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Design of An Intelligent Model for Strategic Planning in Mineral Holding: Case study, Shahab-Sang Holding

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Abstract

Business logic is one of the most important logics based on the decision matrix. However, using this logic alone and environmental uncertainty leads to problems such as low accuracy and integrity in strategic planning. In this work, we use an intelligent model based on the neural-fuzzy approach aiming at a desired decision-making and reducing the uncertainty in the strategic planning in mineral holdings. Here, the strategies are presented based on three logics, namely business, added value, and capital market. After extracting the primary indices, the final indices of the three logics are selected by consulting with the mineral holding experts. Modelling of the indices is accomplished by the Matlab software, and the model computation is done by the root mean square error for the test data and train data. The case study (Shahab-sang holding) findings show that by a combination of these three logics, the proposed strategies include more integration and accuracy, which lead to a lower uncertainty and more speed in the strategy formulation. Also the test result indicates the validity of all the extracted strategies.

1. Introduction

Holdings follow the companies' administration, and try to hold their management by increasing their share [1]. Holdings have a partial structure, and enforce strategies in sub-companies via merging purchasing, analyze, and control [2]. The holding strategies are related to their choices such as what business units should be sold or bought and how resources should be allocated between multi-businesses activities [3].

Matrix analysis is the first point of strategy formulation in a company, and is used to recognize the current combination of business units [4]. The management consulting companies such as Boston (1970) and McKinsey have developed the holdings strategy formulation approaches by transferring the portfolio concept from the financial field to the economic one [5]. They often use one matrix to layout businesses, resource allocation, strategy formulation, performance goal set, and portfolio balance evaluation [6].

In a paper entitled "From Competitive Advantage to Organizational Strategies", Porter has stated that a strategy at the parent company level makes the company more than just the sum of its business components. He found that the holding companies by using a suitable strategy should manage their businesses to increase the performance in comparison when they act independently [7]. Anderius has defined a strategy in the holding company level as "to formulate the decision-making pattern align to the organization goals". This definition is used to determine scope of a company businesses. In this research work, the organizational variables, market share, performance, competition severity, and value creation have been recognized [8]. Sholze has

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noted that attention to suitable methods to manage holding and investment is the main reason for holding failure, and the parent company's investment in subsidiaries is based on a set of factors such as the parent company characteristics, business characteristics (subsidiaries), and market conditions [9]. Gold et al. have presented a new concept of company level strategy, holding advantage, and holding management methods. They evaluated the management levels role among 300 companies. They found that the variables such as the business nature, market share, life cycle, competition power, organization performance, competition severity, and value creation have important effects on the strategy formulation. The research work by Gold and Cample has shown that the parent companies follow different maternal approaches and philosophies. Their studies led to the identification of three important and fundamental methods of parenting including the strategic planning, strategic control, and financial control [10]. The hybrid intelligent method has been used for strategic technology planning in construction of the industry companies by Yu et al. [11]. Chen et al. have used business logic for strategic planning in semi-conductors in Taiwan, presenting a strategic planning model with an artificial intelligence approach for the semi-conductor industry [12].

Booman and Helfat have found that the variables such as business nature, organization structure, life cycle, organization performance, organization culture, and value creation are important in strategy formulation. They also analyzed the effects of these variables on the management styles [13].

Nipa et al. have recognized that the lack of conceptual frameworks in the company level strategy is the most noticeable gap in the company portfolio management [14].

A model with an intelligent neuro-fuzzy hybrid approach has been proposed by Moqbel et al. for technology strategic planning, which is a combination of the previous models. In this research work, they presented the technology strategies of the petrochemical industry in three topics: capital-oriented, research-based, and knowledge-based [15].

Antonio et al., in their research, identified the life cycle variables, organizational cycle performance, organizational performance, organizational culture, and synergy as the decision variables by studying the methods of value-added assets in subsidiaries. The results obtained showed that these factors affected the investment decisions of the holding, and have been extracted by surveying the performance of the competitors, existence of threats, and business opportunities [16].

By designing a dynamic business model for the strategies of subsidiaries by Cosnez et al., the components of the organizational structure, life cycle, competitiveness, organizational performance, value creation, and synergy have been extracted through elites. They introduced three levels of strategy including the company level, business strategy, and task level strategy [2].

Jialin et al., by presenting a model for integrating the socio-political and corporate strategies of companies, identified the variables of the organizational structure, life cycle, competitiveness, organizational performance, value creation, and synergy as the input to the model [1].

Based on the current resources, the strategy formulation model with a hybrid intelligent approach at the level of holdings is rare, and often an attraction-ability matrix-(business logic) is used to formulate the strategies based on the decision matrix. Due to the expert opinions, this logic does not have a sufficient share in a highly reliable decision-making. In the present work, in order to make a better decision, three logics including business, value adding, and investment market were used. On the other hand, a combination of the intelligent neural-fuzzy method was used to reduce uncertainty and increase the speed and accuracy of the strategy formulation. In the existing strategy development models, the mechanism of validation of strategies is not usually discussed. In this research work, the opinions of the mining experts are the basis for evaluating the validity of the strategies. In addition, the advantage of this research work is the emphasis on extracting the effective indicators in determining the strategies of the country's mineral holdings from the perspective of the business logic, value-added logic, and capital market logic, reducing human errors in identifying and determining the strategy and evaluating the effectiveness and efficiency of the model. Therefore, the proposed fuzzy-neural model leads to reduce the risk of strategy formulation.

2. Theoretical background

2.1. Strategy levels

In general, the three levels of Corporate-level strategy (Holding–Level), business-level strategy, and Functional -level strategy are introduced for the strategy.

