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# Identifying and ranking appropriate strategies for effective technology transfer in the automotive industry: Evidence from Iran

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ABSTRACT

The purpose of the present study is developing technology transfer (TT) strategies in the automotive industry by integrating SWOT and AHP models. The statistical population of this research includes experts in technology transfer within the automobile industry, development and renovation organizations, and presidential office of technology. A total of 70 individuals were selected to participate. An open-ended questionnaire was designed for this study to determine the strengths, weaknesses, opportunities and threats (SWOT) in technology transfer in the automobile industry. After analyzing information using the SWOT approach, 6 appropriate strategies were formulated. These strategies were ranked by AHP (analytic hierarchy process) method from first to third. They showed that extending interaction with knowledge-based companies, education and research centers, weighing (0/308), and paying attention to the training of human resources suitable to the required technologies weighing (0/254) and paying attention to environmental issues and sustainable development weighing (0/163).

## 1. Introduction

Throughout the Knowledge Age, the use of new technological innovations is a main need of every country. Developing societies have a need to develop technology to foster creation and competition. One of the methods to access technology is technology transfer from advanced countries, but through this process certain aspects of the technology can be lost. In cases that technology transfer is not done properly a developing country can receive a collection of machines, maps, catalogs, and instructions but with little guidance or assistance in applying them.

Nowadays, strategic planning is considered by experts and planners as one of the most efficient management approaches in organizations. Comprehensive Planning considers the internal and external limitations of an organization and makes predicts according to them [53]. Transfer and adoption of technology in the developing countries is complicated; Such an endeavor involves not only the developing countries themselves, but also many western research collaborators and international organizations. These different actors bring with them their own scientific approaches, as well as unique cultural, political, and economic dimensions. There is a remarkable gap in the level of technology in developed countries when compared to developing countries. Technology transfer is the best option for reducing the technology gap between advanced and developing countries [3]. Our country, Iran, has lagged behind developed countries for 20–40 years because of arrogance, domination, and neglect in understanding the importance of technology [1].

By accuracy in the record of advancement of the developing countries, it is considered that they reinforce technology foundation of their country by transferring it to other developed countries to accelerate the solution of industry problems, and then, they seek to strengthen academic and research centers by establishing a proper economic infrastructure [2].

Prior to technology transfer in any industry, the contexts and limitations in the areas of hardware (machine tools) and software (technical knowledge, information, and human resources) should be examined. Opportunities, threats, strengths, and weaknesses should be identified and appropriately managed in the various stages of technology transfer. Within Iran, sanctions, banking rules and a lack of competitive environment in the automotive market are the most important factors surrounding the lack of proper technology transfer. Previous studies indicate that despite efforts to effectively transfer technology and reaching acceptable standards in obtaining satisfaction of domestic and persistent customers in the international markets, activists of the industry face with many challenges. Considering the rapid scope of global development and weakening of economic boundaries, it is necessary for managers and experts in the automotive industry to diagnose current problems while providing models that to provide a suitable model so that the possibility of activity of this industry in competitive markets to

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be provided with more extension. Also, according to the widespread approach in recent years in the use of modern technologies in Iran's automotive industry, and the lack of practical and documented research to understand the status quo in this process, the necessity for research in this area is felt strongly. Therefore, the purpose of this paper is to identify and formulate appropriate strategies for effective transfer of technology in the Iranian automotive industry. As this has not been considered in previous research, this gap will be covered in this paper by answer the following questions:

1. What are the automotive industry's strengths, weaknesses, opportunities, and threats for effective transfer of technology?
2. What are the appropriate strategies for effective transfer of technology in the automotive industry?
3. What is the priority of appropriate strategies for effective transfer of technology in the automotive industry?

It is noteworthy that automobile companies currently trying to establish themselves in the global industry are from industrially developing countries. With this in mind, it is not surprising that many countries have made their automotive industry an industry of strategic importance. This paper will address these issues by first examining what it takes to compete in the commercial automotive industry. Then a case study with evidence from Iran is analyzed to determine its technology strategies and transfer approaches to determine how it scores on key success factors.

## 2. Definition and concept of technology

Technology is a set of techniques, skills, methods, and processes that are used to produce goods or provide services, or to achieve goals such as scientific research.

The term technology has been given various definitions by previous literatures. According to Kumar et al. [4] technology consists of two primary components:

1) A physical component which comprises of items such as products, tooling, equipment, blueprints, techniques, and processes; and
2) The informational component which consists of know-how in management, marketing, production, quality control, reliability, skilled labor and functional areas.

An earlier definition by Sahal [5] views technology as 'configuration', observing that the transfer object (the technology) relies on a subjectively determined but specifiable set of processes and products. Current studies on technology transfer have connected technology directly with knowledge, with more attention given to the process of research and development [6]. By scrutinizing the technology definition, there are two basic components that can be identified:

1) 'Knowledge' or technique; and
2) 'Doing things'

Technology is always connected with obtaining a certain result, resolving certain problems, completing certain tasks using particular skills, or employing knowledge and exploiting assets [7]. The concept of technology does not only relate to the technology that is embodied in the product but is also associated with the knowledge or information of its use, application, and the process in developing the product [8,10].

### 2.1. Technology transfer (TT)

#### 2.1.1. Technology transfer definitions

The process of transferring skills, knowledge, technology, and production methods is accomplished by sharing production-samples among governments, universities, and other institutions. This sharing ensures scientific and technical development can be implemented among a wide range of users who can develop and exploit new products, processes, practical plans, material and services [9].

Tidd and Bessant [47] illustrate technology transfer as a point-to-point phenomenon, with an emphasis on the knowledge of how to implement. In other words, the movement of ideas from the laboratory to the market or the movement of technology from one place to another [48]. The literature on technology transfer and international technology transfer is extensive and includes various perspectives from disciplines such as political science, economics, sociology, public policy, marketing, and management of technology [4]. The issues that have been investigated, among others, are technology transfer process, appropriateness of technology, cooperation and conflict between transfer countries, the success of technology transfer, and the social and economic benefits of technology transfer for both suppliers and recipient countries [11,12]. Baranson [13] defines technology transfer as transmission of know-how (knowledge) which enables the recipient enterprise to manufacture a particular product or provide a specific service.

