons. The signs are that there will be a need for skilled labor in a wide variety of professions.

An internationally renowned, active and attractive mining and minerals industry

The Iranian mining brand is characterized by innovation, cost-efficiency, quality and sustainability. Iran's strong global brand in the mining industry should be used to further strengthen the country's large-scale enterprises while utilizing the opportunities for small and medium-sized enterprises (SMEs) to develop into the mining companies of the future IRNA:Iran.

Government financiers can promote the establishment of new mines by helping to finance different types of activities associated with such establishments. This might consist of support industries to provide the mining industry with the goods and services it requires or consist of basic service industries to make it attractive for people to live close to the mine, as well as for other businesses to ensure an overall well-functioning labor market. It may also consist of more innovation- and knowledge-intensive activities linked to the mining industry, with the aim of developing products and services to increase productivity and profitability in mine exploration, mine establishment and mine operations.

According to explains up, major strategies for iron mines products are five aspects that they are arranged as shown in table 1.

Table 1. Improvement strategies of iron mines.

Code	Description strategies
T1	A mining and minerals industry in harmony with the environment, culture and other industries
T2	Dialogue and cooperation to promote innovation and growth
T3	Framework conditions and infrastructure for competitiveness and growth)
T4	An innovative mining and minerals industry with an excellent knowledge base
T5	An internationally renowned, active and attractive mining and minerals industry

3. Methodologies

This study is concentrating on the truth that strategies are generated and created because of various views; thus, the breakdown of priority should be managed from diverse aspect, and the potential as well as the uncertain relationship of accomplishment among the integral strategy as formulated should be analyzed according to different time slots.

This study has selected join up GRA and ISM methods to resolve for the binary comparison of priority among strategies and analysis integrate system related them. The summarized the model flowchart showed in Figure 1.

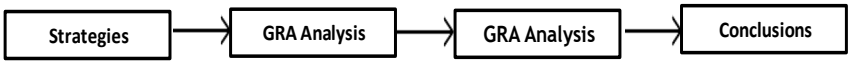

Figure 1. The Model of Improving Strategies.

3.1 Grey Relational Analysis (GRA)

Grey relation analysis was first suggested by professor Deng 1982, The proposition of Grey theory occurring in the 1990 to 1999-time period resulted in the uses of Grey theory to each field, and the development is still going on. The key advantage of Grey theory is that it can handle both incomplete information and unclear problems very precisely.

GRA is an important method of Grey System theory. The word “grey” is used to show the degree of information accessibility that is used to illustrate system structure. Especially terms, word "black" shows that the essential information used to illustrate system is completely inaccessible. On the other hand, “white” shows that the required internal information is completely accessible. “Grey” sets for the information that is incomplete and relatively unknown which comes between black and white.

There are several aspects for the theory of Grey system Kung and Wen (2007) and Chen and Ou (2009):

1. Grey generation: This is data processing to supplement information. It is aimed to process those complicate and tedious data to gain a clear rule, which is the whitening of a sequence of numbers.

2. Grey modeling: This is done by step 1 to establish a set of Grey variation equations and Grey differential equations, which is the whitening of the model.

3. Grey prediction: By using the Grey model to conduct a qualitative prediction, this is called the whitening of development.

4. Grey decision: A decision is made under imperfect countermeasure and unclear situation, which is called the whitening of status.

5. Grey relational analysis: Quantify all influences of various factors and their relation, which is called the whitening of factor relation.

6. Grey control: Work on the data of system behavior and look for any rules of behavior development to predict future's behavior, the prediction value can be fed back into the system in order to control the system Chang (1999).

Let P(X) represent the factor set of a specific topic, Q is the influence relation, {P(X); Q} is influence space. It must have the following properties:

1. Dimension: the numeric value for all factors must be no dimension.

2. Scaling: the factor value for various series must be at the same level.
3. Polarization: if the factor value in the series is described as the same direction, the series is comparable. Then the measurement space is expressed as {P(X); xi*(k)}, the Grey relational space formed by the satisfaction of both factor space and comparability is termed by {P(X); Γ}.