Corporate level strategy can be designed for the multi-business companies and parent companies. The business strategy is relevant to the single business companies, and deals with how the businesses compete to achieve a competitive advantage, and the task level strategy is performed with the aim of implementing higher level strategies. On the other hand, the development of the Corporate-level strategy requires the following two strategic decisions [17]:

1- What businesses and how should the parent company's resources be invested?

2- How should the parent company influence and relate to its subsidiaries?

Therefore, in this analysis, the strategic planning in subsidiary businesses is specifically focused on decision number 2.

2.2. Neuro-fuzzy inference system in strategy formulation

Combining neural networks with fuzzy systems has been better than other combinations of intelligent technologies in terms of the features such as the explicit knowledge expression, accuracy, learning ability, and knowledge discovery [18]. The neuro-fuzzy model has the advantages of the fuzzy logic and neural network. These models represent a system with fuzzy logic rules in the neural network structure [19]. An important feature of the fuzzy inference system is understanding the non-linear behavior of a system [20]. Fuzzy systems have a good ability to turn problems into the features that can be interpreted by the humans, and create expert systems that can convert the data into the fuzzy knowledge in the form of if/then rules [21]. In the present work, the Tagaki Sugeno inference system is used, as shown in Figure 1. This system was selected due to its flexibility and higher accuracy.

This system is a type of adaptive networks that provides a powerful format for solving classification problems [22]. The Takagi-Sugeno fuzzy system has 5 layers, and its algorithm is supervised learning. All layers, except the first and fourth layers, contain fixed nodes. Each layer is described as follows [23]:

- First layer: Each node in this layer corresponds to a function parameter, and its output is one degree of the value of the membership function, which is given by the input of the membership functions.
- Second layer: The nodes in this layer are fixed. The output node is the result of multiplying the input signals by that node, and is delivered to the next node. Each node in this layer represents the firepower for each rule

$$O_{2i} = w_i = \mu_{Ai}(x) * \mu_{Ei}(y) i = 1.2 \quad (1)$$

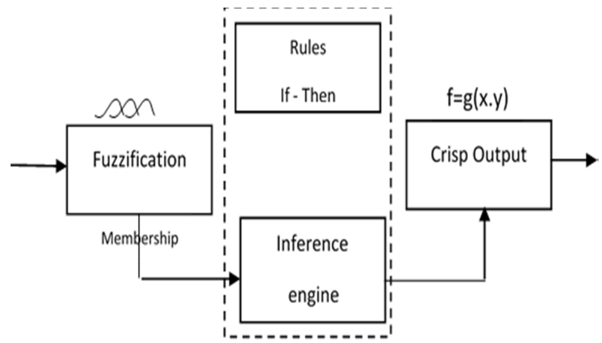

Figure 1. Tagaki Sugeno inference system diagram.

Third layer: The nodes in this layer are also fixed. Each node in this layer is calculated as the ratio of the firepower of the M-i rule to the sum of the firepower of all the rules. This result is known as the normal firepower.

$$O_{3i} = \overline{w_i} = \frac{w_i}{\sum_i w_i} \quad (2)$$

Fourth layer: In this layer, each node is an adaptive with an output that is defined as:

$$O_{4i} = \overline{w_i}\, f_i = \overline{w_i}\,(p_i\, x + q_i\, y + r_i) \quad (3)$$

$\overline{w_i}$ is the normalized firepower from the third layer, and $(p_i\, x + q_i\, y + r_i)$ is a parameter in the node. In this layer, the parameters refer to the resulting parameters. Fifth layer: In this layer, the node is a fixed node that is the sum of all signals received from the previous layer, and is represented by Formula 4 .

$$O_{5i} = \sum_i \overline{w}_i\, f_i = \frac{\sum_i w_i\, f_i}{\sum_i w_i} \quad (4)$$

In this work, the MATLAB software was used to simulate the proposed method, and 85% of the data was used for the training phase, and the remaining 15% for the test phase. The selection of this amount of data for the training and testing stages was random from the total data available in each simulation. The generated fuzzy neural inference system with its characteristics is shown in Table 1.

Table 1. Structure of the neural-fuzzy inference system.

Output membership functions	Input membership functions	Algorithm	Fuzzy system type
Linear	gaussmf	FCM	Tagaki Sugeno

2.3. Model validation

There are some criteria for measuring the validity of models, which can be referred to as the Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Nash-Sutcliffe Efficiency (NSE). In this research work, the RMSE criterion was used to measure the validity of the model.

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|z^{*}(x_i) - z(x_i)| \quad (5)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}[z^{*}(x_i) - z(x_i)]^2} \quad (6)$$

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}(z(x_i) - z*(x_i))^2}{\sum_{i=1}^{n}(z(x_i) - z^{mean})^2}\right] \quad (7)$$

In the mentioned formulas, Z * (xi) is the estimated value of the variable, Z (xi) is the measured value of the variable, Z^{mean} is the observational mean of the variable, and n is the number of data.

2.4. Research model matrices

Matrix analysis, which is the starting point for the firm-level strategy development and is used to identify the existing composition of business units, facilitates the micro-macro-level strategy development. By focusing on each business unit, the top management determines its position accurately in a matrix that reflects the opportunities of the industrial environment and competitiveness. The presentation of the business unit by the matrix at the company level provides the information and tools required to control and evaluate the decisions about the overall directions of the unit, and decision-making about the allocation of the major resources [4].

The three decision matrices of the ability/attractiveness matrix (business logic), parenting value matrix (value-added logic), and fair value matrix (capital market logic) can be combined to guide decisions about how managers should decide which business, market or geographic area to invest in, and where to avoid investing or to reduce their investment or sell off their business for the portfolio decision-making [17]. In this research work, the above three matrices were used to develop the strategy of mining holdings.

