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Notes

[1] Stage of Development Model
[2] Transaction Cost Analysis
[3] Build-Operate-Transfer
[4] Research and Development

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5. Conclusion

In this research, foreign investment method and the effective criteria on prioritizing them were considered through literature review studies (papers, special books and internet searches); documents existed in archive and library of shipping and ports organization and interview with experts. Then, we conducted average test for criteria based on Fuzzy logic technique in order to determine the most important criteria for prioritizing the foreign investment methods. As a result, eight criteria were selected. At the next stage, these criteria were weighted using Fuzzy hierarchical process; then prioritized by Fuzzy decision making method and Fuzzy TOPSIS technique. The results show that joint investment is the best solution followed by mutual purchase, BOT and partnership in production. Regarding the research findings, various methods may be applied for foreign investment. No method is in itself good or bad. It is just a framework for dividing the benefits achieved through cooperation. Various factors affect the kind of method which may satisfy the parties' benefits. Decision about foreign investment methods and their being appropriate based on the name and some conditions are not logical, since each method has advantages depending on parties' benefits and conditions. Any contract without meeting the financial requirements and without necessary studies and scientific approach is inappropriate and wastes the country's wealth.

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A set of criteria must be specified as an index for determining the amount of technology transferring by each foreign investment method to evaluate and prioritize these methods. In fact, when it is possible to determine numeral values as importance coefficient for each foreign investment method prioritizing criteria in an industry, and to recognize the amount of criteria's requirements meeting, then one can determine priority of each foreign investment method relative to each other. If an axis is devoted to each basic criterion, the number of axes will be equal to basic criteria number. In this research, the effective selective criteria in prioritizing and evaluating the foreign investment method have been summarized in eight basic factors; therefore, if for each foreign investment method, one may calculate the basic factors and draw it on the axis of point finding along with specifying each method's current situation (weak points and advantages), then he/she is able to determine competitive situation of foreign investment method in an industry relative to each other. The basic factors for foreign investment method in an industry may be drawn and pointed on an octagonal diagram; so that the competitive situation of foreign investment methods is determined relative to each other along with specifying the current situation. Figure 3 shows the competitive situation of foreign investment methods relative to each other.
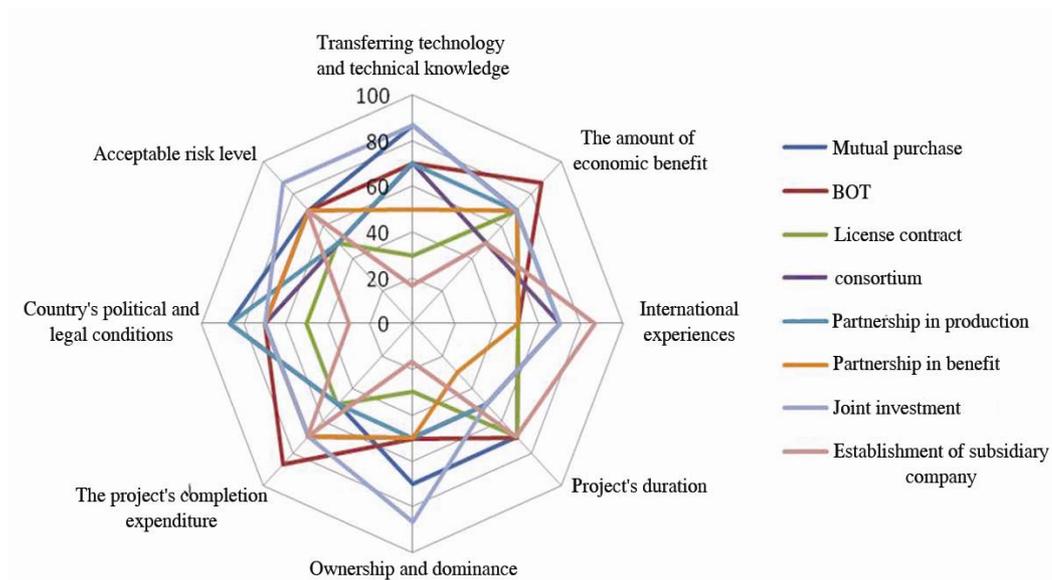

Figure 3: Competitive situation of foreign investment method in ship making industry