Since the term "technology transfer" provides many dimensions, it has often been used to describe the process by which ideas and concepts are moved from the laboratory to marketplace [14,15], the transfer, knowledge, concept from developed to less technologically developed countries [16,17], and the transfer of inventive activities to secondary users [18].

A majority of the previous studies have defined technology transfer as the transmission or movement of knowledge as a process. A successful technology transfer will eventually lead to a deeper and wider accumulation of knowledge [19].

The technology transfer concept is not only concerned about the transfer of technological knowledge or information but also the technology recipient's capability to learn and absorb technology into functional production [20]. Das [21] argues that technology transfer can be of two types:

1) Production of new product (product or embodied technology transfer); and
2) More efficient production of existing products (process or disembodied technology transfer). Hall and Johnson [22] define technology transfer as a technology system in terms of whether it is embodied in people (person-embodied), things (product-embodied), or processes (process-embodied). Farhang [23] suggests that transfer of technologies with manufacturing processes requires not only the transfer of technological knowledge in the form of process sheets, blueprints, products, and materials specification but also the transfer of know-how of high-caliber engineering and technical personnel.

Management researchers tend to focus on intra-sector transfer and relationships between technology transfer and strategy [24–27]. Most of the literature on management have shifted their focus to alliances among enterprises and how alliances are crucial to the development of technology transfer [28].

#### 2.1.2. Technology transfer channels

Technology transfer takes place through a variety of channels. For instance, through foreign direct investment (FDI) a bundle of technology has been regarded as a main approach for the transfer of advanced foreign technologies to developing countries. In this way, local employees are hired and trained by the foreign firms in their subsidiaries [49,50] Joint venture activity is high in the Iranian automobile industry, as automakers seek to acquire external technological know-how to assist in reducing present technological uncertainties. In practice, FDI in the Iranian automobile industry contributed to several economic successes. In a joint venture, companies pool their technologies and resources in a freshly established company that is characterized by joint ownership.

#### 2.1.3. Technology transfer motivations

Reisman, Motwani, and Kumar [51] explain that each technology transfer transaction takes place due to some motivations on the part of the respective participants. According to Reddy and Zhao [52], the impact of international technology transfer can be divided into transferee perspective and transferor perspective. From the transferor perspective, international technology transfer helps them accrue economic and technological benefits as a supplier. It means they can take advantage of generated exports, tax revenues, employment, accumulated capital, and entrepreneurial skills, and they pointed out both transferor and transferee benefit from cultural and social elements. In addition to personal motivation factors, economic factors exist which include long-term arrangements that feed technology enhancements, vertical and horizontal integration of an industry, process and product innovation improvements.

### 2.2. Features of suitable technology

The evaluation and selection of technology is considered as one of the important activities of technology transfer. Sometimes inappropriate technology selection has irreparable consequences.

In one of his lectures, Professor Abdul Salam stated: "In Egypt, 3 million dollars were spent on building a factory to produce thermionic lamps". The factory was established in the same year when more complete transistors were built and widely distributed to the world market. Consequently, foreign advisers recommended the establishment of such a factory, but the officials, who were responsible for implementation of this recommendation, were not aware of this knowledge as they had accepted it without consulting with their country's qualified physicians. The most appropriate lifetime of technology for transfer is the introduction and development period of that technology. The period in which the risk of research has passed and enough time is available for economic utilization of it [29]. The complexity of the transferred technology should be at the level of technical and economic capacity of the technology applicant, or one step beyond to make technology absorption possible [46].

The pace of technology changes must be appropriate to the environment that needs technology so that the technology can be continued and developed and accompanying technologic changes in the world can happen [30].

### 2.3. Success factors of technology transfer to developing countries

Sung et al. [40] identified factors influencing technology transfer and examined the role of these identified factors on success of technology transfer in Korean IT industry. Results showed 'Concreteness of Technology' as the most influential factor for technology transfer. Lee et al. [41] investigated the priority factors for the transfer of technology through AHP methodology and correlation analysis. Results suggested that emerging technology and bargaining power dimensions should be considered decision-making process towards successful implementation of TT processes by business organizations.

Malik and Hattasinghe [42] identified and analyzed the main human resource barriers to technology transfer by looking into case studies of sixteen multinational corporations' subsidiaries in Thailand. Findings suggested that the lack of basic skill sets and techniques were a key barrier to technology transfer. Human skills and knowledge of technologies will help them absorb more complex knowledge whilst participating in technology transfer projects. Jung et al. [43] identified the factors leading to success and failure in technology commercialization in public R&D in Korea. They also investigated the barriers to various stages of technology commercialization. Results suggested that 'marketing capability' and 'cooperation with developer' were the most critical factors between technology commercialization successes and failures. Additionally, 'insufficiency of funds', 'deterioration of market condition' and 'insufficiency of marketing capabilities' were reported as the top barriers to technology commercialization.

Leischnig et al. [44] empirically explored the role of alliance management capability, organizational compatibility, and interaction quality in inter-organizational technology transfer. Results showed linkages between important antecedents and consequences of interaction quality to understand the inter-organizational technology transfer process successes.

Generally, developing countries can acquire valuable lessons from successful experiences of previously industrialized and newly industrialized countries (especially those in East Asia and Latin America) in technology and industry development areas. Successful experience from these countries has shown that widespread acquisition and transfer of suitable and modern technologies enables them to increase their productivity, and consequently result in rapid industrial development. For instance, countries such as South Korea, Taiwan, Brazil, and Mexico are considered as newly industrialized countries in East Asia and Latin America largely through the import and transfer of foreign technology [45]. The success factors of these countries can be divided into internal and external factors. Within these countries, national resolve for the development of technology is at the forefront of all plans and actions, with the necessary substrates and structures having been put in place to achieve this. Additionally, western investors and international companies have been eager to cooperate with each other and invest in these developing countries due to saturated, competitive markets and lack of growth opportunities in their own developed countries. Although these countries can be distinguished from others due to unique features and macroeconomic indicators such as per capita income, finding patterns of economic volume, primary resources, and industrialization processes can be very useful for other countries that seek to follow a similar pattern of industrial development success. Some of most important factors in successful transfer of technology to newly industrialized countries included [31]:

- Efficient and effective management
- Close cooperation between research centers and industries
- Attention to research and development activities
- Availability of sufficient market
- Good potentiality and absorption capacity of the receiver-country
- Effective support of government
- Tendency of transferor and receiver of the technology
- Export Development Policy

### 2.4. Technology transfer in automotive industry

The current automotive industry is extensively integrated into global production networks with high levels of foreign ownership. It produces high-quality vehicles and components for both domestic and export markets. This level of development has naturally required large scale transfers of technology, necessitating the industry develop a reasonably high level of technological capability, especially with regard to process development. However, the Iranian automotive sector remains highly dependent on imported technology due to low levels of domestic R&D and limited links to the domestic science and technology establishment. In this sense the sector differs considerably from other sectors of Iranian manufacturing, where domestic firms play a bigger role and there are higher levels of domestic R&D.

