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Research Paper

A System Model for Technological Capabilities Assessment in High-speed Train Industries

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Abstract
The purpose of this study is to provide a model with a dynamic system method to investigate the factors affecting the technological capabilities enhancement in the high-tech industries of high-speed train of the rail transportation system. For this purpose, after reviewing the literature and conducting several meetings with experts in the rail transportation industry, a conceptual and qualitative structure of the subsystems and how they relate in this area were obtained. Then, in order to identify the effective dynamics in upgrading technological capabilities in high-tech industries in high-speed rail transportation, causal loops were drawn and the model was simulated with VENSIM software. Then, using a simulation model, the technology development process was modeled based on the developed structure. Finally, in order to consider the uncertainty space, based on the expert's opinions, two scenarios of optimism and pessimism were considered. Based on the obtained results, variables such as having a suitable vision for technology development, recognizing basic technological priorities, ability to use and control technology effectively in main and support processes, ability to learn from one technology to another, ability to identify, evaluate, negotiate and finalize the terms of technology acquisition and support facilities, the ability to identify customers, announce auction prices and negotiate terms of sale, the ability to plan, monitor and control research and development projects and having a proper system for evaluating technological projects, have great impact.

Keywords *Technological Capability Assessment; High Technology; High Speed Train, Dynamic System*

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Introduction

Technologies play a key role in a firm's success, as they contribute positively to creating value and standing in the market leader position in a competitive environment. (Aloini et all, 2018). Technology and its evaluation has always been a major challenge for business executives. Paying attention to this issue is especially necessary in countries that consume technology more than they create it (Renasi, 2010). One of the important factors in the failure of the technology application to gain a competitive advantage in firms is the lack of awareness and knowledge of the level of technological capabilities of the firm and their use for comparative advantages. The high importance of technology development has led the company's senior managers to identify and evaluate the technological capabilities of their firm and in parallel to identify technological developments in the world and monitor the efforts of competitors to achieve new technologies and to improve the technology capability of the firm. On the other hand, evaluating technological capability is one of the key tools in the field of technology management that uses this tool to identify strengths and improvements to measure the technological gap (Khamseh, Marei, 2020). Today, with the advancement of technology at various levels and also the need to use modern technologies, the need to manage and evaluate technological capabilities is felt more than ever. Technological evaluation is a tool or framework of thought that helps to better understand technology and make decisions about it. Therefore, in order to develop and use new technologies, the current situation should be evaluated and managed by the existing technological capabilities. On the other hand, evaluating and managing technological capabilities is one of the tasks of strategic managers which they do it according to environmental conditions and their capabilities and capabilities, as well as examining the weaknesses of strategies and policies necessary for the growth of the organization and achieve its goals. Also, management and evaluation capabilities of technological capabilities are a valuable decision-making tool in the industrial sector, and evaluation creates a framework in which the physical, human, and information results are placed, so that its benefits are maximized and its effects are minimized. The need for coordinated and integrated development and the achievement of solutions that reach human beings goals in a more limited time and at a lower cost, is itself the reason for the need to develop advanced high-speed train technologies in the world, because it creates structural socio-economic changes that fit The structure of all activities and roles of society and human beings is formed. The structure of the current world without the use of high-speed trains will be incoherent and incomplete. Achieving harmonious development is possible with the use of advanced high-speed train technology. Rapid growth and development of technology in the field of rail transportation in recent decades and predicting the extraordinary development of high technologies in this field are very significant differences in comparison which we have today and the opportunity to transfer technology as the fastest possible way to achieve these technologies for countries like ours has a special sensitivity through which we can partially reach the industrialized countries, so it is necessary to evaluate the technological capability in this field before the technology transfer. In our country, very little attention has been paid to the issue of evaluating technological capabilities in the rail transportation industry, and in this regard, few studies have been conducted. Even if organizations are willing to move in this direction, very few references and resources are available to them. Therefore, the existence of a system model to evaluate the technological capabilities in the rail transportation especially in the high-speed train high technologies can help in this regard. Therefore, this research has been defined to address this need and its results can improve and enhance the current state of technological capabilities in the field of rail transport industry.

