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High-Speed Train Technology Transfer Dynamic System Model

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Abstract. Nowadays Iran's position on the international corridors, the loss of Iran's roads accidents and the emergence of environmental and energy issues, have made the development of transportation in Iran a prerequisite. The purpose of this research is to identify the effective factors on the he high speed train technology transfer and provide t its framework. Data collection has been done with library and field studies. After these stages, from 73 extracted indicators, 54 main indicators were selected by the experts of the rail transportation technology field. According to these indices, the research questionnaire was designed and distributed. Finally, after completion of the questionnaires by 37 experts in the technology transfer field, the collected data were analysed using structural equations and PLS Smart software and the research model was fitted. The 49 indicators were accepted in 3 factors and 8 dimensions for the designed model. Also the results indicate that in the selecting and acquiring technology factor,the technology selection ranked first, the technology acquisition ranked second and technology recognition ranked third and in the Deployment factor, the technology adaptation and localization,the technology absorption and analysis and technology exploitation dimensions were ranked first to third respectively and in the maintaining factor, the technology development and improvement and technology diffusion dimensions ranked first and second respectively.

Keywords: Technology, Technology Transfer, Rail Transportation, High Speed Train.

1. Introduction

Technology transfer is a complex and difficult process. Without analysing and studying carefully, technology transfer will not be useful and it may also weaken national

technology and wasting capital and time. Despite the obstacles and difficulties involved in the complete transfer of a technology from a developed country to a developing country, if this transfer is done based on a systematic technology program, the developing country can get advantages of the technology through the transfer process. Considering the environmental and energy issues, as well as the high death rate of road traffic accidents, many governments started to optimize the use of advanced rail networks and high speed train technology because of the increased demand for transportation. The transportation sector has a major share in the production of pollutants. But the least polluting share belongs to the rail transportation sector. One of the main challenges in the development of rail transportation with modern and advanced technologies is the lack of the necessary technical knowledge and the suitable model for the technology transfer, especially in the field of new high-speed transportation systems. In order to reach less expensive and more efficient routes, Iran needs to develop knowledge and technology in the field of new systems for the efficient rail transportation, especially high-speed rail and trains. One of the problems of Iran in the field of rail transportation is the ineffectiveness of transmitted technology. The most important factor is not to pay attention to the phases of technology transfer and not having the proper patterning of these types of technologies and the lack of suitable use of the technology transfer method. Therefore, the existence of a model for technology transfer in the field of high speed rail transportation could help this issue. So, the main question of the research is:

"What is the technology transfer framework for the high-speed rail transportation?"

2. Literature Review

The technology is all about the knowledge, systems, tools, processes and methods that are used in the production of products or the provision of services.in other words technology is the way to work and the means by which we achieve our goals. NASA defines the technology transfer as a process to use the technology of an organization (country) by which the organization (country) has developed in other organization (country) with other goals.(Khalil, 2000). Step & Widim (2016) note that technology transfer is not a new concept. Many studies indicate that the definition of technology transfer, because of the complexity of the process, is difficult and its definitions vary according to the organization, technology, and technology maturity. Vitamor et al. (1973) considers the technology transfer as the transfer of knowledge, products, or processes from one organization to other ones for business interests. The important thing in technology transfer is that the full and successful transfer of technology is achieved when all the phases of the technology transfer process are completed. Also, attention to the basic activities of each phase is important. Transferring technology in general includes the ability to use and adapt, and in many cases, innovate in the process of equipment or production. Finally, the technology transfer is the exchange of competences and ideas, to enhance existing competencies or to support the industries of developing countries in the design and development of products and processes (Malekifar, 1999). Figure 1 shows the main phases of technology transfer process.