The series formed by P(X) is:

xi =(xi (1), xi (2), …, xi (k)) ∈I

Let I= 0, 1, ..., m, k= 1, 2, ..., n∈N

Suppose xi (k) can be the reference series with the rest of them be comparison series, the grey relational coefficient can be defined as:

$$r\left(x_i(k), x_j(k)\right) = \frac{\Delta \text{ min.} + \xi\Delta\text{max.}}{\Delta_{ij} + \xi\Delta max.} \quad (1)$$

Let I=1, 2, 3, ..., m, k=1, 2, 3, ..., n j∈ I

xi is of the reference series, while xj is a specific comparison series.

Δij =‖xi (k)- xj (k)‖is the norm between x0 and xj for k

$$\Delta min. = \forall {}^{min.}_{j} \in i \, \forall^{min.}_{k} \parallel x_i(k) - x_j(k) \parallel \quad (2)$$

$$\Delta max. = \forall^{max.}_{j} \in i \, \forall^{max.}_{k} \parallel x_i(k) - x_j(k) \parallel \quad (3)$$

ζ ∈ [0, 1] is the differentiating coefficient (it's adjustable)

In grey relation coefficient, the primary function of differentiation coefficient (ζ) is to conduct the contrast between background value and the object to be estimated, and the size of the value can be adjusted accordingly based on actual need. Generally speaking,

the value of the differential coefficient is all considered as 0.5; however, to enlarge the contrast of the result adjustment can be conducted according to actual need. As learned from mathematical validation, any change of the differentiating coefficient will only affect the size of the relative value, and not the ranking order of the grey relational grade Shiau and Hsu (2003) and Wu *et al.* (2008).

When grey relational coefficient is obtained, the resolution for the average value will be of the grey relational grade.

$$r(x_i, x_j) = \frac{1}{n}\sum_{i=1}^{n} r(x_i(k), x_j(k)) \quad (4)$$

Rank by value sizes obtained from comparison series against the same parameter series x0 of the grey relation, and a grey relation ordinal is found from such a relationship ranking the largest value order accordingly.

Therefore, in the reference series x0 and comparison series xi

let x0= (x0 (k)), xi = (xi (k)), k=1, 2, 3, ..., n i=1, 2, 3, ..., m
if γ (x0, xi) ≧γ (x0, xj)
The relational grade of xi against x0 is larger than xj against x0, and it is indicated by xi > xj.

3.2 Interpretive Structural Modeling (ISM)

The ISM planned by Warfield is a computer-assisted method to understand and construct the necessary relations of the elements in complex systems. An ISM can be used to develop the skill of inquiring, understanding and looking at a problem from an integrated systems perspective, a perspective that perceives a real and complex world with many types of interactions, for example, between social, economic and biophysics subsystems. Communication and discussion function: an ISM can be used as a platform which facilitates discussions among system experts and between system experts and stakeholders. These discussions are aimed to arrive at a common view of the problems and common ways to solve them. The important idea is to use experts' useful experience and knowledge to disintegrate a complex system into several sub-systems (elements) and construct a multilevel structural model Sage (1977) and Ghodsypour and O'Brien (1998).

Thus suppose the system have nth elements that it is indicated by T, then T= {t1, t2, t3, ..., tn}

Simply can be defined The relationship of each of the elements in set T as binary relation, while the set arranged by the ordered pair (ti, tj) that meets the binary relation in the Cartesian Product T× T can be defined as R. Thus, the binary relation R is the subset of the Cartesian product, which is

$$R \subseteq T \times T \quad (5)$$

Should the order be (ti, tj) ϵ R, it indicates that there is relationship between element ti

and tj, and it can be written as:

$$t_i R\, t_j \quad \forall\, t_i ; t_j \quad \epsilon\, T \tag{6}$$

Correspondingly every factor in set T can be considered as node, and can be resolved by graph theory. Should there be relationship between two nodes it can be connected with a directed line. Thus tiRtj relationship a line can be drawn from the direction of node ti to node tj.

With expand the binary relation R in set T, having been conducted of comparison according to all of the ordered pairs, can come up with n ×n binary matrix A, which is defined as follows:

$$A = [\, a_{ij}]_{m\times n} \tag{7}$$

$$a_{ij} = \begin{cases} 1\ if & t_i R t_j \\ 0\ if & t_i \bar{R} t_j \end{cases} \tag{8}$$

In matrix A since every node can reach its own node, therefore, path length being 0 or 1 can then be used to indicate the possibility to reach once the adjacency matrix is added with identity matrix. It mathematical equation can be shown as follows:

$$N=A+I \tag{9}$$

Within it matrix N is termed as element connection matrix.