Literature Review

Technology capability assessment is a process in which the current level of the organization technological capabilities is measured to identify the strengths and improvements of the organization and also by comparing the technological capabilities of the organization with competitors or the ideal level, the technological gap is identified (Putranto et all, 2003) . According to UNIDO, technology is the application of science in industry, the use of up-to-date knowledge in the production of goods or services using developed and standard methods. Therefore, the most important components of technology include machines, technical equipment, technical knowledge and human skills. On the other hand, technology evaluation and auditing is one of the tasks of strategic managers who does it according to their environmental conditions and capabilities, as well as examining the strengths and weaknesses of strategies and policies necessary to grow the organization and achieve its goals. The evaluation and management of technology in the firm deals with which technology can do a better, cheaper and simpler activity than other technologies in order to create a competitive advantage for the firm and also states that is this technology compatible with the organization's technologies , structure and culture or not? By obtaining the necessary information from the evaluation of technological capabilities, it is possible to make the right policy and planning for the organization's strategy and management of these capabilities, which leads to the proper use of technologies and also it determines important and key technologies of the organization. So that the organization manages them specifically and invests in these technologies and plans for their development (Tabatabayan, 2005). The ability to create innovation and properly evaluate a technology lies in the organizational competencies of a firm. In addition, creativity, culture, understanding of the market and business model are other key elements of an organization's ability to effectively evaluate a technology. (Ganguly et all, 2017). Technology evaluation has been established as a way of proposing procedures for the issues and implications of science, technology and innovation in the European Parliament for more than three decades (Weber et all, 2018). Various models have been introduced to assess technological capability at the enterprise level. Tabatabayan (2005) believes that a suitable model is a model that is simple and understandable and provides acceptable results in a short time. Radfar (2016) have presented the classification according to Table 1 to evaluate the technological capability models.

Table 1

Classification of Technological Capability Assessment Models (Radfar, 2016)

Technology Gap Determination Models	Models for Assessing the Causes of Technology Gaps	Models to Provide Solutions to Bridge the Technology Gap
- Atlas Model of Technology - Porter model - Panda and Ramanassen models - Floyd model - Technology needs management model - Technology content evaluation model - Technology position assessment model - Economic value added model	- Ford model - Lindsay Model - Atlas Model of Technology - Floyd model - Technology needs management model - technology capability levels Model - Panda and Ramanassen model	- Ford model - Lindsay Model - The Fall model - Garcia-Arula Model - Lane Model - Technology needs assessment model - Science and technology management information systems model - Technology needs management model

On the other hand, technological capability in industry includes technical, managerial and institutional skills that enable companies to use technical information and equipment (Lall, 2006) and the need to choose the appropriate technology is its use to ensure the society and the organization interests and its evaluation. Technology is in a human environment and therefore technologies interact with the physical environment and with different systems of the human environment, including the economic system, social system, cultural and political system and other systems that make it up. In other words, different technologies affect Different systems of the human environment around them, and these systems, in turn, have reactions. Therefore, technology evaluation should be done with a general attitude. In examining the advantages and limitations of technology, the criterion should not be only technical effectiveness and economic efficiency. It should be studied in relation to the surrounding human environment. The concept of technology evaluation is to maximize the positive effects and develop the technologies compatible with the environment (Jafarnejad, 2006). Another dimension of the evaluation is addressing the technology capabilities. Technology capabilities are broad concepts that focus on the ability to use technology effectively and the ability to make changes and innovate in technology (Kianwie, 2003). To achieve the technology competitive advantage, it is not enough to look at it only from the perspective of using it as a specialty. Also it is not enough to look at it from the point of view of doing things at an acceptable cost. We need to know more about technology to be able to use its competitive advantage. Technology evaluation is actually a mental framework or tool that the firm can rely on to examine technology in depth and within the framework of its interests and capabilities as well as within the society in which it is located (Brown, 2003).