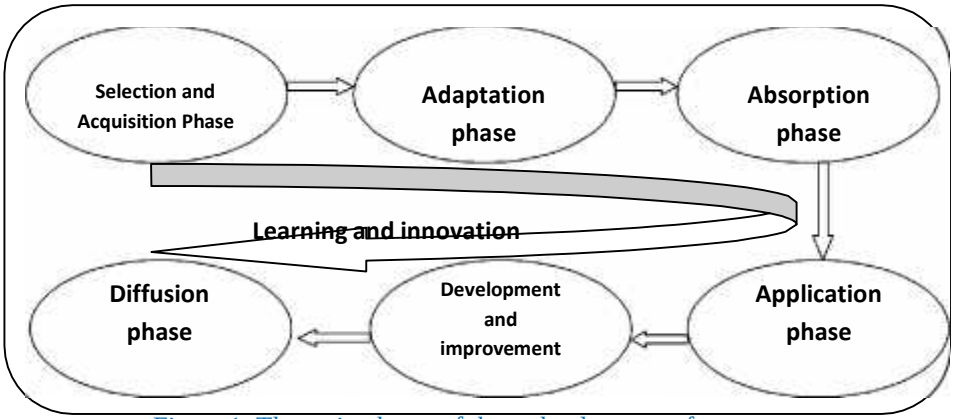

Figure 1: The main phases of the technology transfer process
(Radfar and Khums, 1395)

Kazemi (1395) in his research pointed out that the relationship between types of knowledge and the type of transferable technology and the relationship between maturity and tacit knowledge with the transfer of technology and effective factors in technology transfer play a crucial role in the technology transfer process. In this regard, Joomati, George Momumela (2010), mention that capacity building for sustainable development, increased levels of technology transfer literacy and 12 effective factors including infrastructure, understanding needs, government, science level, participation, needs, criteria, etc are the most effective indicators for the technology transfer. Also, Haji Hosseini et al. (2012) categorize the factors affecting the successful process of technology transfer in the rail industry, such as capacity, hardware and software, labour division, education and skills as the important indicators affecting the transfer of technology in the transportation industries. On the other hand, Mahboodi and Antenne (2013), in their study mentioned the effective technology transfer factors and the relationship between them. they are including knowledge and learning factors, human skills, tools and equipment, and the factors related to organizational technology, cultural factors, structural factors, infrastructural factors, global factors and they conclude that these factors are effective for the technology transfer. Kabiri et al. (2012), in their research, have emphasized the impact of education - technology knowledge and transferring conditions on technology transfer. In this regard, Barry Boseau (2003) has examined the technology transfer process and has been reached to the effective indicators on the successful technology transfer such as the circumstances of the transferor, the transferee and the formal and non-formal transfer channels. Kumar et al. (2015), for the same reason, in their research, note that management, strategic transfer of technology, regulations and rules of technology transfer and R & D activities are the indicators that affect the process of technology transfer. On the other hand, Ayesha (2015), in his study, has pointed to the impact of tacit knowledge and explicit knowledge of the technology on the technology transfer process. Ansari and Zarei (2009) have also done research on the technology transfer process and concluded that the factors affecting the transfer of appropriate technology are maintenance costs, qualification documents, capital returns, and payment method and supply records. Mehdi Zadeh et al. (2010) acknowledge in their research that absorption capacity should be considered as an effective factor in the success of technology transfer. Several factors affect the enhancement of technology absorption capacity, such as human resources, physical capital, and adaptation of imported technologies to goals, values, and facilities of the country. Each of these factors refers to the availability of appropriate infrastructure for incoming technology. Khamseh and Azadi (2011) also referred to the factors such as reforms in organizational research infrastructures, communications, and

the use of research organizations and etc. in absorbing technology successfully, because the reform of the research infrastructure of the organization increases the technological capabilities and helps the transferee to develop technology and produce new products. Also, Umar (2011) has focused on technology absorption capacity in his research. In this research, factors such as employees' ability and motivation as well as employee training in increasing the absorption capacity have the significant effect. The mentioned researchers consider the process of technology transfer as a learning process that has results and benefits. Therefore, managers should expand the company's prior knowledge and learning processes and the organization's absorption capacity in order to maximize the benefits of technology transfer.