Table 4: Choices' Fuzzy values (foreign investment methods) in each index

Indices \ Choices	Mutual purchase	BOT	License contract	Consortium	Partnership in production	Partnership in benefit	Joint investment	Establish subsidiary company …
Transferring technical/ knowledge and technology	VH	H	L	H	H	M	VH	VL
Economic benefit amount	H	VH	H	M	H	H	H	M
International experiences	M	M	M	H	H	M	H	VH
Project and dominance	H	H	H	M	M	L	M	H
Ownership and dominance	H	M	L	M	M	M	VH	VL
Projects expenditures	M	VH	M	H	L	H	H	H
The country's legal and political conditions	VH	H	M	H	VH	H	H	L
Acceptable risk level	H	H	M	M	M	H	VH	H

In order to prioritize the foreign investment method for technology transferring in ship making industries, the required data (choices' importance coefficients i.e. "selected criteria" and the amount of choices' requirements meeting by indices i.e. "foreign investment methods" were entered in FDM. Table 5 shows the result of conducting Fuzzy TOPSIS technique by FDM.

Table 5: Prioritizing foreign investment methods for ship making industry

Rank	Foreign Investment Methods	Score
2	Mutual purchase	70.57
3	BOT	68.72
7	License contract	47.35
5	Consortium	60.61
4	Partnership in production	62.33
6	Partnership in benefit	57.34
1	Joint investment	75.61
8	Establishment of subsidiary company with perfect foreign ownership	46.89

Table 3: The choices' relative importance in Fuzzy hierarchical process

Choices Indices	Technology transferring (0.406)	Technology acquiring (0.352)	Technology dispersing (0.242)	Coefficient of the choice relative importance
Transferring technical/knowledge and technology	0.201	0.163	0.197	0.187
Economic benefit amount	0.121	0.098	0.101	0.108
International experiences	0.085	0.071	0.187	0.105
Project and dominance	0.099	0.101	0.083	0.096
Ownership and dominance	0.119	0.198	0.131	0.150
Projects expenditures	0.141	0.129	0.075	0.121
The country's legal and political conditions	0.143	0.102	0.102	0.119
Acceptable risk level	0.091	0.138	0.124	0.116

At the fourth step foreign investment methods were recognized and then prioritized based on the selected criteria, using TOPSIS technique. In decision making problem, the selected criteria act as indices and foreign investment methods for technology transferring in ship making industry are considered as choices. Data required to be applied in Fuzzy TOPSIS technique are: choices' relative importance (selected criteria) and the amount of meeting indices requirements by each choice (foreign investment methods) by Fuzzy logic. Information about indices relative importance coefficient (selected criteria) may be extracted from third step. In this regard, the fourth questionnaire was designed. It contained five choices based on Likert Scale. At this stage, to determine the Fuzzy values of indices' requirement meeting by choices (foreign investment methods in ship making industry). The result which is indices Fuzzy amounts for each under study choice are presented in table 4.
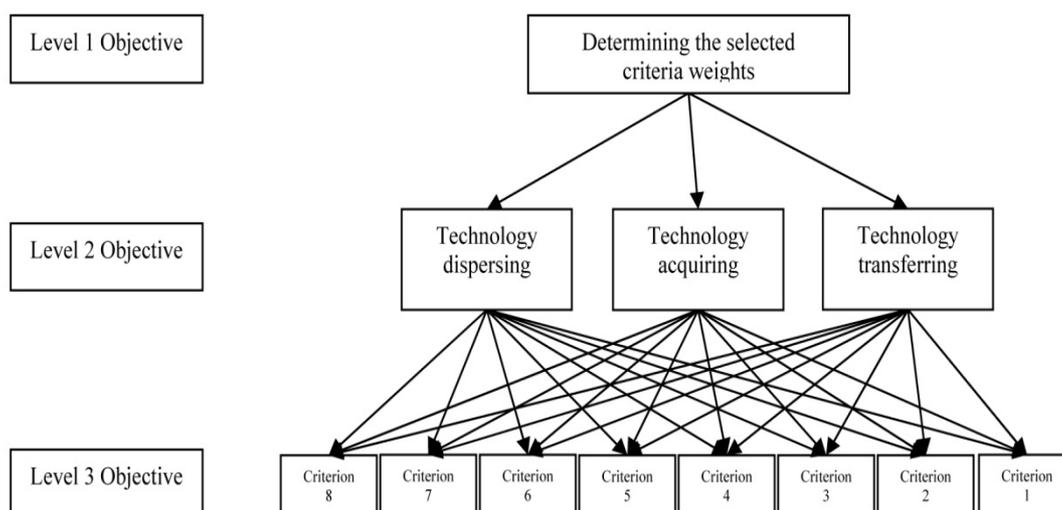
Figare2: Decision hierarchical the for determining the relative importance of choices