2.4.1. Ability/attractiveness matrix (business logic)

This matrix is the GE/Mckinsey matrix (Figure 2). According to the Mackinsey matrix, the horizontal axis shows the company's ability, and the vertical axis shows the attractiveness of the market, and the strategies include the three strategies of selective investment, invest and growth, and harvest and divest.

The businesses in the lower right corner of the matrix have more priority than the bottom left. In general, the companies should retain or acquire the businesses to the right of the mid-sloping line, and move out of or re-establish the businesses to the left of the mid-sloping line [17].

24.2. Heartland matrix (value-added logic)

This logic is the main driver of decision-making in order to centralize and decentralize the type of tasks or activities required in the headquarters, manner of organization structure, and amount of interaction required between the business units [17]. Based on the value-added logic decision matrix (Figure 3), the horizontal axis includes the parent company's abilities and competencies to help businesses, and the vertical axis includes the parent company’s perception and understanding about the key business success factors, and the strategies include the heartland, edge of heartland, ballast, value trap, and alien territory.

In the first area, the parent company has a high understanding of its businesses, and can have a valuable intervention in them. This area is the heartland of the parent company. In the second area, the parent company has a relatively good understanding of its businesses. This area is the edge of the heartland of the parent company. The parent company has a high understanding of the business but lacks the skills to help create value in those businesses. As a result, the parent company in this area does not have a parental advantage, and if it decides to enter such businesses, it is first necessary to acquire the necessary competencies for a value-added intervention. This area is called the ballast (territory development). In the third area, the parent company has a low understanding of businesses but has the necessary skills to help create value in those businesses. This area is a value trap because in most cases, due to the lack of a proper understanding of the parent company about the business, the parental assistance not only is not valuable but also is destructive. In the fourth area, the parent company does not have a high understanding of businesses and lacks the qualifications to help those businesses. This area is called the alien territory [9].

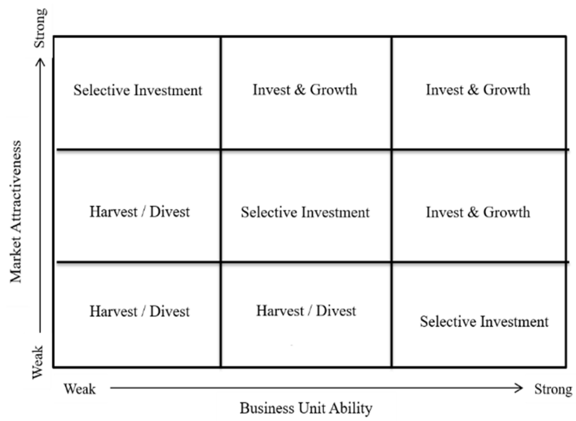

Figure 2. Mckinsey/GE matrix.

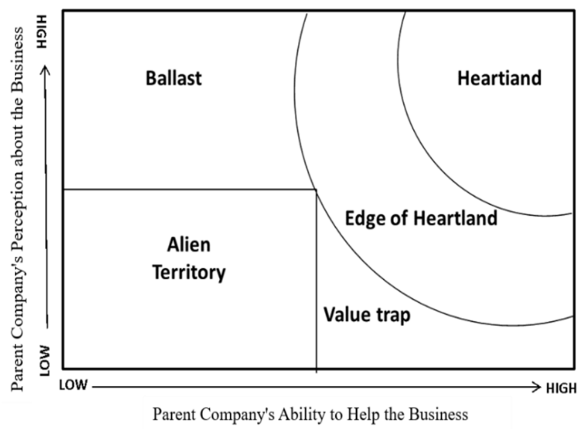

Figure 3. Heartland matrix.

2.4.3. Fair value matrix (capital market logic)

According to the capital market logic matrix (Figure 4), the horizontal axis includes the current value of the business, and the vertical axis includes the price in the capital market, and the strategies include the owner, seller, and no compelling strategies.

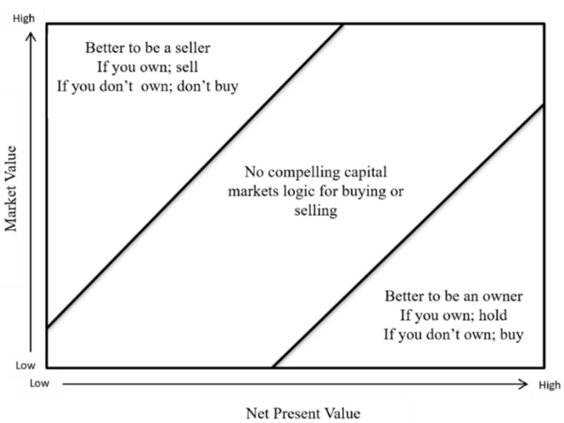

Figure 4. Fair value matrix.

Figure 4 presents the market value versus the net present value (NPV) of the business. When the market value is significantly higher than NPV, the companies should move towards sales, while when NPV is higher, the companies should move towards buying. Also when the market value and the present value are almost the same, this logic has no advice. As a result, depending on the market trends, the businesses can have a different market value than the expected discounted future cash flows. The difference between the market value and the discounted value is partly due to the fact that some buyers and sellers are unaware of the potential cash flows or appropriate discount rates, and the cash flows are not the only factors influencing the decision to buy or sell. The logic of capital markets leads the companies to buy cheap businesses and sell expensive businesses. This logic probably has more impact on the timing of the decision to form a business portfolio than its core composition [17].

2.5. Shahab-sang Mining Industries

The shahab-sang mining industry was established in 1991 to explore, extract, and process the minerals. The company became a holding company in 2012 through a merger with several other companies. Today, this holding has 6 subsidiary companies and operates in about 25 mining fields in all regions of the country.