3. Method

Since the results of the research are applicable to the transfer of high-speed train and rail transportation technology in Iran, therefore, the research is an applied study and according to the direct relationship between the researcher and the phenomena that is studied, so this study is a field one. Because of the data gathering, the researcher has been in the organizations and data collected by using the questionnaire and interviewing. So, the research is a survey method. This research is for the transfer of high-speed train technology so it is the case study. Reliability of the questionnaire was assessed with using Cronbach's alpha and the Validity of the questionnaires was confirmed by expert judgment. After summarizing the study of literature, in relation to the topic of research and opinion of experts in the field of technology transfer, the researchers have yielded 73 effective indicators on the transmission of high-speed train technology, which 54 indicators were accepted. These indicators were classified as 3 factors and 8 dimensions. The main dimensions identified include: the selection and acquisition of the technology composed of the following dimensions (identifying the required technology -the choice of technology-technology acquisition), and the deployment and implementation composed of the following dimensions (adaptation and technology-absorption and technology analysis-technology utilization) and implementation, Stabilization and maintenance consists of the following dimensions (technology development and technology enhancement and diffusion). Accordingly, the final questionnaire was designed and distributed among 77 experts in the field of technology transfer. Finally, from 77 distributed questionnaires, 73 completed and returned. Then, using structural equations and PLS Smart software, the research model was analysed and fitted.

Findings

To answer this research question, 54 main filtered indexes were obtained. Finally, for validating the research model with Smart PLS, the analysis of the research model was presented as Fig. 2, which represents the initial measurement model with the estimation of the standard coefficients and Figure 3, which represents the correctional model (confirmed model), is shown in the non-standard coefficient estimation (Z value) and all questions with a factor load less than 0.7 are excluded from the research model and indicators whose factor load is close to 0.7 and can be offset by other factor variables, can be kept in the model (Hair, 2006). According to Fig. 2, for the homogeneity of the research model, 5 indicators of our model were eliminated.