According to the calculation of Boolean operation, the matrix of r power $N^2; N^3; N^4; \ldots . N^{r-1};\ N^r$ can be further resolved. Should the following conditions be accommodated:

$$N^2 \neq N^3 \neq N^4 \neq \cdots N^{r-1} \neq N^r = M \tag{10}$$

Will be known as reachability matrix, and there is such transferring relationship between this matrix and element connection matrix. If M (si, sj) =1 it shows that there is a path between node ti to node tj; If M (si, sj) =0 it shows that it is impossible to reach from node ti to node tj. From all of the directed figures obtained from the reachability matrix A, all of the nodes can be deducted into two categories:

$$R = \{t_j | t_j \ \in T\ M(t_i\ , t_j\ ) = 1\} \tag{11}$$

$$A = \{t_j | t_j \ \in T\ M(t_j\ , t_i\ ) = 1\} \tag{12}$$

R is of the set construed with factor ti to all that can reach factor tj, and is termed as the adjacency reachability set. A is of the set construed with all of the factors tj that can reach factor ti, and is termed as adjacency antecedent set.

If n factors in set A can contain to following conditions:

$$R(t_i) \quad \cap A(t_i) = R(t_i) \quad \forall\, t_i\ \epsilon\, T \tag{13}$$

Factor ti can then be drawn out and be listed in the same hierarchy, and the drawn factor can be taken out from the reachability matrix M. And the method is repeated

continuously to determine for adjacency that can reach succulent set R and adjacency antecedent set A, after which the previous equation is followed again to determine the factor that will be drawn out from the next hierarchy. The process is applied once again until all of the factors have been drawn out Thakkar *et al.* (2007) and Mandal and Deshmukh (1994).

4. Model application

This study has used GRA and ISM relation analysis to determine for the relationship of binary assessment of priority strategies. Once the relationship among strategies has been clarified, interpretive structural model is utilized to deal with the analysis problem of strategy hierarchy. With respect to the above mentioned problem, this study has conducted following modification: (1) criteria are used to analyze the ranking order of strategy implementation with comprehensive judgment; (2) binary comparison is used to analyze the ranking order of strategy implementation; (3) integrated approach is used to analyze sub-systems of decision-making levels.

There are two evaluation criteria as found in this study:

M1. Ability of implementation strategy: the being able to do strategy the better, the higher the priority.

M2. Marketing of implementation strategy: the higher sell of market to carry out the strategy the better, the higher the priority.

The explanation on the operation procedures of model is as follows:

Step 1. For each criterion all strategies are comparison and they are denoted with numbers of 1, 3, 5, 7, and 9, and in parity comparison strategies the higher the score it shows that such strategy under the evaluation criterion is more favorable than the other strategy evaluated.

Step 2. The results obtained from the questionnaires in previous step, priority score can be derived for each of the strategy against the rest of strategies.
Step 3. Grey relational calculation after score matrix is obtained in follows:

(1) If the grey relational grade is obtained in step 2 larger than 0.5 it is inferred that its strategy priority relationship is 1.

(2) If the grey relational grade is equivalent or smaller to 0.5 it is reefed that its strategy priority relationship is 0.

(3) Special cases are (i) when coefficient are all smaller or equivalent to 5 and grey relational grade will be all larger than 0.5 the strategy relationship should then be inferred as 0; (ii) when coefficient are all larger than or equivalent to 5 its grey relational grade will all be greater than 0.5 the strategy relationship should then be inferred as 1 Nadkarni and Shenoy (2001).

Step 4. Integrated system analysis based on obtained system levels and draw cognitive map and casual influence.

In table 2 are calculated results of step 1 to 3 and in flow with ISM method is determined hierarchy strategies.

This is the decision-making group formed by scholars and experts who are similar in the study, and subjective value judgment is conducted by this group to see the relevant importance of each evaluation criteria Questionnaire which is employed by the group to conduct the investigation and find out that the experts and scholars will focus on six strategies (Indicated by T1, T2, T3, T4, T5 and T6).