Regarding the above tree (Figure 2), Fuzzy hierarchical analysis was performed at the first stage pair comparisons using the third step questionnaire was conducted. It contained four tables: table of indices pair comparison matrix from the viewpoint of decision maker; table of choices pair comparison matrix relative to technology transferring index; table of choices pair comparison matrix relative to technology acquirement index and table of choices pair comparison matrix relative to technology dispersing index.

In the questionnaire, we mean the effective criteria by choices and three main technology management factors are referred to by indices including technology transferring, acquiring and dispersing. The experts were asked to use triangular Fuzzy numbers, because the questionnaire was designed based on Fuzzy hierarchical analysis technique. In this regard, the pair comparison matrix was formed as triangular numbers through applying Saati's 9 element scale. The experts pair comparison of each level's elements relative to those of higher level. From 15 distributed questionnaires, 12 were returned. At the next stage, coefficients of each pair comparisons matrices and coefficients of choices' relative importance were calculated.

information achieved in this stage. Aggregation function of the decision making body is considered as medium function. In this way each choice with the value higher than 3 was accepted and succeeded in screening process.

Table 2: Total evaluation of choices and the selected choices By Fuzzy logic

Choices	Number related to U_i	Scale Symbols	Choices	Number related to U_i	Scale Symbols
Export increase	3	L	Project perfection expenditure	4	M
Technology and technical knowledge transfer	5	H	The country's legal and political conditions	5	H
Economic profit amount	4	M	Applied engineering-technical capability	3	L
Cultural differences	3	L	Product marketing	2	VL
Government support	3	L	Acceptable risk level	5	H
Project time	4	M	Observing environment affairs	3	L
Ownership and dominance	5	H	Benefit of the investment expenditures	2	VL
Entrepreneurship	3	L	-	-	-

At the second step Fuzzy hierarchical analysis process conducted to determine the relative importance (weight) of the selected indices at the first step of operation. In fact the goal of decision making at this stage is to determine each selected criteria's weight relative to evaluation and prioritizing the foreign investment methods, regarding the three main elements of technology transferring, acquiring and dispersing. Figure 2 shows the decision tree of this step.

legal risk level, the country's legal and political limitations, marketing products, technological and technical knowledge transfer, promotion of product quality, exports increase, management and control, observing environmental requirements, human resources training, type and time of repayment of the main capital and investment expenditures, governmental supports (legal, financial, etc.), utilizing domestic engineering and technical capabilities, economic benefits, cultural and international differences in foreign companies' experiences.

At the second stage, Fuzzy technique was applied to recognize the crucial and effective criteria among the 19 effective foreign investment methods prioritizing criteria.

A questionnaire was designed and distributed among experts requiring them to fill tables using S_i scale (table 2 shows data devoted to each lingual variable). This questionnaire called the second step questionnaire and contained two tables including: table of various indices importance degree for evaluation of effective criteria on prioritizing foreign investment methods and table of indices requirements meeting by choices. Using the term choices we mean the above mentioned 19 criteria and by criteria we mean 6 Fuzzy process criteria, i.e. selling price, product quality, reliability, flexibility, time and services.