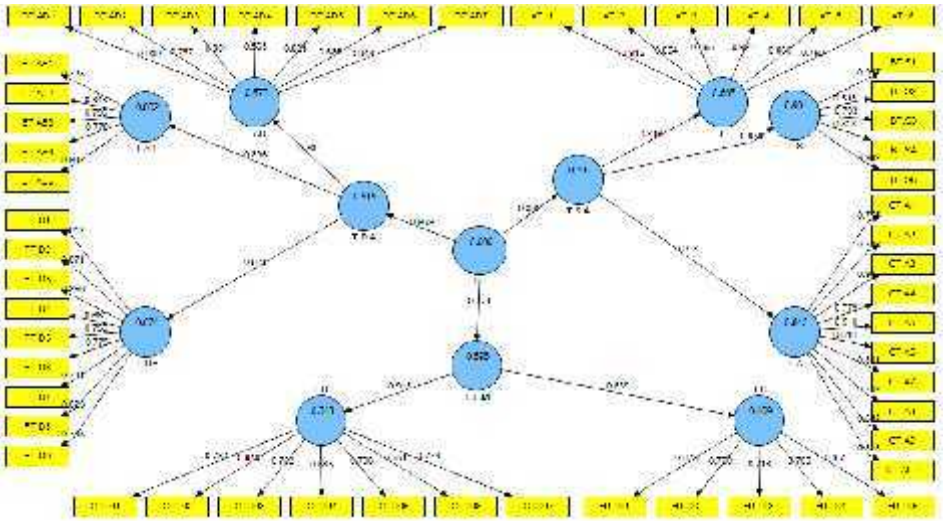

Figure 2: Model of initial structural equation modelling

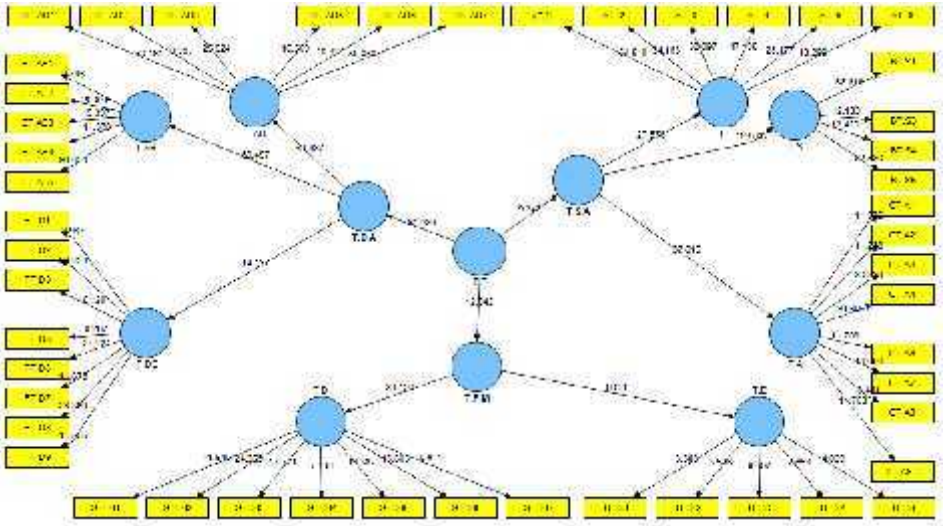

Figure 2: The research model after the fitting together

The results of all tests of reflexive measurement models, structural model and general model are presented in Table 1. Finally, Figure 3 shows the structural model in the estimation of path coefficients and Figure 4 shows the structural model in the significance of the path coefficients.

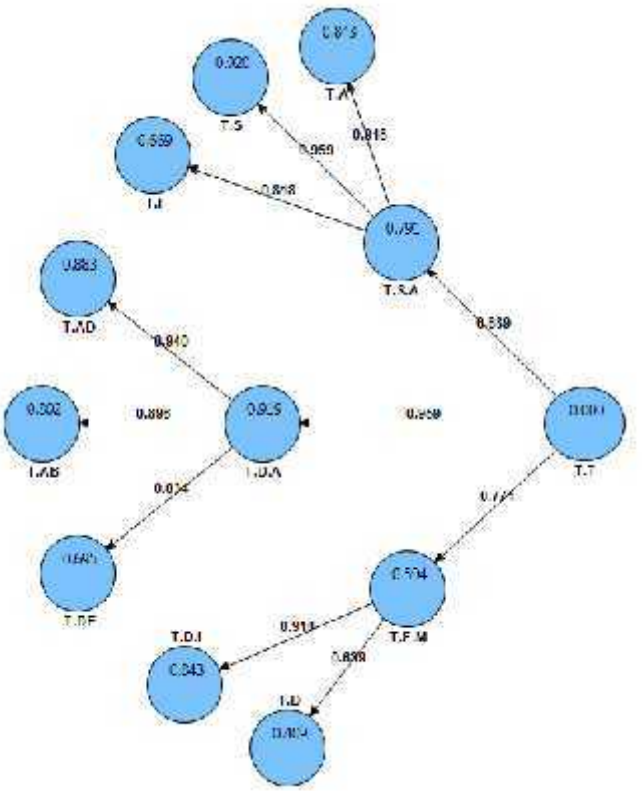

Figure 3: Structural model in estimation of path coefficients (standard)