Reseach Methodology

This research is applied in terms of purpose because its results can be used in the field of high-tech rail transportation in the country. Also, considering the use of the dynamic system method, the research methodology is mathematical modeling method. The research sample includes experts in the field of rail transportation in the country, especially managers and experts in the field of high-speed trains, which their opinions have been used to extract and approve indicators and draw causal loops, and finally its modeling and test. In this research, the dynamic system method with VENSIM software has been used for modeling. The following steps have been taken to extract the research model using the expert's opinions:

Upgrading the technological capabilities in the high-tech industries of the country's rail transportation, and in particular the high-speed train, requires the creation of numerous hardware and software infrastructures. One of the most important capabilities that should be created in this field is strategic capabilities, which include the ability to formulate an effective vision for technology development, strategic planning, the ability to identify and evaluate technological weaknesses, readiness to evaluate technological opportunities. Also, financial capacity for technology development and marketing and sales capabilities (communication and interaction with the market) are quite effective at this stage. Undoubtedly, without the improvement and upgrading of such items, the upgrading of technological capabilities in the High-Tech rail transportation industry will not be achieved, because the main input for identifying the technologies that should be on the agenda will be affected by this item. Increasing strategic capability, by increasing the number of identified technologies that are in line with the vision of technology development, provides the basis for prioritization and effective selection of technology. In the next step, either through technology transfer or through endogenous development, technology acquisition occurs. In this context, selection and acquisition capabilities, R&D capabilities, leadership capabilities as well as operational capabilities are influential. The level of self-selection and acquisition capabilities is affected by recognizing the basic technological priorities, the level of awareness of foreign and domestic technological resources and financial capacity for technology development. The research and development capabilities rate is also affected by cooperation with research and academic centers in the implementation of important technological projects, the ability to plan, monitor and control research and development projects, the ability to reconstruct or rebuild purchased technology and the ability to adapt to purchased technology or created one. Leadership capabilities are also affected by having a suitable system for evaluating technological projects, financial capability for technology development, marketing and sales capabilities, networking and information support capabilities, planning capability, monitoring and coordination of sourcing processes, cooperation with research and university centers in the implementation of important technological projects and the ability to plan, monitor and control research and development projects. The next step is to localize the acquired high-speed train technologies. In this regard, the operational capabilities rate, the learning and innovation capabilities rate and the research and development capabilities rate are effective. The Learning and innovation capabilities are also affected by the ability to learn from one technology to another, the ability to improve existing products and processes, the research and development capabilities rate, and the financial capacity for technology development. The learning and innovation capabilities rate is also affected by the ability to plan, monitor and control the design and engineering activities of the contracts, the ability to effectively use and control technology in core and support processes, and the learning and innovation capabilities rate. Finally, the technology marketing and sales capabilities by finalizing the process of identifying, acquiring and localizing technology, generates revenue from the technologies used by high-speed train, which leads to an increase in financial capacity for technology development. It is noteworthy that this capability is frequently effective in the process described above. The marketing and sales capabilities rate is also affected by the ability to identify customers, announce auction prices and negotiate about the sales conditions. Also it is affected by the ability to identify, evaluate, negotiate and finalize the terms of technology acquisition and support facilities, and the strategic capabilities rate.

Findings

The following figures shows the items affecting the promotion of technological capabilities in the high-tech industries at high-speed rail transportation field.