Table 1: S_i Scale

Lingual Variable	Symbol	Related	S Scale Elements
Outstanding	OU	7	S_7
Very High	VH	6	S_6
High	H	5	S_5
Medium	M	4	S_4
Low	L	3	S_3
Very Low	VL	2	S_2
None	N	1	S_1

Since the number of experts and managers who are familiar with foreign investment affairs in ship making industries is not too much, the questionnaire designed by judgment sampling method distributed among 12 experts from Sadra Co. and Industries and Mines Ministry and finally 10 individuals returned their questionnaires. The collected questionnaires were analyzed. Table 2 shows the
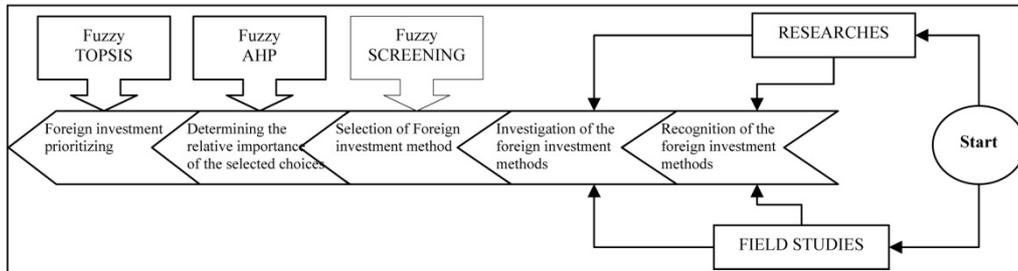
Figure1: The Research Process

4. Research Finding, Case Study; Applying the Suggested Algorithm in Ship Making Industry

Prioritizing and evaluating of foreign investment methods were conducted to test the suggested algorithm using the Fuzzy approach in a step by step way in ship making industry.

At the first step, foreign investment methods and effective criteria on their prioritizing were studied besides a search on papers, books, data bases of documents Iran sea industries association library, Sadra Company, Iran Industries and Mines Ministry and interviews with ship making industry experts on technology transfer through foreign investment; they resulted in 8 foreign investment methods:

- Joint investment;
- Production partnership contract;
- Establishment of subsidiary company with hundred percent foreign ownership;
- Consortium;
- BOT;
- Contract of partnership in benefit;
- License contract;
- Mutual purchase.

Effective criteria on prioritizing the foreign investment methods, project duration, project completion expenditure (required capital), ownership and dominance, entrepreneurship, acceptable financial, trade, executive, political and

$$\begin{cases} \vee (M_1 \geq M_2) = 1 \\ \vee (M_1 \geq M_2) = hgt(M_1 \cap M_2) \end{cases} \qquad (4)$$

Otherwise:

$$hgt(M_1 \cap M_2) = \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)} \qquad (5)$$

Equation (6) gives the magnitude of a triangular Fuzzy number among k other triangular Fuzzy numbers:

$$w_i = \frac{w_i'}{\sum w_i'} \qquad (6)$$

Also, calculation of indices weight in pair comparison matrix is as follow:

$$W'(x_i) = \min\{\vee(S_i \geq S_k)\} \qquad (7)$$

Therefore, indices weight vector is:

$$W' = [w'(x_1), w'(x_2), ..., w'(x_n)]^t \qquad (8)$$

This vector is non-normative coefficient of the Fuzzy hierarchical analysis process. Equation (9) is used to determine the normalized weight values for indices.

$$w_i = \frac{w_i'}{\sum w_i'} \qquad (9)$$

3.4. Step Four

Prioritizing foreign investment methods; at this step, Fuzzy TOPSIS technique applied along with the third step's information (each criterion relative importance) to consider and prioritize foreign investment methods based on selection criteria. Figure 1 shows the procedures of the research with details of the introduced steps.

$$U_i = \underset{j}{M} \{Q(j) \wedge B_{ij}\} \qquad\qquad i = 1,2,...,m \qquad\qquad (2)$$

Where:

B_{ij}: Is the value of Jth good score for i^{th} choice;

$Q(j)$: It reveals that how does the decision maker feel about requirement of at least j experts' support?

$Q(j)$ $8b_{ij}$: It may be considered as weighting of the ith good score for the choice I (B_{ij}) according to the decision maker's opinion.

The max operand plays the role of add in usual numeral averaging method.

3.3. Step Three

Determining the relative importance (weighting) of the first step's selected indexes, using Fuzzy hierarchical analysis technique.