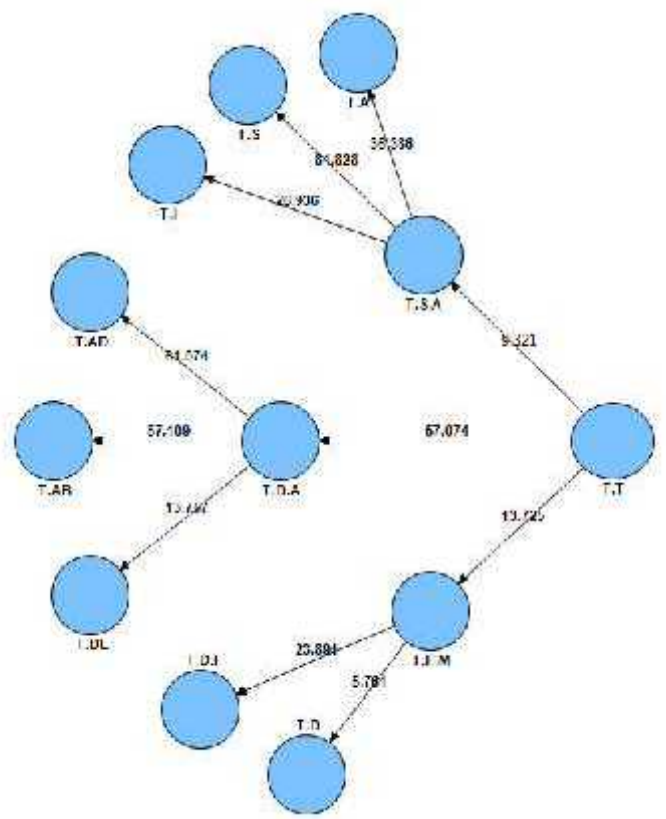

Figure 4: Structural model in the significant state (non-standard)

Table 1: Results of the fitting tests of the research model

Model	Test type			Acceptance criteria	Test result
Reflection Measurement Model Analysis	Homogeneity test			Factor loads of indicators should be greater than 0.7	Excluding 5 indicators with factor load below 0.7
	Reliability Test	Cronbach's alpha		Larger than 0.7	Confirmation for all factors
		Combined reliability		Larger than 0.7	Confirmation for all factors
		Shared reliability		Larger than 0.5	Confirmation for all factors
	Validity test	Convergent Validity	significance	The value of t.value is greater than the absolute value of 1.96	Confirmation for all indicators and factors
			Being homogeneous	All factor loads after fitting should be greater than 0.7	Confirmation for all indices except for the GTD.I4 index, which is close to 0.7 and compensated by adjacent factor loads.
			AVE	Larger than 0.5	Confirmation for

Model	Test type			Acceptance criteria	Test result
					all factors
			CR>AVE	The combined stability value for all factors should be greater than AVE	Confirmation for all factors
		Divergent Validity	Transverse loads test	The factor load of all visible variables on its corresponding hidden variable is at least 0.1	Confirmation for all Indicators
			Fornell Larker Test	square root of the AVE for each factor is more than its correlation with other reflective factors in the model	Confirmation for all factors
			Quality test of the measurement model	Coefficient of variation of the shared index with the three values 0.02 weak, 0.15 average 0.35 strong	The quality of the measurement model is strong for all variables and factors
Structural Model Analysis	Significance Coefficient			The values of t.value for all relationships between ind dependent and ependent variables are greater than the absolute value of 1.96.	Confirmation for relationships all research
	R2 determination coefficient			determination coefficient values: 0.67 strong, 0.33 average, 0.19 weak	For most factors are at strong level except the maintenance and technology diffusion that are at the medium level upward.
	Projection relation Q2			Q2 value with predictive power: Strong 0.35, Medium 0.15, Poor 0.02	For most factors are at strong level except the maintenance and technology diffusion that are at the medium level upward.
General model analysis	GOF			The value of this indicator with three values: Strong 0.35, Medium 0.15, Poor 0.02	GOF = .716 Appropriate fit for the general model is verified

According to the above table, the indicators and factors affecting the transmission of high-speed train technology were shown in Table 2.

Table 2: Indicators and Factors Affecting the Transmission of High Speed Train Technology

row	Factors	Dimensions	Indicators	code	Factor load	r^2	rank
1	Selection and acquisition of technology	Identifying the required technology	The systematic process of	AT.I1	0.9163	0.839	Second
2			Identifying technology holders Identifying technology in	AT.I2	0.8539	0.727	Fifth