Thus, we can incorporate the integral strategy relationship matrix as (that is the adjacent matrix to ISM):

$$\begin{vmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 \end{vmatrix}$$

From the calculation of element, the reachability matrix continued is:

$$\begin{vmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \end{vmatrix}$$

Table 2. Results of GRE and ISM methods for ranking strategies.

Steps	B1	B2	B3	B4	B5	Descripsion Operation		
1 and 2	0	9	7	5	5	M1 Criteria	Questionary Results	Compare B1 barrier With Other Barriers
	0	3	5	3	5	M2 Criteria		
3	0/37	0/82	0/85	0/58	0/76	GRA Coefficients		
	0	1	1	1	1	ISM Coefficients		
1 and 2	1	0	3	1	3	M1 Criteria	Questionary Results	Compare B2 barrier With Other Barriers
	5	0	7	5	9	M2 Criteria		
3	0/54	0/39	0/85	0/54	1	GRA Coefficients		
	1	0	1	1	1	ISM Coefficients		
1 and 2	7	7	0	0	3	M1 Criteria	Questionary Results	Compare B3 barrier With Other Barriers
	3	3	0	1	1	M2 Criteria		
3	1	1	0	0/44	0/51	GRA Coefficients		
	1	1	0	0	1	ISM Coefficients		
1 and 2	1	1	3	0	1	M1 Criteria	Questionary Results	Compare B4 barrier With Other Barriers
	3	5	5	0	7	M2 Criteria		
3	0/45	0/53	0/82	0/33	0/71	GRA Coefficients		
	0	1	1	0	1	ISM Coefficients		
1 and 2	1	3	1	1	0	M1 Criteria	Questionary Results	Compare B5 barrier With Other Barriers
	3	3	1	1	0	M2 Criteria		
3	0/71	49	0/44	0/44	0/39	GRA Coefficients		
	1	0	0	0	0	ISM Coefficients		

Thus, the ranking order relationship for the implementation of the five strategies from literature review, obtained is as shown in figure 2, and is arranged as shown in table 3.

Table 3. Strategies Hierarchy.

Hierarchy	Strategies decryption
First	T4 : An innovative mining and minerals industry with an excellent knowledge base
Second	T2 : Dialogue and cooperation to promote innovation and growth
Third	T3 : Framework conditions and infrastructure for competitiveness and growth)
Fourth	T1: A mining and minerals industry in harmony with the environment, culture and other industries T5 : An internationally renowned, active and attractive mining and minerals industry

A structure of a system, in view of systems modeling, can comprise: a spatial arrangement of elements, ordered levels (hierarchy) of subsystems or/and elements, and concentration and types of algebraic relationships between subsystems and/or elements. These three factors, together with the variety of elements (related to ordered levels), determine the complexity of a system. An extremely complex system model can be characterized by a rich variety of elements, a heterogeneous and irregular distribution of elements in space, many hierarchic levels, and nonlinear algebraic relationships between the elements. Therefore, in flow is an analyzed relation subsystem with dynamic approach Kwahk and Kim (1999).

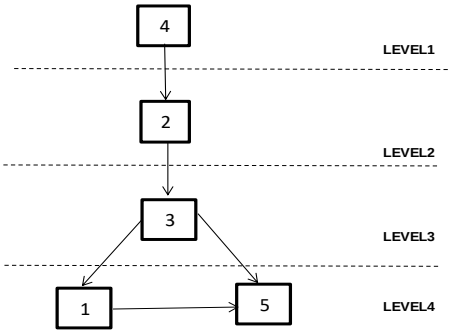

Figure 2. Strategies Hierarchy Diagram.

5. Conclusions and Recommendations

This study starts from the consideration of knows of strategies for improvement iron mines productions that are divided into five categories and then focus on the fact that strategy is formed because of varied views; therefore, it is a matter of course that the analysis of priority should be accomplished from diverse aspects. Furthermore, since the comparison of strategy priority is of binary comparison in this study has chosen combination model with GRE and ISM and analysis for resolution as according to the abovementioned reasons.