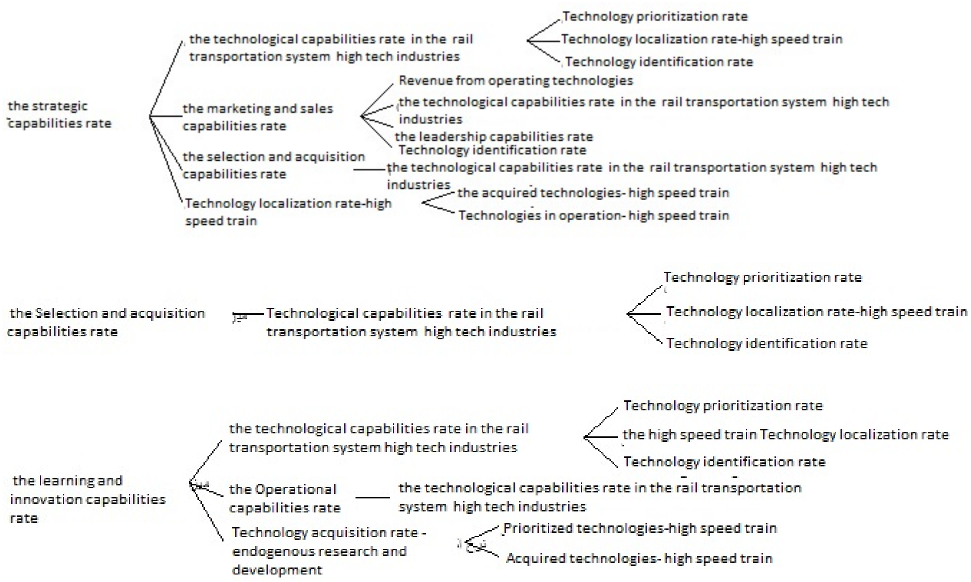
Figure 1

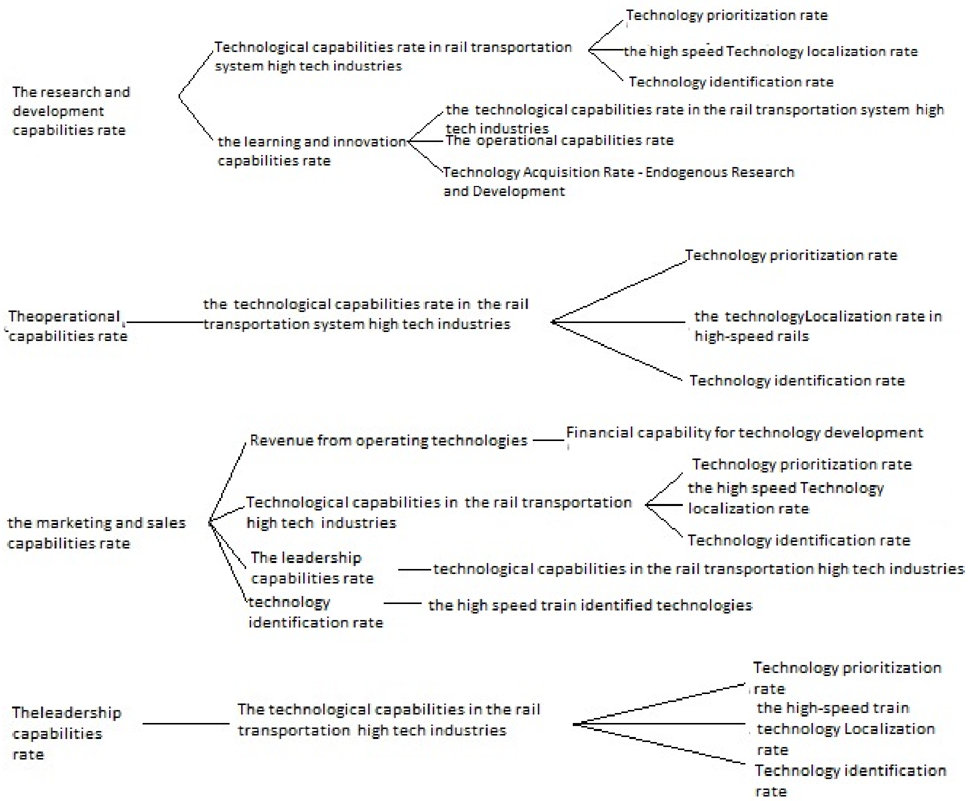
Effective Ffactors on the Technological Capabilities Enhancement

Figure 2 shows how the capabilities mentioned in Figure 1 affect each other and on the process of technology development. Also as in the previous figure, how they create the technological capabilities in the rail transportation system high-tech industries.