row	Factors	Dimensions	Indicators	code	Factor load	r^2	rank
			accordance with national goals, needs and priorities				
3			Prediction and foresight of the	AT.I3	0.8649	0.746	Fourth
4			The analysis of technology required technology	AT.I4	0.9214	0.848	first
5			Attention to business strategies, organizational goals and priorities	AT.I5	0.8662	0.749	third
6			Documentation of knowledge derived from the technology identification phase	AT.I6	0.7496	0.561	sixth
7		Selection of the technology	Contact with holders to visit and receive a proposal for technology transfer	BT.S1	0.9468	0.894	first
8			Assessing the organization's	BT.S3	0.7894	0.622	fourth
9			Review the proposals of technology holders and select the best offer	BT.S4	0.8314	0.690	third
10			Documentation of knowledge derived from the phase of technology selection	BT.S5	0.9287	0.861	second
11		Technology acquisition	Establishing a specialized technology transfer team and organizing it	CT.A1	0.7742	0.599	seventh
12			Use of consultants and technology acquisition	CT.A2	0.8183	0.669	fifth
13			Teaching the negotiating principles and techniques for technology transfer team	CT.A3	0.9029	0.813	first
14			Technology transfer training according to acquisition method	CT.A4	0.7858	0.616	sixth
15			Holding simulation meeting on negotiation of technology transfer	CT.A6	0.8276	0.683	third
16			Contract for technology transfer with technology transfer partner	CT.A7	0.8385	0.702	second
17			Organizational design and reorganization according to the technology to be transferred	CT.A8	0.7378	0.543	Eighth
18			Documentation of knowledge derived from the acquisition phase...	CT.A9.1	0.8276	0.683	fourth
19	Technology implementation and deployment	Adaptation and localization of technology	Establishment of a specialized team for adaptation and localization phase	DT.AD1	0.9481	0.898	second
20			A detailed study of the documents received from the technology provider	DT.AD2	0.7507	0.562	sixth
21			Make the necessary corrections and adaptations in transitional technology	DT.AD3	0.8632	0.744	third
22			Identification of the necessary resources for adaptation and localization within the country	DT.AD5	0.8215	0.674	fourth
23			Detailed design of units, product and ... based on adapted technologies	DT.AD6	0.7787	0.605	fifth
24			Documentation of knowledge from the of adaptation and localization phase	DT.AD7	0.9508	0.902	first
25		Absorbing a the g nd analysin	Determine all the functions of	ET.AB1	0.7252	0.525	fifth
26			Identifying the inputs and transferred technology	ET.AB2	0.8479	0.717	second

row	Factors	Dimensions	Indicators	code	Factor load	r^2	rank
		technology	outputs of each of the transferred technology functions				
27			Analysis of the interaction of various transmitted technology functions	ET.AB3	0.7896	0.622	third
28			Training the transferred technology functions to the executive team	ET.AB4	0.7779	0.603	fourth
29			Documentation of knowledge derived from the absorption and analysis phase	ET.AB5	0.9320	0.868	first
30		The exploitation of technology	Design and implementation of the management systems and structures according to the adapted technology	FT.D1	0.8063	0.649	fourth
31			Provide and train manpower in accordance with transferred technology	FT.D2	0.8904	0.792	first
32			Identifying the supplier's network and evaluating, selecting and organizing the supply chain	FT.D3	0.8621	0.743	second
33			Contract with the appropriate suppliers to supply materials, equipment, maintenance and quality control	FT.D5	0.7367	0.541	seventh
34			Experimental exploitation of adapted transferred technology in a systematic way	FT.D6	0.7927	0.627	fifth
35			Troubleshoot possible bottlenecks	FT.D7	0.7437	0.552	sixth
36			Commercial exploitation of adaptive transferred technology in a systematic way	FT.D8	0.8145	0.662	third
37			Documentation of knowledge derived from the exploitation phase	FT.D9	0.7303	0.532	eighth
38	Consolidation and maintenance	Development and improvement of technology	The existence of an appropriate program to improve transferred technology	GTD.I1	0.7373	0.543	sixth
39			Continuous study of trends and curves of the transferred technology life globally	GTD.I2	0.8402	0.705	first
40			Examine the country and organization's potentials for the transferred technology development	GTD.I3	0.7824	0.611	third
41			Continuous research to improve processes, materials, systems, methods, organization,management, and standards	GTD.I4	0.6849	0.467	seventh
42			Using consultants from universities and other organizations to develop and improve technology	GTD.I5	0.7963	0.633	second
43			Obtaining customer feedback with various techniques to improve the use of transferred technology	GTD.I6	0.7509	0.562	fifth
44			Documentation of knowledge from the development and improvement phase	GTD.I7	0.7741	0.599	fourth
45		Technology diffusion	technology diffusion through public media for audience	HT.DI1	0.8733	0.762	first