The strategic interaction and parenting methods in this holding are often strategic planning and strategic control. The shahab-sang's ability to help subsidiaries is high, and the parent method is interventionist and centralized so shahab-sang considers himself the main planner, and by adopting a centralized approach, significantly in plans and strategies.

Strategic planning in this company is mostly based on the business logic, and is done according to the qualitative evaluation of the market attractiveness and capabilities of subsidiaries. According to the opinions of the managers and experts of this holding, strategic planning in this way has a high risk, and in most cases have caused damage to the holding; so they want to use a method that reduces risk and uncertainty in decision-making. They believe that the use of new methods such as artificial intelligence can solve the problem of strategic planning of the holding. Thus in their opinion, the subject of research was necessary for mineral holdings, and they cooperated a lot during the research.

3. Conceptual model of research work

This research work was applied based on the purpose and was analytical-descriptive in terms of the nature and data collection and quantitative and qualitative in terms of the data type. Using the hybrid neuro-fuzzy intelligent technique and the three discussed decision matrices, the conceptual model of strategic planning with the neuro-fuzzy approach is presented in Figure 5.

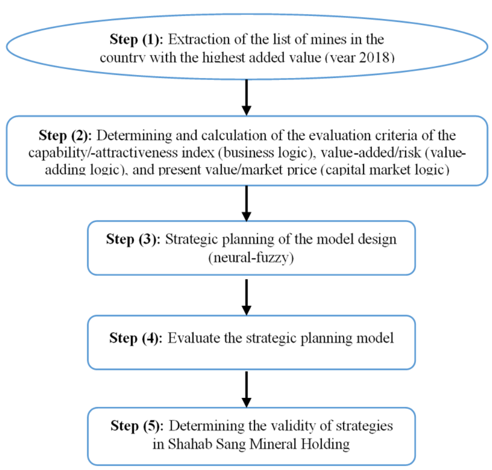

Figure 5.Conceptual model of intelligent strategic planning in mineral holdings

Step 1- First, a list of mineral fields in the operations in the country with the highest added-value (year 2018) was prepared. This list included the following: extraction of iron ore, copper ore extraction, extraction of decorative stones, coal mining, extraction of limestone, extraction of lead and zinc ores, sand extraction, gold mining, extraction of carcass stones, and extraction of mineral pumice.

Step 2- In this step, the evaluation criteria of the ability/attractiveness (business logic), value-added/risk (value-added logic), and net present value/market value (capital market logic) were determined based on the library resources and the opinions of the mineral holding experts. Also the evaluation criteria were calculated based on the opinions of the mineral holding experts.

In this regard, 2 questionnaires were designed and the opinions of 35 managers and experts on the preference of each criterion on the Likert scale were collected. In order to finalize the indicators, a one-sample student's t-test was used and to evaluate the reliability of the questionnaire; the Cronbach's alpha test was used. The first questionnaire is related to the attractiveness criteria of the mining market. The list of the attractiveness criteria and a summary of the frequency of answers provided by the respondents are given in Table 2, and the second questionnaire is related to the competency criteria of the mining field. A list of the competency criteria and a summary of the frequency of answers are given in Table 3.

Table 2. Summary of the frequency of answers.

Criteria of attractiveness	Frequency of degree of importance				
	0	1	2	3	4
Creating job opportunities	0	3	5	10	17
Solving the needs of the community	0	3	3	12	17
Scope of application	0	2	3	14	16
Market growth rate	0	2	6	12	15
Impact on GDP	0	1	6	17	11
Impact on increasing exports	0	1	8	15	11
Impact on the expansion of international partnerships	0	3	6	15	11
Strategic importance	0	2	9	13	11
Number of competitors	0	2	8	14	11
Overall risk of return on investment	0	2	12	11	10
Government laws and regulations	0	0	7	21	7
Inflatable vulnerability	0	2	9	17	7

Table 3. Summary of the frequency of answers.

Competency criteria	Frequency of degree of importance				
	0	1	2	3	4
Certified staff	0	2	3	11	17
Experience, knowledge, and information required	0	1	3	14	15
Managerial experience	0	1	6	13	13
Production quality	0	1	5	17	10
Technological ability	0	1	7	15	10
Distribution network	0	2	7	14	10
Having market share	0	1	9	13	10
Business skills	0	1	8	13	10
Quick and accurate market assessment	0	3	11	10	9
Financing	0	0	7	19	7
Branding	0	1	8	17	7
Use of information systems	0	0	7	20	6
Sales service	0	1	6	20	6

The Cronbach's alpha test was used in order to evaluate the reliability of the questionnaires. The value of this statistic was 0.834 for the attractiveness questionnaire and 0.620 for the competency questionnaire, which was statistically acceptable. In order to check the validity of the questionnaires, the opinions of the respondents, who were a kind of industry experts, were used. For this purpose, the information of the questionnaire was tested using a one-sample t-test. Table 4 shows the test results for the attractiveness questionnaire, and Table 5 shows the test results for the competency questionnaire.

Table 4. Result of the one-sample t-test (attractiveness questionnaire).

Criteria of attractiveness	Average = 2		
	Mean difference	P-value	t-value
Creating job opportunities	1.85714	0	11.641
Solving the needs of the community	1.54286	0	8.557
Scope of application	1.65714	0	9.820
Market growth rate	1.57143	0	10.516
Impact on GDP	1.80000	0	11.413
Impact on increasing exports	1.82857	0	10.985
Impact on the expansion of international partnerships	1.80000	0	10.407
Strategic importance	1.91429	0	11.540
Number of competitors	1.77143	0	11.945
Overall risk of return on investment	1.82857	0	10.985
Government laws and regulations	1.80000	0	12.272
Inflatable vulnerability	1.57143	0	10.141

Table 5. Results of the one-sample t-test (competency questionnaire).