Figure 2

The Capabilities Influence



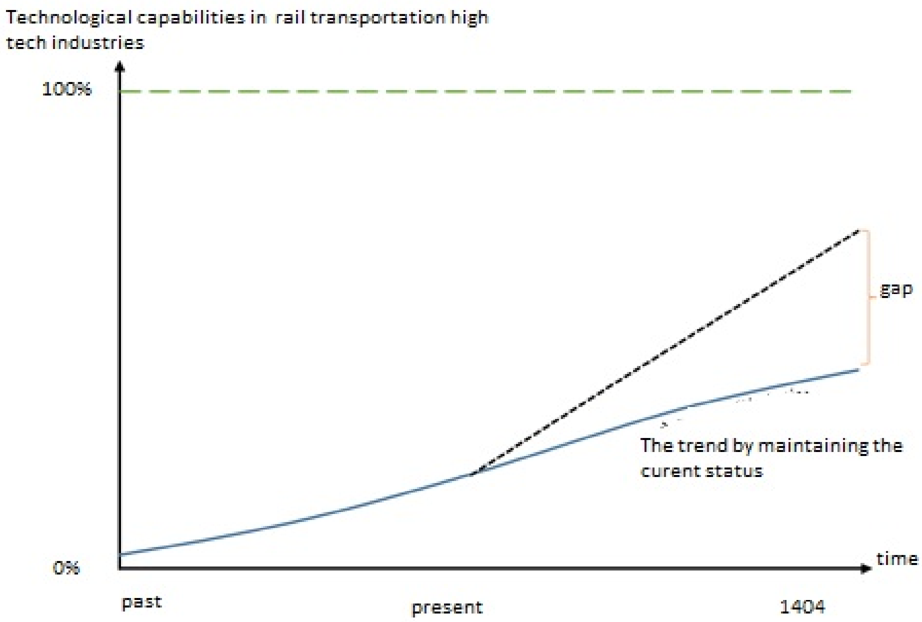


Based on the dynamic hypotheses mentioned above, it can be briefly stated that in this research, the purpose of modeling is to improve the technological capabilities in high-tech industries in the field of high-speed rail transportation. According to Figure 1, if the past trend of upgrading technological capabilities in these industries is followed, the goals and the ideal situation for the country will not occur.

Therefore, in this study, we seek to create a dynamic model to take into account the influencing factors and their action mechanism, to study the optimistic and pessimistic scenarios and policies in this field so that we can improve the current trend of the research variable.

Figure 3

Reference Diagram of Dynamic Hypotheses

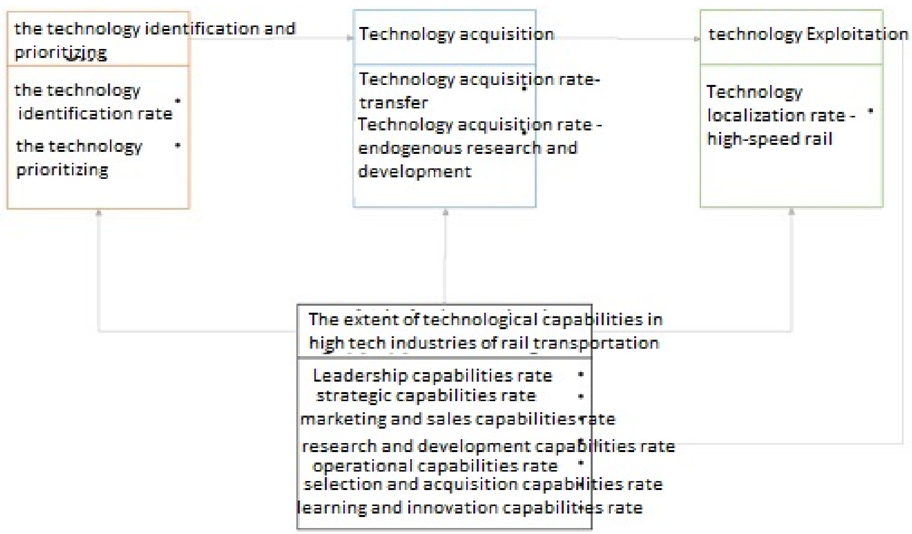


In fact the subsystems diagram shows the effective parts in upgrading the technological capabilities in high-tech industries in the field of high-speed rail transportation. As can be seen in Figure 3, in this study, four subsystems are identified and its variables and internal relationships are examined, which will be mentioned below.