At this step, the relative importance (weight) of each index is determined in comparison with the previous step using the Fuzzy hierarchical analysis process. In the suggested technique the extent analysis method is applied. The technique's procedure is as follows: (Momeni, 2006)

- First stage: Drawing the decision making hierarch tree;
- Second stage: Pair comparisons for which triangular Fuzzy numbers are used in developing analysis methods. Pair comparisons matrix may be formed as triangular numbers using a 1 to 9 Saati Scale. At this stage, the decision maker explains his/her preferences by pair comparisons of elements at each level relative to elements of higher levels in a Fuzzy method.
- Third stage: Calculating which is as equation (3) for each raw of the pair comparison matrix. This leads to value S_k which is a triangular Fuzzy number.

$$S_k = \sum_{j=1}^{n} M_{kj} \times \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1} \qquad (3)$$

Where:

K is representative of row number and I and j indices. After calculating $S_k{}^s$, their magnitude rank must be achieved relative to each others. Generally, if M_1 and M_2 are two triangular Fuzzy numbers, their magnitude ranges are defined as follow:

If $M_1 \geq M_2$

approach. This process consists of two steps. At the first step the experts were asked to provide their evaluation from each choice besides weighting various criteria. This evaluation includes ranking the choices based on various criteria, (Azar and Faraji, 2002) i.e. they were asked to state their opinions about the effect of each choice on satisfying various criteria. This evaluation of criteria satisfaction in the framework of a seven- choice scale(S_i) containing values from Very High to Very Low (Outstanding: S_7; Very High: S_6; High: S_5; Medium: S_4; Low: S_3 ;Very Low: S_2; None: S_1). At this stage the unit score of each expert (U) is calculated as follow:

$$U_{ik} = \min_{j}\{Neg(I_{kj}) \vee \pi_{IKJ}\} \qquad i=1,2,...,m; k=1,...,r; j=1,2,...,n$$

$$(1)$$

Where:

U_{ik}: The k_{th} expert's unit scores for the i_{th} choice;

I_{ki}: The Jth criterion's importance from the view point of the kth expert;

π_{ijk}: The amount of the jth criterion satisfying by i^{th} choice from the viewpoint of kth expert.

Neg $(S_i)= S7_{i+1}$: Negative value of the ith choice's importance the result of the first screening process step is the experts' unit score for various choices: $\{U_{ik}\}=\{U_{i1}, U_{i2}, ..., U_{ir}\}$

Where:

U_{ik}: The ith choice's unit r is the total number of experts.

At the second step of Fuzzy logic process, the experts' evaluations were considered to achieve a unique evaluation for each choice. Here, an aggregation function (Q) was defined, firstly for the decision making body. This function makes it clear that how many experts' agreement is required for a choice to be accepted and passed screening.

So, for each I (k^{th} expert= 1, 2, …, r), a Q(k) value is provided by decision making body. Q(k) states that if k^{th} expert is satisfied by a choice, how will be its acceptance. Experts' unit evaluation of each choice must be evaluation of each choice must be dissentingly ordered.

Total evaluation of choice I may be calculated as following:

3. Methodology

Evaluating the foreign investment methods is the main problem of the present study to prioritize based on the amount of the effects on transferring, acquiring and dispersing technology. In this regard, firstly the literature, methods and models of evaluating the foreign investment have been studied. These studies show that the qualitative models have been applied in most cases to evaluate and to select foreign investment methods relative to quantitative ones. According to the conducted studies and the goal of this paper foreign investment methods and their selection criteria were recognized. Then evaluation algorithm and foreign investment methods prioritizing were planned using Fuzzy approach to transfer technology. Algorithm for foreign investment methods has four steps as follows:

1. Recognizing foreign investment methods and the effective criteria for their priorizing;
2. Selecting the effective criteria on prioritizing the foreign investment methods;
3. Determining the relative importance (weighting) of the selected criteria;
4. Prioritizing the foreign investment methods.

3.1. Step One

Recognizing foreign investment methods and the effective criteria for their prioritizing: at this stage, foreign investment methods are recognized using library studies and the research literature, and then the effective criteria were determined to prioritize the methods in industry.