Competency criteria	Average = 2		
	Mean difference	P-value	t-value
Certified staff	1.82857	0	13.774
Experience, knowledge, and information required	1.88571	0	14.015
Managerial experience	1.94286	0	13.173
Production quality	1.62857	0	9.905
Technological ability	2.05714	0	12.981
distribution network	1.82857	0	11.719
Having market share	1.97143	0	12.635
Business skills	1.94286	0	12.692
Quick and accurate market assessment	1.97143	0	13.095
Financing	1.82857	0	11.719
Branding	2.00000	0	18.439
Use of information systems	1.97143	0	13.095
Sales service	1.94286	0	13.173

The above tables show that first of all, from the respondents' viewpoint, all the factors are important. Secondly, this difference is statistically significant with 99% accuracy, and is reliable. Hence, this assumption is confirmed that all the identified indicators are involved in decision-making on the theoretical grounds. In this way, the validity of the questionnaires is confirmed.

Step 3- MATLAB programming was used for neural-fuzzy modeling.

Step 4- In order to evaluate the accuracy of the neural-fuzzy model of strategic planning, the criteria of the root mean square error (RMSE) for test data and the train data were used.

Step 5- Finally, in order to evaluate the validity of the developed strategies, the opinions of the managers and experts of **Shahab-sang holding** were used.

4. Population and sample

The population in this work is a selection of managers of the country's mining holdings, experts, and specialists in the strategic fields of the country's mining holding with the following characteristics:

1. More than 10 years of experience in the field of mining;
2. Master's degree or higher;
3. Having a managerial position in the mining field.

The sample of the research work is the population; it means that the complete enumeration method was used. The sample in this work, due to the lack of specialized personnel in the strategic areas of the mining holding, consisted of 40 experts of mining holding managers.

5. Proposed operational model of research

By performing steps two to five of the conceptual model, for each one of the identified mineral fields, three tables including two inputs and one output were prepared as follow:

1- Based on the business logic decision matrix (Figure 2), the inputs included the company's ability {0 to 10} and the market attractiveness {0 to 10}, and the output was (1, 2, 3), which represented the selective investment strategy, invest and growth, and harvest and divest, respectively.

2- Based on the value-added logic decision matrix (Figure 3), the inputs included the value-added potential {0 to 10} and the risk of devaluation {0 to 10}, and the output was (5, 4, 3, 2, 1), which represented the strategies of the heartland, edge of heartland, ballast, value trap, and alien territory, respectively.

3- Based on the capital market logic matrix (Figure 4), the inputs included the present value of the business {0 to 10} and the market value {0 to 10}, and the output was (1, 2, 3), which represented the owner, seller, and no compelling strategies, respectively.

Based on the opinions of forty experts during the research work, forty tables are created for each identified mineral fields. The samples were divided into two parts for model training and model testing. The final intelligent strategic planning model in neuro-fuzzy-based mineral holdings for the decision matrix of ability/attractiveness (business logic) and each mineral field is alike (Figure 6).

Also for the decision matrix, the matrix of heartland (value-added logic) and each mineral field is as follows (Figure 7): For the decision matrix, the fair value matrix (capital market logic) and each mineral field is as follows (Figure 8):

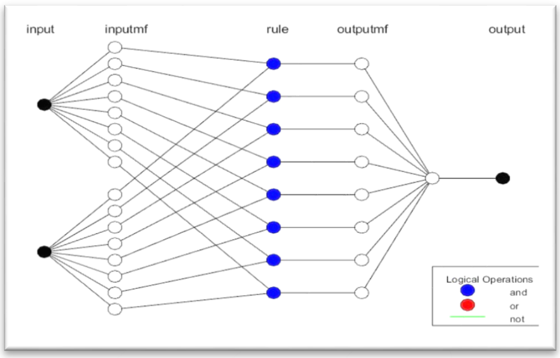

Figure 6. Final model of business logic intelligent strategic planning.

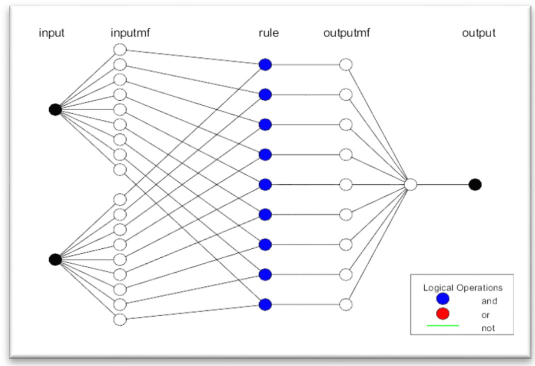

Figure 7. Final model of value-added logic intelligent strategic planning.

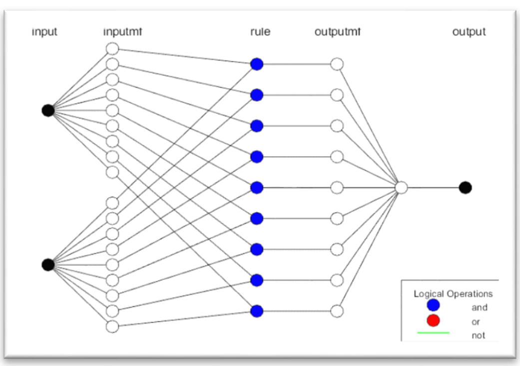

Figure 8. Final model of capital market logic intelligent strategic planning.