The first subsystem is the technology identification and prioritization subsystem, the two main variables of which are the technology identification rate and the technology prioritization rate. The input to this subsystem is financial capability and the other its items under the technological capabilities in high-tech industries in the field of high-speed rail transportation, and its output is the priorities of technology. The next subsystem is technology acquisition, which includes the two main variables of technology acquisition rate through transfer and technology acquisition rate through endogenous research and development. This subsystem conducts the prioritized technologies acquisition by providing the required resources through cooperation with the internal and external stakeholders and exploiting the ability to define and control contracts. In the technology exploitation subsystem, technology localization occurs, which practically provides an opportunity to generate revenue from the developed technology.

Figure 4

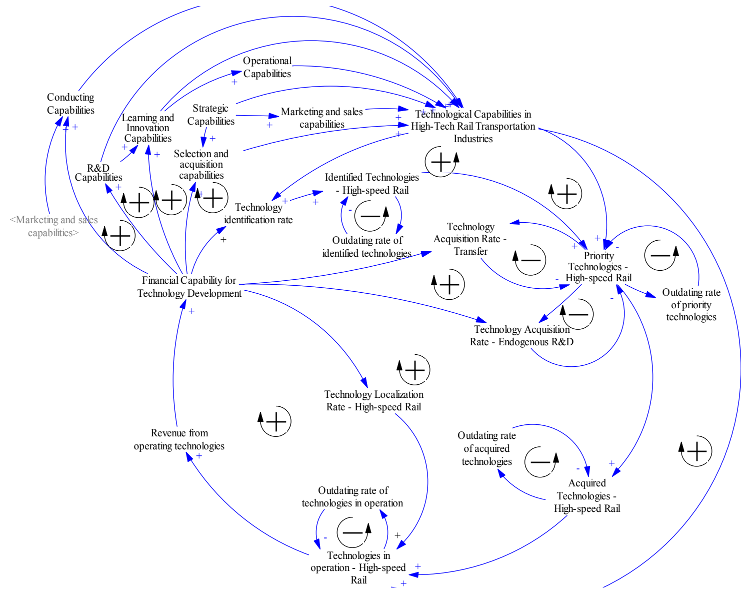
The Identified Subsystems Diagram



Causal loops represent the relationship between influential variables and also show the effective dynamics in increasing or decreasing technological capabilities in high-tech industries in high-speed rail transportation. Figure 5 shows the total cause and effect loops that are aggregated into partial loops and extracted with the expert's opinion.

Figure 5

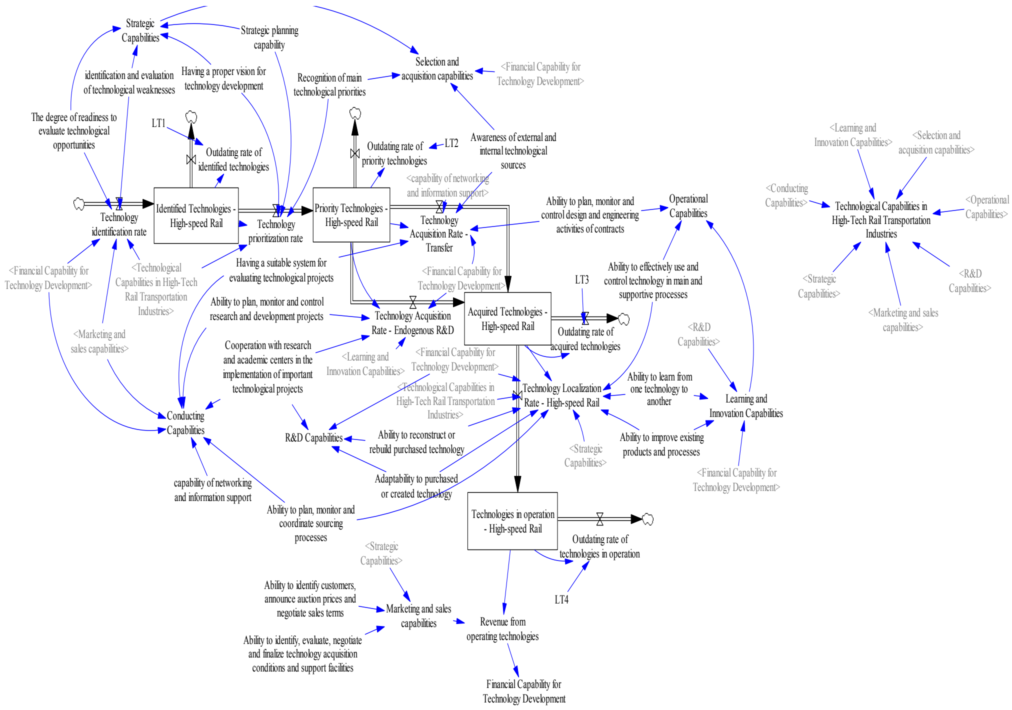
Total Causal Loops - Technological Capabilities in High-tech High-speed Train Industries