The experience has been mixed and has important implications for industry policy in emerging markets, especially in countries that are at the early stage of automotive industry development. The role of national automotive policy and broader national economic policies are important because they have an impact on the structure of the industry, and in turn on the mode of technology transfer. For a significant part of its history the industry has been highly protected. Nearly all vehicles sold in Iran are locally assembled.

The automotive industry currently plays a significant role in the economic development of countries around the world, and predictably

many developing nations, including Iran, have made substantial efforts to employ efficient models for successful technology transfer. Unfortunately, numerous studies on this topic show these developing countries have faced many challenges implementing these models due to inadequate related infrastructure, particularly managerial performance. Therefore, it is of great importance for the managers in the field of automotive industry in particular and the other industries in general to carefully assess the present state and to develop a managerial model to evaluate the readiness of the industry for successful transfer of necessary technologies that will ultimately facilitate the growth of this industry in the competitive markers.

Of the research completed on technology transfer within the automotive industry, the following examples are some of the most noteworthy.

Akbarpour and Abdi [32], in an article entitled "Techniques for Technology Transfer in Iran's Automotive Industry" stated that in the age of knowledge and change, applying technological and modern innovations is one of the main needs of each country. Developing societies need to develop technology to both create value and foster competition. The effectiveness of foreign investment in the proper transfer of technology in all industries, especially automobile and components manufacturing industry as a leading industry in developing countries has been quite tangible.

In an article entitled "A Model for an Effective Technology Transfer to Iranian Automotive Industry", Jafari, and Samiei Nasr [33], stated that currently the automotive industry can be considered a mirror that reflects the economic development of country and plays a significant role in moving the economic wheels of the country. But both previous and present studies show that despite efforts to achieve effective technology transfer, reach acceptable standards of satisfying local customers, and have a stable presence in international markets, the activists of this industry face various challenges. Given the rapid pace of global development and the weakening of economic boundaries, it is necessary for managers and experts in the automotive industry to address the current situation, to present a suitable model so that the industry can operate in competitive markets with ever expanding scope.

Zargar and Gharayi [34], in an article entitled "Identifying and Prioritizing Main Barriers to Technology Transfer in Iran's Automotive Industry" stated that technology transfer is one of the most important issues for a nation's political and managerial class. These stakeholders include government policymakers, international investment firms, and business managers as there is a close relationship between the economic growth of the country and technology transfer. Despite all of this attention, studies that focus on issues related to the technological development of the automotive industry of the country show that, unfortunately, the process of technology transfer in the automotive industry faces barriers in several areas.

Fattahi [35], in an article entitled "The Study of The Effectiveness of Technology Transfer in Iran's Automotive Industry Based on David's Model " stated that the reason for the inefficiency of transferred technologies is a lack of attention to localization and lack of recognition of the technology's capacity, and that importers should adjust their technology or processes considering the industry.

In an article entitled "Technology management in Indian automobile industry- Hero Honda experience", Sushil [31] stated that as strategies will determine the type of selected technology, considering the strategies that lead to the growth of industry should be addressed in the technology transfer.

In an article entitled "Technology Transfer in Chinese Automobile Industry" Qiu [37] stated that industry policies have a direct impact on how technology is transferred, so the policies that seek to achieve industry development should be selected and through this it is possible to transfer technologies that are modern and updated. Husain and Sushil [54] stated in an article entitled "Active transfer of technology in the automobile industry", paying attention to innovation and R & D has led to the demand for modern technologies and, in addition, the automotive industry as an environmental polluter should consider sustainable development when considering technology transfers.

It is obvious that without managerial evaluation of the receiving country's or company's readiness that technology transfer will result in not only unsuccessful implementation but may also result in wasted time and resources and leave those in the industry disappointed. Unfortunately, experience has shown that due to the failure of technology importers' to account for this determining factor, even those technologies that have been carefully evaluated and selected are sometimes not successfully transferred. Without careful assessment of readiness importers face numerous problems in both the development and the exploitation of the purchased technology. Therefore, due to the rapidly evolving nature of the world automotive industry and its related technologies, the Iranian automotive industry must both constantly employ effective strategic management for technology transfer as well as constantly evaluate and improve its readiness for applying newly transferred technologies.

### *2.5. Competing in the automotive manufacturing industry*

The automobile market is oligopolistic. An oligopolistic market implies that the industry is dominated by a small number of carmakers. Such a market is unique because the business action of one car manufacturer significantly influences the operations of the other players. Statistics published in 2013 by the carmakers association OICA show that the top 10 global carmakers controlled more than 70% of the world's automobile market. The financial operations of the players in this industry are mutually inter-reliant [36]. All the manufacturers use marketing and advertising as crucial tools for competition.

To get insight into the characteristics of the automotive industry we analyzed a range of automotive industry studies, and they provide a good starting point to get insight into the automotive industry. The literature reveals a combination of characteristics that distinguishes commercial automotive manufacturing from many other industries.

1. The production of automobiles requires skilled labor.
2. Automobiles are sold frequently and in large quantities, necessitating high quantity orders. Due to the high value, large amount of money is tied up in production.
3. Selling automobiles requires global sales and after-sales networks, financial packages for customers, and dealing with political processes.
4. Technology has been a key determinant in the industry. Therefore companies competing in this industry will have to be able to develop new and state-of-the-art automobiles, typically requiring large and long-term R&D investments.

