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An ANP–SWOT approach for interdependency analysis and prioritizing the Iran's steel scrap industry strategies

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ABSTRACT

Supplying raw materials plays a central role in the Iran's crude steel plants. Iran's scrap recycling industry, as a major supplier of steel scraps, requires identifying and performing the efficient strategies to utilize the substantial amount of steel scrap. In this research, by designing a model and implementing the efficient strategic factors (Strengths, Weaknesses, Opportunities and Threats), via the SWOT analysis, the appropriated strategies, SO, ST, WO and WT are determined. This model consists of four factors, 14 sub-factors and eight strategies. Since the SWOT method is unable to rank the factors and strategies, the MADM technique is applied to prioritize them. The dependency between the factors affects the priority of strategies. Therefore, AHP and ANP methods are applied discretely to examine whether the dependency among the factors changes the priorities of strategies.

Comparison of the outcomes from the AHP and ANP methods presents that the dependency among the factors in ANP method causes major changes in ranking the alternatives particularly for the principal alternatives.

Introduction

The intensive consumption of non-renewable mineral resources, leads to further utilization of metal scraps as one of the most significant substitution of raw material in the metal industry. In many countries, after classification and cleaning, metal scraps are crushed and turned into powders for different industrial applications. Steel is the most consumed metal in the world. It is produced from iron ore or scrap through variety of processes. Steel scrap generally is obtained from recycling of the appliances, foods packages, outdoors wastes, industrial metal wastes, rebuilding production lines, machineries, and scabbed cars and ships. The amount of scrap recycling in each country depends on different factors such as economic development level, steel consumption and production rate as well as the accumulated metal scraps.

Iran's steel industries with 20 million tons of crude steel production capacity as well as 14.5 million tons of annual productions in 2012, is the 15th crude steel producer in the world (WSA, 2013). According to the Iran steel industry master plan, this capacity will reach to 55 million tons in 2025. This sum will need a high volume of raw materials such as iron ore, coal, natural gas and water. Since Iran has huge natural gas resources, the majority of Iran's steels are produced from Direct Reduction of Iron ore (DRI) technology. This method requires a substantial consumption of steel scraps, as one of the most important and non-substitutable raw material used in the crude steel production.

Although Iran has more than 100 units of steel metal recycling plants, with approximately one million tons capacity, there are remarkable amounts of unused scrap potentials. This significant gap necessitates identification of existing obstacles in the Iran's scrap industry development and recycling activities to fulfill preparation of major part of the steel industry material requirements. Precise analysis of effective internal and environmental strategic factors can lead to recognition and presentation of efficient strategies to develop steel recycling industries and more utilization of country potentials.

Literature review

Organizations are facing with different challenges and opportunities to carry out their goals and missions. Strategic planning is

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an efficient framework for enterprises to promote their position with rapid environmental changes. SWOT technique as a powerful strategic and environmental analysis tools, are applied in order to identify key internal and external strategic factors (Babaesmailli et al., 2012). This method determines the best combinatory strategies that maximize the strengths and opportunities and minimize the weakness and threats effects. The most significant step of SWOT analysis is identifying the strength, weakness, opportunity and threat factors. After creating the SWOT matrix through the mentioned factors, based on their combination, four pair wise SO, ST, WO and WT groups of strategies are identified (Hill and Westbrook, 1997).

In spite of the broad application of SWOT analysis, this method encounters several restrictions including impossibility of ranking criteria and strategies (Pahl and Richter, 2009). Thus, one of the challenges in SWOT analysis is how to rank the strategies and factors. Multiple Attribute Decision Making (MADM) methods are used as a major tool for ranking alternatives in the complex and multi-dimensional problems. These techniques consider the different criteria and alternatives depending on the type of problems.

Analytical Hierarchy Process (AHP) presented by Saaty (1982) is one of the most applied methods of MADM. It is a mathematical technique based on the pair wise comparison matrix. By use of pair wise comparison method, the participants can focus, on each part of the problem. Simply two criteria should be considered at any one time in order that the participant's judgmental task is simplified. This method is more accurate and simply compared to other comparative scale methods. The most important advantage of AHP approach is its ability to change a complex problem with a hierarchy structure including: goal, criteria, sub-criteria and alternatives. The major capabilities of this method are creating a hierarchical structure without limitation of layer's number, establishing preferences by simple pair wise comparisons and also inspecting logical compatibility by using measurements (Saaty, 1982). In order to solve the problem accompanied with hierarchical structure, the AHP procedures are defined as follows:

Step 1: Hierarchy structure is defined in such a way that the goal is placed at the top of hierarchy, and the criteria and strategies attaining from SWOT analysis are placed in descending order.
Step 2: At each level, the pair wise comparison matrix is derived. In order to identify priority of any criterion (alternative) respect to other criteria (alternative) in the matrix, a fundamental scale of crisp number ranging from 1 (equal) to 9 (absolute importance) is used.
Step 3: All the pair wise comparison matrices are synthesized to calculate relative and global weight of each criterion, sub-criterion and alternative.