row	Factors	Dimensions	Indicators	code	Factor load	r^2	rank
			knowledge				
46			Having specialized exhibitions for the acquaintance of suppliers and contractors	HT.DI2	0.7595	0.576	fourth
47			Release of Transferred and Developed Technology Achievements throughout the Organization	HT.DI3	0.7181	0.515	fifth
48			Transmission the transferred and improved technology achievements to research institutes , universities and supply networks	HT.DI4	0.7647	0.583	third
49			Documentation of knowledge	HT.DI5	0.8574	0.734	second

from the diffusion phase

Considering the extracted indexes from the review of literature and studies, as well as the views of experts in the field of technology transfer of rail transportation industry, and after confirming the model fit, the transfer technology of high-speed train framework was presented as Fig. 5. In this research, by using the previous studies related to the subject of research and also using expert opinions, the above criteria were extracted as the effective variables on the transfer of high-speed train technology. These criteria are divided into three main factors and eight dimensions. In the Selection and acquisition of technology factor, (identifying the required technology, selection of the technology and technology acquisition) dimensions are considered. In Technology implementation and deployment factor (Adaptation and localization of technology, technology Absorbing and analysing and The exploitation of technology) dimensions are considered. In the Consolidation and maintenance factor, (Development and improvement of technology and Technology diffusion) dimensions are considered.

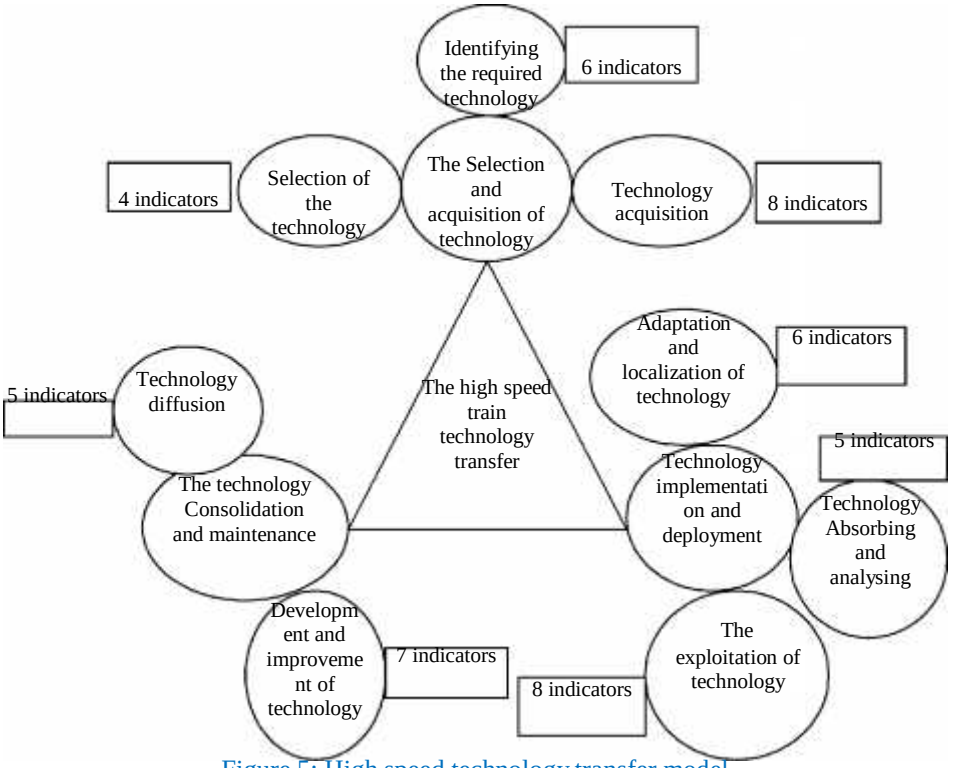

Figure 5: High speed technology transfer model

According to the output of the PLS SMART software, the effective factors are ranked based on the coefficient of determination. Therefore, the ranking of the factors and dimensions affecting the transfer of high-speed train technology is shown in Table 3.