## 3. Materials and methods

The target groups of respondents are middle-managers experienced in technology transfer in the automobile industry. These managers work in organizations such as components manufacturing companies, development and renovation organizations, and the presidential office of technology. All have a relationship to technology transfer processes in their positions. A total of 70 people were selected purposefully to determine the appropriate strategies. Accordingly, these individuals were considered the best respondents to evaluate the importance and effectiveness of variables pertaining to the TT process and the outcomes it can potentially generate. The criteria for enter the interview has been at least 10 years of experience in automotive industry and certification of bachelor's degree.

The questionnaire for the study consisted mainly of three parts and included 63 questions in total: 26 questions were used for analysis, 26 were utilized for descriptive analysis, and 11 questions focused on the background of the respondents. To confirm that the data was obtained from a reliable source, the background section contained questions

about the participant's years of work experience and number of TT projects they have been involved with. Definitions were provided for the different TT factors participants were responding on. The questionnaire survey was prepared based on two key indicators. First, by picking out the answer, participants would provide their opinion on the effectiveness and success of a factor in the TT process. Subsequently, the participants would rate the impact of this factor on the TT process. The choices on the questionnaire were designed on a seven-point Likert scale, ranging from "too high'' to "too low'' in the first part, while the impact assessment of the answer ranges from "strongly positive'' to "strongly negative''. Moreover, they enabled causal links between variables to be established. (Too high = 7, very high = 6, high = 5, intermediate = 4, low = 3, very low = 2, too low = 1).

Data screening is a vital precaution before proceeding with analysis to ensure that the data accurately reflects the responses of study participants. This screening is undertaken to check if some of the data is missing and if there is a pattern to the missing data, and in addition, to look for extreme responses present in the data set that may distort the understanding under study. Moreover, it is done to ensure that multivariate assumptions are met, and to decide what to do if there are violations. Determining the experience of process participants was critical for ensuring the validity of the results. The greater the respondent's automotive industry experience means a greater understanding of process, outcomes, and influences. Respondents were asked to detail the number of processes they had been involved with where TT was incorporated. Almost 65% of the questionnaire participants had been involved with at least three past processes involving TT. 1.5% of the sample had been involved in more than seven TT processes. These provide a good basis for evaluating the importance and success of individual TT processes and outcome variables. Obviously, the analysis determined that the experience of respondents and the number of past TT processes they were involved in were to some extent related.

Most participants with experience on one-to-three TT processes had between six-and-ten years of experience. Respondents with experience on more than three TT processes generally had more than ten years of experience.

Input sources for the SWOT analysis are:

**Strengths:** Government support from industry/Knowledge-based and technology-based management/Access to advanced equipment and technical tools/Development of technological capabilities/Proper enterprise infrastructure/Positive outlook of the industry.

**Weaknesses:** Belonging large part of the industry to government/Lack of real attention to innovation and R&D/Lack of technologies localization/Weakness in the training of expert human resources/Absence of qualified technology infrastructure/Weakness in earning profit on technologic investments.

**Opportunities:** Technology absorption capacity/Participation in technology transfer projects/Desire and ability of the transferor and receiver of technology/Government policy on export development/Weak culture in paying attention to modern technologies/Political relations.

**Threats:** International sanctions/Exchange rate fluctuations/Technology transfer process/Lack of financial resources/Starting effective cooperation between research and industry centers/Enough access to markets.

A semi-structured questionnaire, designed for determining the strengths, weaknesses, opportunities, and threats (SWOT) in technology transfer in automobile industry was utilized. The importance of each of these situations was then specified through weighing by experts to help assess the status of automotive industry within the strategic planning matrix according to the matrix analysis of evaluation of the internal and external factors. After analyzing information using the SWOT approach, six appropriate strategies were formulated. Finally, identified strategies were prioritized in terms of their importance using analytic hierarchy process (AHP) technique.

The SWOT analysis consisted of three phases

1. Selection of analytical parameters;
2. Data collection; and
3. Analysis and reporting.

### 3.1. SWOT technique

As a systematic method, SWOT analysis can help us to identify the internal and external environment, the advantages and disadvantages of the industry, and opportunities and threats to provide a basis for developing an industrial development strategy.

### 3.2. AHP technique

The AHP technique compares alternatives/criteria with reference to specified criterion, in pairwise manner and resulting final comparison matrix may be utilized to evaluate rank of alternatives to help in decision making process. It has following three steps [56–59]:

- Establish structure (hierarchical in nature) with decision elements;
- Construct pairwise comparison matrices
- Calculate the consistency using Equation (1) and Equation (2).

$$CI = (\lambda max - n)/(n-1) \quad (1)$$

$$CR = CI/RI \quad (2)$$

The value of RI depends upon the size matrix Saaty [60]. (see Table 1)

Consistency ratio range (acceptable) varies as per the matrix size i.e. 0.05 for 3*3matrix, 0.08 for 4*4 matrix and 0.1 for higher order matrices.

Based on the ratings obtained through expert's inputs, matrices are formulated and subsequent calculations for obtaining priorities are done using the methodology of AHP.

### 3.3. SWOT & AHP techniques

Due to the broad application of a SWOT analysis this method encounters several restrictions, including the inability to apply certain ranking criteria to strategies. Thus, one challenge of the SWOT analysis is measuring how to rank the determined strategies and factors.

The Analytic Hierarchy Process (AHP) is a hierarchical weighted decision analysis method. It is the most widely used multiple attribute decision-making (MADM) method and combines qualitative analysis with quantitative analysis [57,61]. The AHP procedures are defined as follows:

* Hierarchy structure is defined in such a way that the goal is placed at the top of hierarchy, and the criteria and strategies taken from SWOT analysis are placed in descending order.
* Comparisons between each factor at each level are made to determine which is more important.
* The global priorities of criteria, sub-criteria and alternatives are synthesized to identify using the eigenvalue method (EM). The EM is the solution of the eigenvalue problem: Equation (3)

$$Aw = \lambda max\ w \quad (3)$$

Where λmax is the largest or principle eigenvalue of the pairwise

**Table 1**
Random index.

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 |

comparison matrix and w is the corresponding principle eigenvector. The CR (Consistency Ratio) of matrix A is used to check judgment inconsistencies. CR=CI/RI, where CI= (λmax − n)/(n−1) and λmax is the maximal eigenvalue of A. RI (Random Index) is an experimental value which depends on n [57].