In these models, each node in the first layer transports the input value based on the business logic matrix and company's ability, and the market attractiveness to the next layer, based on the value-added logic matrix, transfers the value-added potential and the risk of devaluation to the next layer, and in the capital market logic matrix transfers the current value of the business and price in the capital market to the next layer. The second layer is the fuzzification layer, which is selected based on the membership function. In this layer, the membership degree of the inputs is determined by the high and low linguistic labels based on the specified membership function. In the third layer, each node multiples the inputs and sends the product out as output. The output shows the coefficient of importance of each rule. The fourth layer is the fuzzy output layer. The neurons in this layer determine the result of the fuzzy rule. The neurons in this layer combine all the inputs that enter the layer. Finally, the fifth layer is the defuzzification layer. The deffuzification layer is the output of the model, and its values in the business logic decision matrix are (1, 2, 3), in the value-added logic decision matrix are (1, 2, 3, 4, 5), and in the capital market logic matrix are (1, 2, 3).

6. Results and Discussions

Regarding the output of the intelligent fuzzy-neural model, the status and place of the mineral fields are determined in decision matrices of business logic, added-value and capital market, shown in Figures 9, 10, and 11.

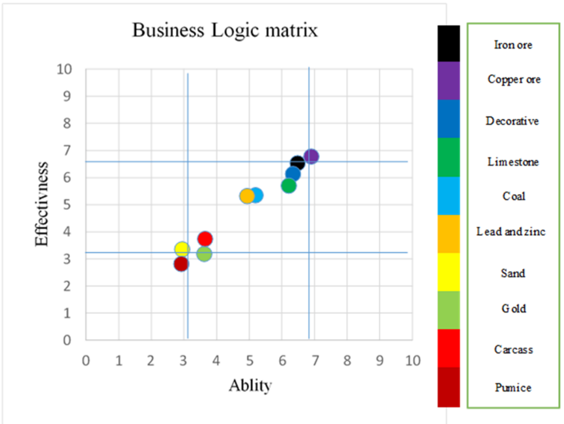

Figure 9. Distribution of mine places in the business logic matrix.

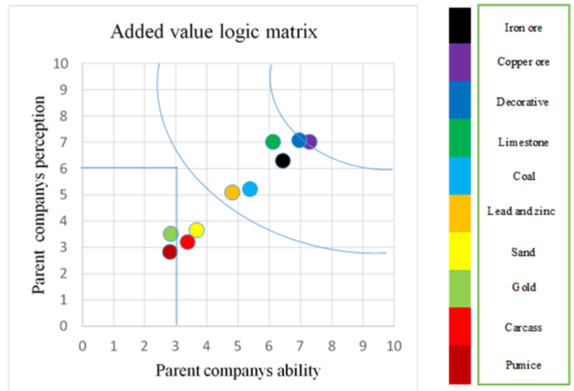

Figure 10. Distribution of mine in the added-value logic matrix.

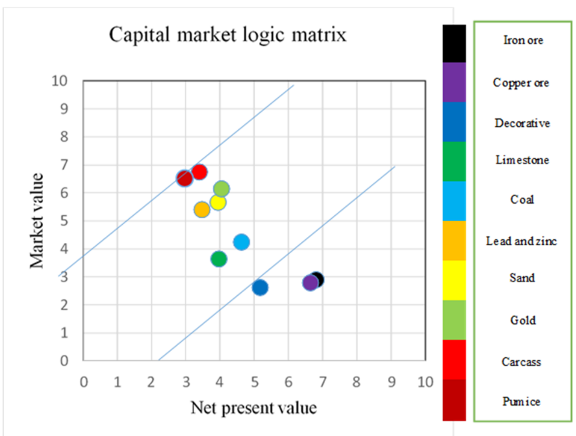

Figure 11. Distribution of mine in the capital market logic matrix.

As shown in figures 9, 10, and 11, there are different combinations of these three logics, the most important of which include the followings. In the first combination, all the three logics are aligned and decision-making is clear. Here, the example is mineral field for extracting ore; otherwise, the second to fifth combinations are created and decision should be made accurately. In the second combination, if the business is unattractive, the company should add value such as extracting limestone. In the third combination, if the company is not able to add value, it can consider two situations in which the ownership maybe reasonable. One, to develop holding skills, and two, to invest for a period of time and then to sell it to a suitable owner such as ironstone extraction. The fourth combination is difficult. It occurs when the capital market to valuate business that belongs to your company is more than the real value. In this case, it seems that protecting the business or finding a way to buy it may be reasonable such as copper ore. Finally, the fifth combination means to sell the business. If the company sells the business lower than expectation, there are techniques to balance the situation. However, maybe the company needs to protect business such as ballast extraction. The evaluation results are shown in Figures 12, 13, and 14 and Table 6.

Table 6. RMSE for test data & train data.

RMSE (train data)		RMSE (test data)	
0.0559	Business logic matrix	0.158	Business logic matrix
0.0790	Value adding logic matrix	0.2738	Value adding logic matrix
0.3535	Capital logic matrix	0.6123	Capital logic matrix

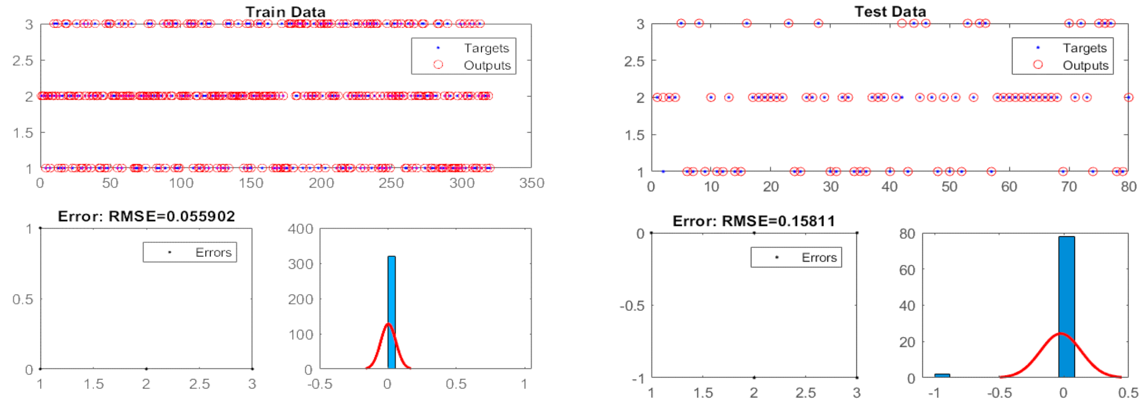

Figure 12. RMSE for test data & train data in business logic.