AHP method was used in different ways to solve decision making problems. It was applied and combined with the other MADM methods in various cases (Ho, 2008; Amiri, 2010; Reza et al., 2011; Vidal et al., 2011; Joshi et al., 2011; Bruno et al., 2012). Also, in some research, the AHP is used in the SWOT analysis (Chang and Huang, 2006; Kajanus et al., 2012). The most important drawback of AHP is that it does not consider the dependency among strategic factors. If dependency is mutual or one component has effect on the other one, using AHP method is not possible (Saaty, 1994a, 1994b). As a result, it is necessary to employ a new approach to consider the possible dependency among factors and apply it in related calculations. Thus, Saaty (1996) presented Analytical Network Process (ANP) as developed method of AHP that consider the entire relations among criteria, sub-criteria and clusters. ANP not only can solve the AHP problem, but also capable to deal with interdependent relationships within a multi-criteria decision making model (Chen and Yang, 2011). In the network structure of ANP model all possible relations can be characterized (Gwo-Hshiung et al., 2011). In the recent years ANP method has been combined with the other operational research techniques to solve various problems such as

- resource allocation in transportation (Wey and Wu, 2007),
- analyzing benefits, opportunities, costs and risks (Wijnmalen, 2007),
- sustainable resource management (Tseng, 2009),
- assessment of information security risk control (Yu-Ping et al., 2009),
- identification of core technologies (Lee et al., 2009),
- evaluation of the suitability of different energy power plant investments (Atmaca and Basar, 2012),
- evaluation of solar–thermal power plant investment projects (Aragonés-Beltrán et al., 2014), and
- assessment of suitable partner for the implementation of a collaborative CO_2 reduction (Theißen and Spinler, 2014).

Because of the existing interdependency and dependency among all components of SWOT analysis, it can be inferred that there is a necessity to apply the ANP method for ranking of strategies, factors and sub-factors. Many researchers developed different techniques to quantify the SWOT analysis. In these studies, by applying the ANP method, each of SWOT factors, sub-factors and alternatives have been calculated. Among the applications of combining ANP and SWOT, we state some of the predominant research. Yüksel and Dağdeviren (2007) used ANP method for SWOT analysis of textile firm. The SWOT analysis was used for identification of factors and strategies. The result identified 14 factors and four types of strategies that were produced by comparing these factors (Yüksel and Dağdeviren, 2007). Sevkli et al. (2012) applied the fuzzy ANP method for strategic planning of airline industry in Turkey. Consequently the important sub-factors and seven alternatives were determined (Sevkli et al., 2012). Also for identification of the best strategies of a tile manufacturing firm, the fuzzy ANP method was combined with SWOT analyze to prioritize strategies (Babaesmailli et al., 2012). In another research, the integrated SWOT–fuzzy TOPSIS combined with AHP were used to prioritize the SWOT factors in the electricity supply chain in Turkey (Bas, 2013).

Analytical network process

ANP is a developed method of AHP that presented by Saaty. Unlike AHP method, ANP has network and cluster structure. The hierarchy formation in AHP is a linear top to down structure while network is a non-linear structures that extent in all directions (Sevkli et al., 2012). This enables ANP to model the complex problems in the real world. This method is able to consider the mutual and interdependent relationships among factors and sub-factors and rank alternatives, criteria and sub-criteria with considering mentioned relationships (Saaty, 1994b, 1996, 2004).

Generally, the ANP technique comprises two methods for ranking the alternatives. The first technique is creating super matrix. W_{ij}, ith row and jth column of the matrix, is the principal eigenvector, that represents the influence of the elements compared in the ith cluster on jth cluster. When $W_{ij}=0$, it means the ith cluster has no influence on jth one. The weighted super matrix is derived by conveying all column sums to unity value exactly. To create super matrix, the weight of options is normalized and their priorities are determined. The weighted super matrix is raised to powers until the global matrix of priorities is obtained. Finally the alternatives, criteria and sub-criteria are sorted (Gwo-Hshiung et al., 2011).