AHP, as an effective decision-making tool, is combined with other MADM methods to solve many complex decision-making problems. In some studies, AHP was combined with the SWOT analysis to optimize and evaluate program strategies [62–65]. (see Fig. 1)

## 4. Findings

Using the SWOT technique, we identified and determined the strengths, weaknesses, opportunities, and threats that existed in formulating technology transfer strategies in the automotive industry that is described as below: (see Table 2 and 3).

In this stage, the most important strengths, weaknesses, opportunities, and threats, extracted from the population by the questionnaire and interview were weighted by the experts. The results are described below: (see Table 4)

According to Table 2, the most important weaknesses in technology transfer are respectively equal to: The lack of real attention to Innovation, Research, and Development with a score of (0.36) as well as lack of technologies localization with a score of (0.36). Also, the most important strengths of technology transfer in this industry are knowledge-based and technology-based management, access to advanced equipment and technical tools, the positive outlook of the industry, and development of technological capabilities that is equal to (0.36) and the most important in terms of experts. In the evaluation matrix, if the exponential score is more than 2.5, (average of 1 and 4) the strengths are more than weaknesses and vice versa. In this matrix, as seen, the final score is more than 2.5, which indicates the strengths of the industry to formulate appropriate technology transfer strategies. In the following we will investigate opportunities and threats. (see Table 5).

According to Table 5, the most important opportunities for technology transfer are technology absorption capacity, attendance in technology transfer projects, the desire and ability of the technology transmitter and receiver to access the market, with a score of (0.36) respectively. The most important threats are: international sanctions, technology transfer process and a weak culture in awareness of modern technologies with a score of (0.36). In the external factor evaluation matrix, if the final score is greater than 2.5 (average of 1 and 4), opportunities are more than threatening and vice versa. In this matrix, as seen the final score is more than 2.5, so the country's automotive industry has many opportunities to formulate strategies for technology transfer. As seen in below diagram, the graph is skewed toward the opportunity and strength points of aggressive status that strategic planning is needed to use strengths and opportunities (see ).(see Diagram 1) (see Fig. 2).

**Table 2**
Results of SWOT matrix analysis -weaknesses and strengths.

| Strengths | Weaknesses |
|---|---|
| S1: Government support from industry | W1: Belonging large part of the industry to government |
| S2: Knowledge-based and technology based management | W2: The lack of real attention to innovation and R&D |
| S3: Access to advanced equipment and technical tools | W3: Lack of technologies localization |
| S4: The development of technological capabilities | W4: Weakness in the training of expert human resources |
| S5: Proper enterprise infrastructure | W5: Absence of qualified technology infrastructure |
| S6: The positive outlook of the industry | W6: Weakness in earning profit on technologic investments |

**Table 3**
Results of SWOT matrix analysis -opportunities and threats.

| Opportunities | Threats |
|---|---|
| O1: Technology absorption capacity | T1: International sanctions |
| O2: Being in attendance at the technology transfer projects | T2: Exchange rate fluctuations |
| O3: The desire and ability of the transferor and receiver of technology | T3: Technology transfer process |
| O4: The policy of export development by the government | T4: Lack of financial resources |
| O5: Starting effective cooperation between research and industry centers | T5: Weak culture in paying attention to modern technologies |
| O6: Access to market enough | T6: Political relations |

The industry studied in this research is located in Situation 2, strength-based and opportunity-based strategy (i.e., aggressive strategies). In these strategies, the strengths are employed to make more profit of the provided opportunities by the external environment, as well as possible to use latent and potential capabilities of technology transfer in automotive industry. According to findings of the research, aggressive strategies should be formulated tailored to the automotive industry to transfer technology. These strategies are as below: (see Table 6).

In the following, we will survey the importance of each formulated strategy using the AHP method so that officials carry out necessary actions to fulfill the goals of each strategy while considering their priority. In this regard, the formulated strategies are provided for experts to determine the importance of each one relative to another via a paired comparison method. First we make the paired comparison matrix. (see Table 7).

As it is clear, all the diagonal elements of matrix are equal to one because each strategy is compared with itself. Also the elements below the principal diagonal are reverse of the elements above it. After