Result analysis shows the level of strategies for improving iron products in Iran: first, an innovative mining and minerals industry with an excellent knowledge base and at the second level, Dialogue and cooperation to promote innovation and growth; the third level, Framework conditions and infrastructure for competitiveness and growth; the forth level, A mining and minerals, An internationally renowned, active and attractive mining and minerals industry.

This model is helpful to the strategy management obtained from the situation analysis and the establishment of GRE and ISM adjacency matrix. Thus, the method can be widely applied onto the discrete-space decision-making problem.

References

1. https://www.economist.com/finance-and-economics/2012/10/13/the-lore-of-ore
2. "Mining in Iran – CountryMine". InfoMine. Retrieved 18 October 2011.
3. Jump up to:[a] [b] "Archived copy". Archived from the original on 24 November 2011. Retrieved 28 November 2011.
4. "Archived copy". Archived from the original on 21 October 2008. Retrieved 2010-03-15.
5. http://www.earthstonegroup.com/blog/?p=709
6. Shiau, T. A., & Hsu, C. Y. (2003, October). APPLICATION OF GRA AND ISM INTEGRATION MODEL FOR THE EVALUATION OF INTERNATIONAL PORT LOGISTICS STRATEGIES. In *Proceedings of the Eastern Asia Society for Transportation Studies* (Vol. 4).
7. http://www.adlittle.com/sites/default/files/viewpoints/adl_iranian_metals_mining_industry-web.pdf
8. http://www.iran-daily.com/News/216078.html
9. https://financialtribune.com/articles/economy-business-and-markets/80205/iran-sixth-largest-iron-ore-exporter-to-china
10. "Archived copy" (PDF). Archived from the original (PDF) on 28 September 2011. Retrieved 15 March 2010.
11. "Iran world's 8th iron ore producer: report". Tehran Times. Retrieved 18 October 2011.
12. "Molybdenum Production by Country (Metric tons of contained molybdenum)". Indexmundi.com. Retrieved 18 October 2011.
13. "Steel Production Capacity at 20m Tons". Zawya. 23 September 2010. Archived from the original on 5 January 2013. Retrieved 18 October 2011.
14. IRNA:Iran: $30 Billion Dollar to be invested in industry. Retrieved 15 November 2008.
15. Kung, C. Y., & Wen, K. L. (2007). Applying grey relational analysis and grey decision-making to evaluate the relationship between company attributes and its

financial performance—a case study of venture capital enterprises in Taiwan. *Decision Support Systems*, *43*(3), 842-852.
16. Chen, F. L., & Ou, T. Y. (2009). Gray relation analysis and multilayer functional link network sales forecasting model for perishable food in convenience store. *Expert Systems with Applications*, *36*(3), 7054-7063.
17. Chang, Y. C. (1999). Grey Relational Analysis: The introduction of Grey System theory.
18. Shiau, T. A., & Hsu, C. Y. (2003, October). APPLICATION OF GRA AND ISM INTEGRATION MODEL FOR THE EVALUATION OF INTERNATIONAL PORT LOGISTICS STRATEGIES. In *Proceedings of the Eastern Asia Society for Transportation Studies* (Vol. 4).
19. Wu, W. Y., Hsiao, S. W., & Tsai, C. H. (2008). Forecasting and evaluating the tourist hotel industry performance in Taiwan based on Grey theory. *Tourism and hospitality Research*, *8*(2), 137-152.
20. Sage, A. P. (1977). Methodology for large-scale systems.
21. Ghodsypour, S. H., & O'Brien, C. (1998). A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. *International journal of production economics*, *56*, 199-212.
22. Thakkar, J., Deshmukh, S. G., Gupta, A. D., & Shankar, R. (2007). Development of a balanced scorecard. *International Journal of Productivity and Performance Management*.
23. Mandal, A., & Deshmukh, S. G. (1994). Vendor selection using interpretive structural modelling (ISM). *International Journal of Operations & Production Management*, *14*(6), 52-59.
24. Nadkarni, S., & Shenoy, P. P. (2001). A Bayesian network approach to making inferences in causal maps. *European Journal of Operational Research*, *128*(3), 479-498.
25. Kwahk, K. Y., & Kim, Y. G. (1999). Supporting business process redesign using cognitive maps. *Decision Support Systems*, *25*(2), 155-178.