Table 3: Ranking of factors

Factors	ID Code	R^2	rank	dimensions	ID Code	R^2	rank
the technology Selection and acquisition	T.S.A	0.791103	second	identifying the required technology,	T.I	0.669064	third
				selection of the technology	T.S	0.920308	first
				technology acquisition	T.A	0.843076	second
Technology implementation and deployment	T.D.A	0.919031	first	technology Adaptation and localization,	T.AD	0.883786	first
				technology Absorbing and analysing	T.AB	0.802482	second
				The technology exploitation	T.DE	0.695218	third
the Consolidation and maintenance	T.F.M	0.594437	third	Development and improvement	T.D.I	0.843328	first
				Technology diffusion	T.D	0.409594	second

4. Discussion and Conclusion

Iran road accidents death rate and casualties are ranked first in the world, and compared to developed countries, the number of casualties in Iran is much more and it is ten times more than world average, so the proportion of rail transportation accidents to roads is close to zero. In this research, 3 factors, 8 dimensions and 49 final indicators were obtained, the results of the research show that identifying the required technology, technology selection and technology acquisition, technology Adaptation and localization, technology Absorbing and analysing, The exploitation of technology, Development and improvement of technology and Technology diffusion dimensions form the technology Selection and acquisition, Technology implementation and deployment and the Consolidation and maintenance factors and they have the significant effect on the high-speed train and rail transportation technology transfer process in Iran. As a result, among these three factors, the Consolidation and maintenance factor have the most impact on the technology transfer process. Also, according to SMART PLS software outputs, the indicators that have the largest share in the relevance of the variance and the strengthening and prediction of the behaviour of the relevant factors, require more attention. In the identifying the required technology dimension, the technology life curve analysis indicator (AT.I4) has the largest share in explaining the variance of this dimension among other indicators, so focusing on the life-cycle curve of high-speed train technology by managers and decision makers are essential. Also, in the technology selection dimension, contact with the technology holders (BT.S1) has the highest contribution in explaining the variance of this dimension, in order to strengthen this indicator, high-speed train technology owners should be identified and for better decision making and selection, some visits from technology resource holders should be done. In the technology acquisition dimension, the training of the principles and techniques of negotiation for the technology transfer team (CT.A3) has the largest share in explaining this factor. Therefore, it is essential for the technology transfer team and to facilitate the efficient transfer of high-speed train technology, to have general training courses in negotiation principles, and specialized negotiation courses, in accordance with the transfer method and the negotiating characteristics of the transferring country. In the technology adaptation and localization dimension, the documentation of the knowledge derived from the adaptation and localization phase indicator (DT.AD7) has the highest contribution in explaining this factor, and in the technology absorption and analysis dimension, the documentation of knowledge from the technology absorption and analysis phase indicator (ET.AB5) has the highest share in explaining this factor, therefore, it is necessary to prioritize the documentation of the findings of the adaptation and absorption phase according to the knowledge requirements of the adaptation and absorption for the exploitation stages. In the technology exploitation dimension, the important part in this factor is related to the supply and training of the manpower indicator, in accordance with the transferred technology (FT.D2), in this regard, it is required that the manpower is hired with the relevant technology knowledge or the experience and useful work experience (such as repair and maintenance forces and overhauls), and the necessary training should be given according to the documentation of the adaptation, absorption and exploitation phase. In the technology development and improvement dimension, the largest share of the explanation, is for the continuously and globally trend and transferred technology life cycle study indicator (GTD.I2). The focus to this indicator helps high-speed train and rail transportation technologies adapt to advances and have been updated and expanded. Also, in the technology diffusion dimension, the best score is for the technology diffusion through the public media for familiarizing the audience indicator (HTD.I1). Therefore, it was suggested that considering the importance of commercialization of technology, the audience and the community using the high-speed train should be aware of the technology and its benefits.

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