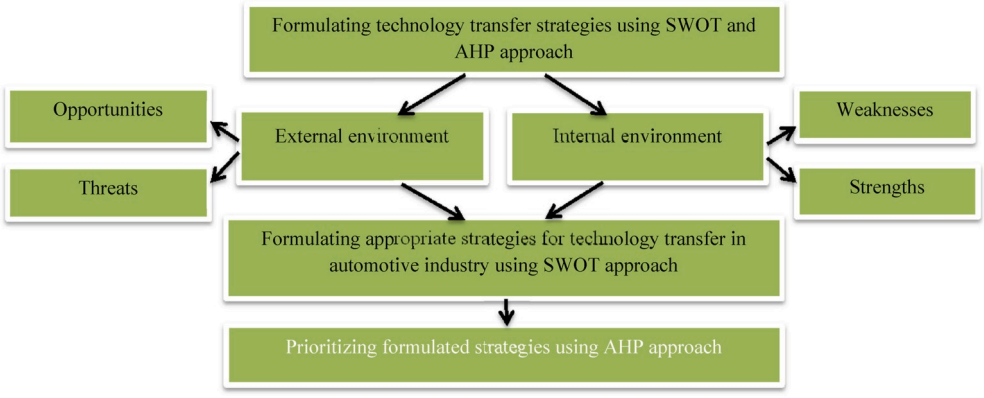


**Fig. 1.** Research process.

**Table 4**
Internal factors evaluation matrix.

| Rank | Strengths | Weight | Ranking | Weight scale |
|---|---|---|---|---|
| S1 | Government support from industry | 0.07 | 2 | 0.14 |
| S2 | Knowledge-based and technology based management | 0.09 | 4 | 0.36 |
| S3 | Access to advanced equipment and technical tools | 0.09 | 4 | 0.36 |
| S4 | The development of technological capabilities | 0.09 | 4 | 0.36 |
| S5 | Proper enterprise infrastructure | 0.08 | 3 | 0.24 |
| S6 | The positive outlook of the industry | 0.09 | 4 | 0.36 |
| | Sum | 0.51 | | 1.82 |
| Rank | Weaknesses | Weight | Ranking | Weight scale |
| W1 | belonging large part of the industry to government | 0.07 | 3 | 0.21 |
| W2 | The lack of real attention to innovation and R&D | 0.09 | 4 | 0.36 |
| W3 | Lack of technologies localization | 0.09 | 4 | 0.36 |
| W4 | Weakness in the training of expert human resources | 0.08 | 3 | 0.24 |
| W5 | absence of qualified technology infrastructure | 0.08 | 3 | 0.24 |
| W6 | Weakness in earning profit on technologic investments | 0.08 | 3 | 0.24 |
| | Sum | 0.49 | | 1.65 |
| | The Sum total | 1 | | 3.47 |

**Table 5**
External factors matrix.

| Rank | Opportunities | Weight | Ranking | Weight scale |
|---|---|---|---|---|
| O1 | Technology absorption capacity | 0.09 | 4 | 36.0 |
| O2 | Being in attendance at the technology transfer projects | 0.09 | 4 | 36.0 |
| O3 | The desire and ability of the transferor and receiver of technology | 0.09 | 4 | 36.0 |
| O4 | The policy of export development by the government | 0.08 | 3 | 24.0 |
| O5 | Starting effective cooperation between research and industry centers | 0.08 | 3 | 24.0 |
| O6 | Access to the market | 0.09 | 4 | 360 |
| | Sum | 0.52 | | 92.1 |
| Rank | Threats | Weight | Ranking | Weight scale |
| T1 | International sanctions | 0.09 | 4 | 36.0 |
| T2 | Exchange rate fluctuations | 0.07 | 2 | 14.0 |
| T3 | Technology transfer process | 0.09 | 4 | 36.0 |
| T4 | Lack of financial resources | 0.07 | 2 | 14.0 |
| T5 | Weak culture in paying attention to modern technologies | 0.09 | 4 | 36.0 |
| T6 | Political relations | 0.07 | 2 | 14.0 |
| | Sum | 0.48 | | .501 |
| | The Sum total | 1 | | 3.42 |

creating paired comparison matrix for strategies, we normalize the elements of paired comparison matrix. To do this, we divide matrix values by the sum of its columns. For instance, for the first column we divide all elements by 2.617. It is better to round up to three decimal places for presentation of the result. After normalization, we compute the mean of each row to calculate the relative weight of each indicator. The calculation results are as follow: (see Table 8).

The inconsistency rate (IR) of paired comparison matrix should be calculated so one may be able to rely on the strategies that affect technology transfer in the automotive industry. So, the steps of calculating the inconsistency rate are as follows. First, we multiply the paired comparison matrix by the relative weights vector (W): (see Table 9).

We divide the elements of weighted sum vector by the relative weights vector. The result vector is called compatibility vector.(see Table 10).

The maximum Eigen value of paired comparison matrix: It calculates by adding up all the numbers of the obtained column, then dividing the result by the count (6) that is equal to 6.365.

### 4.1. Calculating incompatibility index (I.I)

Incompatibility index calculates as bellow:

$$I.I = (\lambda_{max} - n)/(n-1)$$

$$\text{I.I} = (6.365 - 6) / 5 = 0.073$$

### 4.2. Calculating incompatibility rate (I.R)

To calculate the incompatibility rate:

IRI (Incompatibility Random Index) is the amount extracted from the table and it is equal to 1.24 for a matrix with dimension of 6. Finally, incompatibility rate of this matrix is equal to (I.R = 0.059). So, there is (compatibility≤0.1) in paired comparisons because this amount is less than 0.1. Regarding the compatibility in paired matrix, we can rely on the results. (see Table 11).

As seen in the above table, strategies of increasing interaction with knowledge-based companies and educational and research centers, paying attention to human resources training tailored to the required technology, and paying attention to environmental issues and sustainable development are ranked from first to third. They have the greatest impact on the successful transfer of technology in the automotive industry, with the other strategies are ranked in the following ranking according to the above table.

## 5. Results and discussion

Technology transfer may help organizations and supply chains towards innovation of new and better performing products, processes/activities, services, and practices. This leads to increased efficiency and effectiveness, greater market share, and increased profits. However, a need has been felt for transfer of newer technologies in order to compete, and this need for transfer of newer technologies has created a newer niche-market for TT.

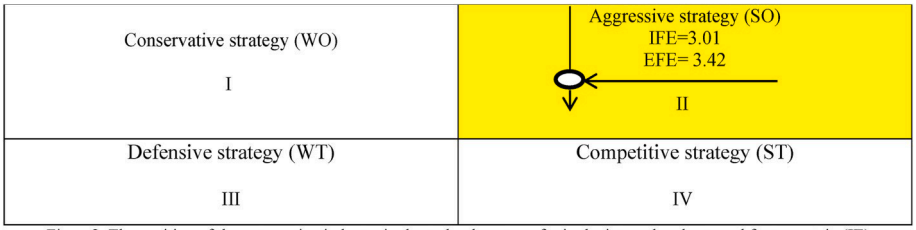

Figure2. The position of the automotive industry in the technology transfer in the internal and external factor matrix (IE)

**Fig. 2.** The position of the automotive industry in the technology transfer in the internal and external factor matrix (IE).