3.2. Step Two

Selecting the effective criteria on prioritizing the foreign investment methods: at this stage, the recognized affecting criteria on selecting the effective criteria on prioritizing the foreign investment methods; foreign investment methods prioritizing are screened in order to transferring technology applying the following six criteria: competitiveness, product quality, reliability, flexibility, time and services. The aim of using Fuzzy approach at this stage is the selection of important and effective criteria for the selection of proper foreign investment methods in order to transferring technology in an industry and their precisely consideration. On the other hand, one may distinguish effective and non-effective criteria for prioritizing foreign investment methods of an industry using Fuzzy

(contractual agreements including: license, R&D^4 contracts and exports including: direct and indirect exports). (Foley, 2008) Tain-Jy studied three Taiwanese companies in electronic industry, invested in Europe. The findings revealed that companies in Taiwan prefer entrance method of establishing subsidiary company with perfect ownership over join stock investment. The most important reason for this selection is their tendency to control local responsiveness perfectly. (Tain-Jy, 2008) Elango (2005) studied the effect of industrial units' characteristics industrial units with concentration on human capital prefer acquiring method for achieving the implied knowledge needed to act in local level. On the other hand, the companies concentrated on physical capital select investment in new project. (Elango, 2005)

Main foreign investment methods defined in this research are as follows:

- **Mutual Purchase:** Providing financial resources in cash and non-cash by the investor and capital return as good and service by the investee; (The rule of encouraging and supporting the foreign investment, 2002)

- **Joint Investment:** A sustainable contract based on establishment of a new company through the partners' cooperation (in financial, knowledge and technical affairs), and dividing the probable risks and benefits among parties; (Hilmi and Safa, 2007)

- **Consortium:** Co-operation of some companies to achieve a common goal e.g. anew technology without any share exchange; (Chiesa, 1998)

- **Establishment of Subsidiary Company with Complete Investment:** Establishing subsidiary company by multinational corporations under the home country's regulation; (Abutorabi, 2002)

- **License Contract:** Issuing the license and the right of using or selling a specific good, industrial design or process; (Mirhoseini 2005)

- **Joint Production:** Producing goods by a foreign company and with cooperation of one country and payment of the origin country's share of production and the related taxes after production; (Ebrahimi, 2004)

- **Partnership in Benefit:** Partnership projects benefits based on investor's expenditures; (Kesmati, 2002)

- **BOT:** Assuming the whole responsibility of providing money, operation and utilizing the project for a specified period of time which has been determined for repaying the expenditures, wages and benefits of the contractor. (Mirmohammadi, 1996)

(Ben Youssef, 2007) Aulakh and Kotabe (1997) in their model called organization capability based on organizational theory, suggest that decisions on method selecting are capability centered in which the growth and development of company's capabilities are of greater importance than those of exchange cost. (Donglin and Zhao, 2007)

Mutinelli considered the effective factors on selection of multi-national companies' entrance in three categories including: technological opportunities, company size and international experiences. Pehrsson considered the effects of international strategy on selection of a method for entering into foreign markets, categorized theses methods in two groups from the viewpoint of control: entrance with perfect control (acquiring, new investment with perfect ownership and direct export) and entrance with partnership control (Joint investment, integration, etc). (pehrsson, 2008) Since, internal resources and other investment methods from internal resources are limited; the foreign financial resource method is the best choice to the meet the required money for production and investment which is often conducted in two ways: borrowing and non-borrowing method. (Ghasemi, 2003)

Usually foreign investment methods are divided in two main categories: foreign direct investment in private section and foreign investment in all sections in the framework of civil partnership, mutual purchase, and BOT[3]. Root (1987) classified foreign investment methods in three groups: exports (direct or indirect distributor, direct sub- company or branch), contractual (license, franchise, technical, managerial, service, turnkey, build and joint cooperation contracts) and direct investing. (Fiberg and Lovenf, 2007) Armstrong and Sweeney also classified entrance into foreign countries methods in three categories: exports (direct and indirect), contractual (license and franchise) and direct foreign investments (joins investment and subsidiary company with hundred percent foreign ownership. (Emerson and Gunaruthe 2004)

Kundu suggested another classification in this regard including sharing methods (subsidiary company with perfect ownership and joint investment) and non-sharing methods (managerial service contract and franchise contract. (Ekeledo, 2004) In another research, Pan classified these methods in two groups of sharing methods (establishment of subsidiary company with perfect ownership including: investment in new projects, acquiring and joint stock investment including: partnership with minor, equal and major shares) and non-sharing methods

superior to domestic one and makes it necessary to concentrate on foreign investment in ship making industry. (Pazuki, 2002)

Regarding the importance of ship making industries, acquiring the required information, reliable financial resources and high technology are inevitable. However, finding the ways of foreign investment is another basic discussion.