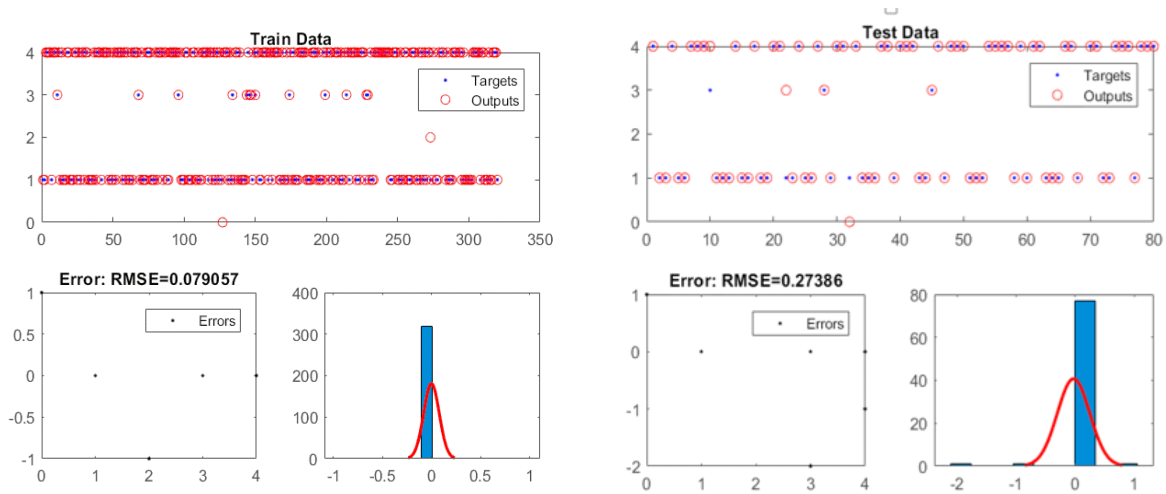

Figure 13. RMSE for test data & train data in value adding logic.

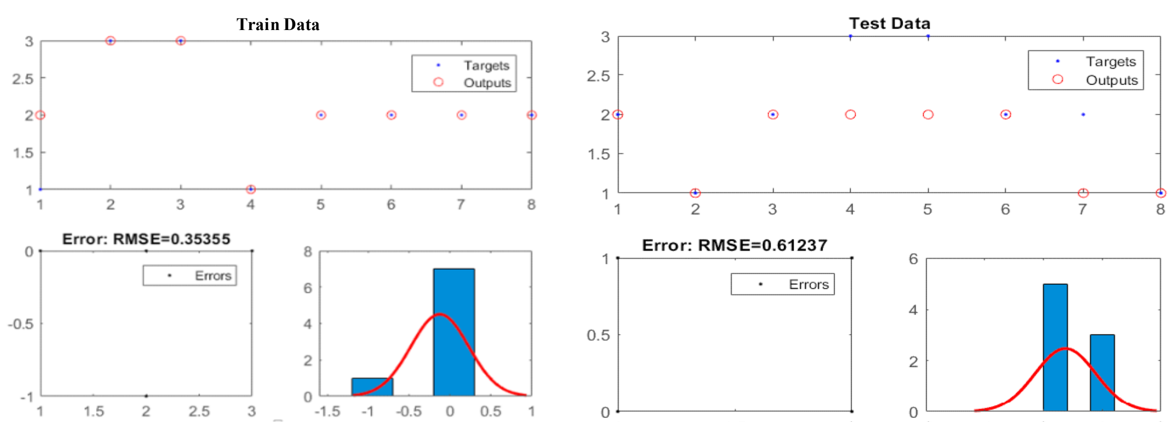

Figure 14. RMSE for test data & train data in capital market logic.

In order to validate the strategies, a questionnaire was designed, and the opinions of 30 experts of Shahab-sang holding were gathered in the likert criterion. The t-student test results showed the validity of all the extracted strategies.

7. Conclusions

The background research works show that in limited cases, the combinatory intelligent approach has been used to formulate the strategies. In this research work, we used three matrices namely the capital market logic, added-value logic, and business logic. In order to validate the strategies, the managers' opinions for the Shahab-sang holding were gathered. The advantages of this proposed model include the human error reduction, an intelligent decision-making, and an uncertainty control.

The results of this research work show that all the three mentioned logics help the managers to make decisions about some businesses that need investment, businesses that need to enter or businesses that need to leave. As each logic plays a role in making decisions, it is recommended that the managers consider all of these logics when they make a decision.

In addition, the advantage of this research work is the emphasis on the extracting effective indicators in determining the strategies of the country's mineral holdings from the perspective of business logic, value-added logic, and capital market logic, reducing the human errors in identifying and determining the strategy and evaluating the effectiveness and efficiency of the model. Therefore, the proposed fuzzy-neural model leads to reduce the risk of strategy formulation.

References

[1]. Du, J., Bai, T. and Chen, S. (2019). Integrating corporate social and corporate political strategies: Performance implications and institutional contingencies in China. Journal of Business Research. 98: pp.299-316.