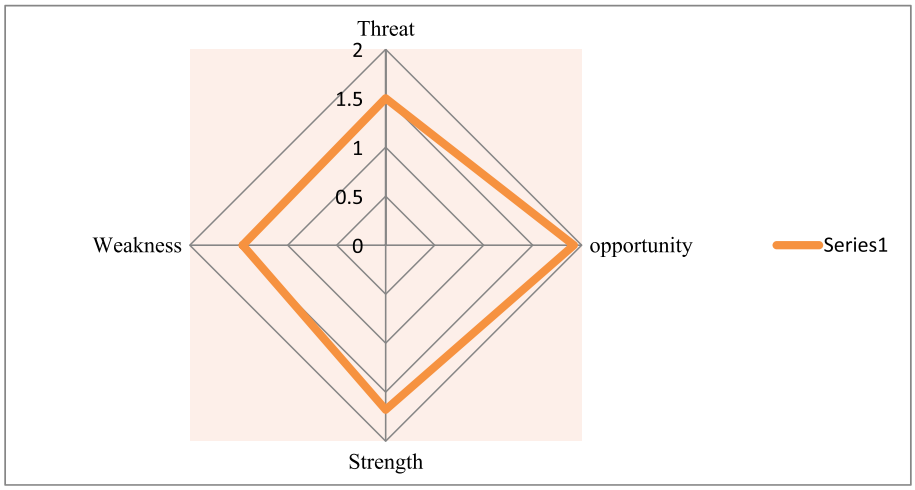


**Diagram 1.** The status of the quadruple factors relative to each other in the SWOT matrix.

**Table 6**
Aggressive strategies for effective transfer of technology in the automotive industry.

| Strengths Opportunities |
|---|
| SO strategies |
| SO1: Increasing interaction with knowledge-based companies and educational and research centers |
| SO2: paying attention to the training of human resources tailored to the required technologies |
| SO3: Paying Attention to environmental issues and sustainable development |
| SO4: Developing strategic relationships with foreign technology exporter companies |
| SO5: Utilizing government support for technology transfer |
| SO6: Paying attention to the localization of technology using reverse engineering |

**Table 7**
Paired comparison matrix of strategies.

| Strategy | SO1 | SO2 | SO3 | SO4 | SO5 | SO6 |
|---|---|---|---|---|---|---|
| SO1 | 1 | 3 | 2 | 3 | 2 | 5 |
| SO2 | .3330 | 1 | 2 | 3 | 2 | 3 |
| SO3 | 0.20 | 0.50 | 1 | 2 | 2 | 3 |
| SO4 | .3330 | 0.333 | .500 | 1 | 3 | 2 |
| SO5 | .500 | .500 | 0.50 | 0.333 | 1 | 3 |
| SO6 | .200 | .3330 | 0.333 | 0.50 | 0.333 | 1 |

**Table 8**
Normalized paired comparison matrix of strategies.

| Strategies | SO1 | SO2 | SO3 | SO4 | SO5 | SO6 | Eigen vector | Rank |
|---|---|---|---|---|---|---|---|---|
| SO1 | 0.390 | 0.529 | 0.316 | 0.305 | 0.194 | 0.295 | 0.338 | First |
| SO2 | 0.130 | 0.177 | 0.316 | 0.305 | 0.194 | 0.176 | 0.216 | Second |
| SO3 | 0.078 | 0.088 | 0.158 | 0.203 | 0.194 | 0.176 | 0.150 | Third |
| SO4 | 0.130 | 0.059 | 0.079 | 0.102 | 0.290 | 0.118 | 0.130 | Fourth |
| SO5 | 0.194 | 0.088 | 0.079 | 0.034 | 0.096 | 0.176 | 0.111 | Fifth |
| SO6 | 0.078 | 0.059 | 0.052 | 0.051 | 0.032 | 0.059 | 0.055 | Sixth |

**Table 9**
Calculation of total weight vector.

| Strategies | SO1 | SO2 | SO3 | SO4 | SO5 | SO6 | Eigen vector | Product |
|---|---|---|---|---|---|---|---|---|
| SO1 | 1 | 3 | 2 | 3 | 2 | 5 | 0.338 | 2.173 |
| SO2 | .3330 | 1 | 2 | 3 | 2 | 3 | 0.216 | 1.406 |
| SO3 | 0.20 | 0.50 | 1 | 2 | 2 | 3 | 0.150 | 0.973 |
| SO4 | 0.333 | 0.333 | .500 | 1 | 3 | 2 | 0.130 | 0.833 |
| SO5 | .500 | 0.50 | 0.50 | 0.333 | 1 | 3 | 0.111 | 0.671 |
| SO6 | .200 | .3330 | 0.333 | 0.50 | .3330 | 1 | 0.055 | 0.347 |

In fact, one increasing TT adoption trend is recognized as one of rationale potential for enhancing business competitiveness in their efforts towards globalization.

**Table 10**
Calculating compatibility vector.

| product | Eigen vector | Quotient |
|---|---|---|
| 2.173 | 0.338 | 6.429 |
| 1.406 | 0.216 | 6.509 |
| 0.973 | 0.150 | 6.487 |
| 0.833 | 0.130 | 6.408 |
| 0.671 | 0.111 | 6.045 |
| 0.347 | 0.055 | 6.309 |

**Table 11**
Ranking of strategies.

| Strategies | Relative weight | Rank |
|---|---|---|
| SO1 | 0.338 | 1 |
| SO2 | 0.216 | 2 |
| SO3 | 0.150 | 3 |
| SO4 | 0.130 | 4 |
| SO5 | 0.111 | 5 |
| SO6 | 0.055 | 6 |

In the current environment that is full of dynamism and change, one of the most important categories that can effectively help us achieve our goals is effective technology changes and technology transfer. Usually, technology is associated with the achievement of important results, solving major problems, completing main tasks using specific skills, applying knowledge, and exploiting assets.

The concept of technology not only relates to the already existing technology in the products but also relates to the knowledge or information about the use, application, and development of products.

Today, the automotive industry has a large part of employment, per capita production, industrial added value in the country (and in the world), and it constitutes a considerable share of gross national income (GNI). Thus, regarding the effective role of this industry in the economic growth of country, it is very important to recognize effective strategies in technology transfer while considering the macro domestic conditions and the micro dimensions of the automotive industry.

Economic development is highly related to technological development. It is therefore not surprising that many developing nations follow explicit strategies to increase their technological competence level. This paper analyzes the strategies of developing countries in a particular technological industry: the automotive industry. While focusing on the case of Iran it is concluded that industrially developing countries are currently stuck in a difficult situation. It is extremely challenging for developing countries to develop a competitive position in this global industry.

## 6. Conclusion

The purpose of this study was to propose a conceptual model for technology transfer that houses several factors. The most significant finding of this study was the need for "development of appropriate strategies of Iranian automotive industry for successful technology transfer."