This paper aims at responding the question of 'how can we evaluate foreign investment methods' based on which to prioritize them according to their effects on transferring, acquiring and dispersing technology. It must be mentioned that the Fuzzy approach has been used in this research because of applying verbal information in analyzing and evaluating foreign investment methods, lack of presenting precise numeral information by the decision makers of the industry and companies and this approaches' high efficiency in changing qualitative information into quantitative ones. We have attempted to recognize and study various foreign investment methods and to apply Fuzzy Multi Criteria Decision Making for prioritizing these methods in ship making industries.

The present research emphasizes on the case requiring nature of such strategic decisions; so that one may not offer worldwide and similar foreign investment methods.

2. Literature Review

Foreign investment means to apply foreign capital in a new or current economic agency through acquiring investment license. (Rowley, 2006) Choosing the proper foreign investment methods is among the most important strategic decisions faced to multinational companies. (Change and Rosenwig, 2001)

Some researchers considered the problem of foreign investment methods and entering into the foreign markets. Johansson and Paul (1975) suggest the SD Model[1] emphasizing that a company selects an entrance method proportionate to its development and growth level, so that the newly established companies acquire methods with less complexity level. (Zhao, 2005) In another study by Anderson and Gatignon (1986) in TCA Model[2] state that the companies use transaction cost as a base of decision making, (Wilkinson, 2002) while deciding about their international activities, e.g. products exchanges in world trade and production. Brouthers (2002) has extended TCA model to theoretical exchanges cost, cultural theory and organizational or fundamental theory and concluded that those companies followed TCA theory had better performance than those didn't have.

1. Introduction

Regarding globalization and global village concept creation, international cooperation is necessary to sustain companies' development and profitability. Developing countries are willing to develop international alliance with developed countries through selecting foreign investment methods; because of various reasons including: shortage of internal financial resources, weakness of private section in meeting long term investments and lack of access to advanced technology. Cooperation between public and private organizations provides developing countries with basic interests. National and international policies consider this cooperation as an appropriate mechanism for transferring and acquiring technical and technological capabilities. (Archibugi, 2003)

In response to the changing world economy, a variety of foreign investment forms have been developed such as joint investment, license contracts, franchise, technical knowledge etc. Selection of proper form is one of the most strategic decisions for companies. Difficulties in world economy competition made the companies decide more precisely in this selection process. (Zehi et al, 2005)

Developing countries have moved toward transferring modern technology in one hand, and foreign investment attracting methods and considering effective factors on attracting foreign financial resources on the other hand; because of financial resources restrictions. Foreign investment and other instruments for providing foreign finance in developing countries are among ever enhancing developing levers and play an essential role in such countries' competition power. (Economy Management, 2004)

Despite of investments in ship making, Iran has not yet an acceptable share among the world ship makers. One of the most important causes is the unfamiliarity with this industry. On the other hand, shortage of domestic financial resources, weakness of private section to meet long term investments, legal restrictions in private section investments and various obstacles in the way of importing required technology have decreased domestic investment possibility and emphasized on foreign investment necessity. Of course, it must be remembered that the foreign investment has a competitive advantage, i.e. having more information about markets, production agents, products and services prices, marketing, skillful management, technical proficiency, production with lower costs, high technology and lastly more financial resources. Foreign investment is

Fuzzy Multi Criteria Decision Making Model for Prioritizing the Investment Methods in Technology Transfer in Shipping Industries

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Abstract

This study aims to identifying and prioritizing various foreign investment methods for technology transferring in ship making industry based on a Fuzzy multi criteria decision making approach. Studying different foreign investment methods and the effective factrs on prioritizing of the methods and using the sample judging, this study considered the viewpoints of managers and experts familiar with foreign investment issues in Iran's ship making industry. The Fuzzy TOPSIS method has been used to analyze the collected data. The results showed that among various foreign investment methods, the joint venture and the subsidiary company are of highest and lowest priorities, respectively

Keywords: Foreign Investment, Technology Transfer, Fuzzy TOPSIS, Multi Criteria Decision Making