[2]. Cosenz, F. and Noto, G., 2018. A dynamic business modelling approach to design and experiment new business venture strategies. Long Range Planning. 51 (1): pp.127-140.

[3]. Johnson G, R. Whittington. (2015). Exploring Corporate Strategies (7th Ed.) New York: Financial Times Prentice Hal.

[4]. Pidun, U., Rubner, H., Krühler, M., Untiedt, R., Boston Consulting Group and Nippa, M., 2011. Corporate portfolio management: Theory and practice. Journal of Applied Corporate Finance. 23 (1): pp.63-76.

[5]. Cummings, S. and Daellenbach, U. (2009). A guide to the future of strategy? The history of long range planning. Long Range Planning. 42 (2): pp.234-263.

[6]. Grant, R.M. (2010). Contemporary strategy analysis. 6th. Malden, MA: Blackwell Pub, 13(482), p.133.

[7]. Porter, M.E. (1987). From Competitive Advantage to Corporate Strategy. Harvard Business Review, May/June.

[8]. Andrews, K.R. (1971). Concept of corporate strategy.

[9]. Johnson, G., Scholes, K. and Whittington, R. (2005). Exploring Corporate Strategy Harlow Prentice Hall.

[10]. Campbell, A. and Goold, M. (1995). Corporate strategy: The quest for parenting advantage. Harvard business review. 73 (2): pp.120-132.

[11]. Li, S. and Li, J.Z. (2009). Hybridising human judgment, AHP, simulation and a fuzzy expert system for strategy formulation under uncertainty. Expert Systems with Applications. 36 (3): pp.5557-5564.

[12]. Chen, H., Ho, J.C. and Kocaoglu, D.F. (2009). IEEE Transactions on Engineering Management. IEEE Transactions on Engineering Management, Feb. 2010.

[13]. Bowman, E.H. and Helfat, C.E. (2001). Does corporate strategy matter?. Strategic Management Journal, 22(1), pp.1-23.

[14]. Nippa, M., Pidun, U. and Rubner, H. (2011). Corporate portfolio management: Appraising four decades of academic research. Academy of Management Perspectives. 25 (4): pp.50-66.

[15]. Moghbell, Ebrahimi. (2014). Design hybrid system for strategic planning.

[16]. Lloret, A. (2016). Modeling corporate sustainability strategy. Journal of Business Research. 69 (2): pp.418-425.

[17]. Campbell, A., Goold, M., Alexander, M. and Whitehead, J. (2014). Strategy for the corporate level: Where to invest, what to cut back and how to grow organisations with multiple divisions. John Wiley & Sons.

[18]. Negnevitsky, Michael, Hybrid intelligent systems: Neural expert systems and neuro-fuzzy systems, Pearson Education (2008).

[19]. Nikravesh, M., Zadeh, L.A. and Aminzadeh, F. eds. (2003). Soft computing and intelligent data analysis in oil exploration. Elsevier.

[20]. Nourani, V., Kisi, Ö. and Komasi, M. (2011). Two hybrid artificial intelligence approaches for modeling rainfall–runoff process. Journal of Hydrology. 402 (1-2): pp.41-59.

[21]. Gai, J. and Hu, Y. (2018). Research on fault diagnosis based on singular value decomposition and fuzzy neural network. Shock and Vibration.

[22]. Shaabani, M.E., Banirostam, T. and Hedayati, A. (2016). Implementation of neuro fuzzy system for diagnosis of multiple sclerosis. International Journal of Computer Science and Network. 5 (1): pp.157-164.

[23]. Suparta, W. and Alhasa, K.M. (2016). Modeling of tropospheric delays using ANFIS.

طراحی مدل هوشمند برنامه ریزی استراتژیک در هلدینگ‌های معدنی ج.ا.ا (مطالعه موردی: هلدینگ شهاب سنگ)

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چکیده:

یکی از مهمترین منطق‌های مبتنی بر ماتریس تصمیم گیری, منطق کسب وکار است. با این حال، استفاده تنها از این منطق و عدم اطمینان محیطی منجر به مشکلاتی از جمله کم شدن دقت تصمیم‌گیری راهبردی و عدم جامعیت برنامه‌ریزی استراتژیک می‌شود. در این مقاله، ما از یک مدل هوشمند مبتنی بر رویکرد عصبی- فازی با هدف تصمیم گیری مطلوب و کاهش عدم اطمینان در برنامه ریزی استراتژیک هلدینگ‌های معدنی استفاده شده است. در اینجا، استراتژی‌ها بر اساس سه منطق، کسب وکار، ارزش افزوده و بازار سرمایه ارائه شده‌اند. پس از استخراج شاخص‌های اولیه، شاخص‌های نهایی سه منطق با مشاوره با کارشناسان هلدینگ‌های معدنی انتخاب می‌شوند. مدلسازی شاخص‌ها توسط نرم افزار Matlab انجام می‌شود و ارزیابی مدل توسط محاسبه ریشه خطای میانگین مربع برای داده‌های آزمون و داده‌های آموزش انجام می‌شود. یافته‌ها در مطالعه موردی (هلدینگ شهاب سنگ) نشان می‌دهد که با ترکیبی از این سه منطق، استراتژی‌های پیشنهادی جامعیت و دقت بیشتری داشته و منجر به کم شدن عدم اطمینان و سرعت بیشتر در تدوبن استراتژی می‌شود. همچنین نتیجه آزمون نشان دهنده اعتبار همه راهبردهای استخراجی است.

کلمات کلیدی: مدل هوشمند، برنامه ریزی استراتژیک، هلدینگ معدنی، ماتریس تصمیم، عصبی- فازی.