Today, technology is the golden key needed to compete in the world of business and economic growth organizations and nations. Years ago, people like Joseph Schumpeter need to invest in the use and development of technology rose. Solo new technologies for more efficient ways of doing things to create new aspects and human activities presented. Thus, the possibility of improving the quality of goods and services, increasing productivity, reducing the time needed to launch new products to market, and the satisfaction of human needs is endless. Offering different products and services to market, technological developments, and changes in the way of planning, implementation, monitoring and evaluation of technical change, each considered as an opportunity to increase capability, competitiveness and growth of industry. In this way, technology, implementation and proper enjoyment of it always, is the best field of socio-economic benefits. Today, despite the theories need more than ever before is the possibility of growth and continuous improvement based on the development of technology know [55]. As a successful and appropriate technology, transfer can significantly affect the economic development of a country's technical and financial, as well as an inappropriate technology transfer has a negative impact on the economy and business conditions and the company become away from its competitive advantage. It is important for corporate executives who are looking for technology transfer that all aspects of the organization and be able to create competitive advantage. For this reason, managers need, as well as the factors affecting the transfer of technology and consider it in its decision. This study has helped identify the factors affecting the transfer of technology, which will aid managers in the decisions regarding their organizations technology.

Technology transfer has been recognized as an approach of high utility for gaining competitive advantage over other organizations/supply chains and a recent and relevant research area in developing countries. Developing countries like Iran may benefit from TT, mainly because the recipient countries grasp know-how, expertise, and skills for implementing and operating the technology towards becoming capable of developing newer production capacities. In this study, a task has been attempted to sort, evaluate, and analyze critical factors towards effective technology transfer from an Iranian perspective.

Practical and strategic implications have been provided followed by strategic action plan presented. We believe that this research work may be served as foundation for extending research in area of technology transfer especially in developing countries such as Iran. In this paper, an attempt has been made to rank the critical factors of for effective technology transfer.

This research shows that the automotive industry within Iran has many opportunities, threats, weaknesses, and strengths in the field of technology transfer, and identifying them can help to find appropriate strategies to avoid threats and create opportunities. In this study, it was found that the automotive industry's focus on several technology transfer strategies can help the domestic industry grow-to increase engagement with knowledge-based companies and training centers; to pay attention to technology-related human resources training; and to address environmental issues and sustainable development. The results of this study are consistent with the research results of Tahmasebi and Tavakol [39] on employee education, Zargar and Gharayi [34] and Akbarpour and Abdi [32] on the technology transfer process, Husain and Sushil [54] on environmental requirements, and Fattahi [35] on the localization of technology. The following practical suggestions are presented for explaining the obtained conclusions:

- Evaluate the capabilities of the company in the field as it is important to the process of localization
- Presence of industry experts in contracts formulation and negotiation techniques
- Special attention to the role of the technology transfer center in linking industry and research centers. In addition to the important role that the center plays in technology transfer process, it can create a useful link between industry and university research centers with high efficiency as a connector.
- Training or recruiting expert human force from inside or outside the country.
- Establishing the technology transfer management office in automotive companies and exploiting the proposed model.
- Establishing a Research and Development center joined with technology owners:

In addition to theoretical studies, the center should be equipped with an internal component testing center (without the need to test components in a technology-owned country) and other facilities for localization and product development as one of the important pillars of technical knowledge transfer.

- Determining the management of the technology transfer process by emphasizing the lower part of the model to absorb, adapt, and innovate in imported technologies and providing necessary mechanisms.

In explaining these findings, it can be stated that the technology transfer will be well-realized when the process is well-known and not merely transferred physically or subjected to the country. But it is needed to the first considered technology to be selected according to the conditions of the automotive industry and the need for the type of technology, and then negotiated with the technology supplier, in which specialist and trained human resources play an important role in the process of choosing the right technology. When considering that the automotive industry is an industry harmful to the environment, technologies that are in line with the concept of sustainable development and result in less environmental damages are needed in Iran. This issue, in addition to the efficient transfer of technology, will cause the automotive industry to use technologies according to world standards that are globally accepted but also usable in the country. It can be expected

that this process will improve the performance of the automotive industry if technology is transferred to them.

The results of the present study are consistent with Tahmasebi and Tavakol [39] results in staff training and Akbarpour and Abdi [32] in the process of technology transfer process, Hossein and Sushil [38] in environmental requirements, and Fattahi [35] in technology localization. The following practical suggestions are provided in explaining the results:

- Paying attention to specialized training for technology users or purchasing specialist human resources services from inside or outside the country for assistance with imported technology can play an important role in the efficient and effective use of technology.
- Paying attention to the technology support agreements provided to the country in the automotive industry by the technology importer can create strategic relationships to the supplier and help issues be solved as quickly as possible when a problem arises.
- In the process of technology transfer, environmental experts are required to provide opinions on the technology and then act to enter appropriate recommendations through their reports.

Also, any research in the process faces issues that limit of the results to the automotive industry and the use of questionnaire is one of the most important limitations of the research, and future researchers can provide a practical model for implementing technology transfer in the automotive industry for achieving more results according to the strategies developed and they can use other methods to rank identified strategies that provide comparability with the results of this study, which can be referred to TOPSIS, Everest methods and …

Based on the above discussion on both technology and technology transfer concepts, this review can shed some dynamic ideas for future researchers to further identify, conceptualize, and understand the underlying theories and perspectives which strongly influence concepts of technology transfer. Such understanding is necessary to enable the automotive industry to relate with the practical and empirical aspects of various relevant theories which explain technology transfer concepts. The simple explanation is that different perspectives/theories underlying technology transfer will have different theoretical arguments and insights, research problems, constructs, variables, and measurements.

Future reviews of national policies by the Iran Government might seek to reduce reliance on these generic production incentives while strengthening the institutional infrastructure to promote technology transfer and upgrading in the automotive industry. Especially critical in the Iranian context is the development of a system of training and skills provision which not only dramatically steps up the provision of skills, but ensures that they are appropriate to industry requirements for upgrading.

## CRediT authorship contribution statement

**Zahra Halili:** Writing - original draft.

## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.techsoc.2020.101264.

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