In this section, the structures used in the simulation model will be described. It should be noted that due to the unavailability of sufficient resources, the opinion of experts in creating the structure of the model as well as its data has been taken into account. The model covers the period from 2011 to 2025 and scenario planning is considered from 2020. The simulation model consists of 45 variables that contains 4 surface or accumulation variables, 9 rate variables and 32 auxiliary variables. Figure 6 shows the flow accumulation diagram. The main flow of the model is the process of developing high-speed train technology, which begins with the technology identification rate. Newly identified technologies are added to the accumulation of identified technologies. Over time, these technologies either become development priorities and add to the accumulation of prioritized technologies or become obsolete over time. Similarly, the prioritized technologies enter the acquisition process or become obsolete over time. Technology acquisition can be done in two main ways: technology transfer or endogenous research and development, which are eventually added to the accumulation of acquired technologies. Acquired technologies will also be exploited after the localization process and will generate revenue by considering their marketing and sales capabilities.

Figure 6

Accumulation-flow Diagram



After developing the model and before analyzing the results and scenario planning, some validation tests are always performed on the dynamic system models to ensure the model validity under different conditions. There are several types of validation tests, including:

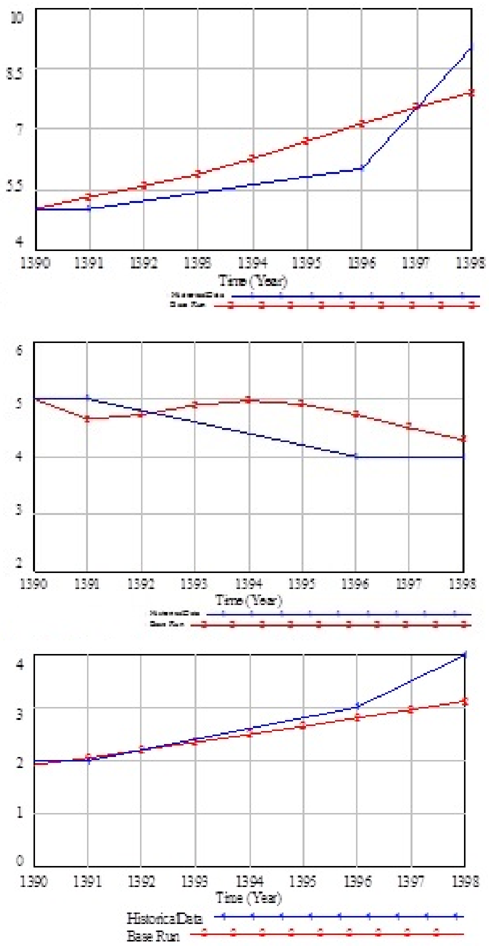
- Boundaries Adequacy: Are the main influential variables endogenously seen? Is the time frame properly considered?
- Structure evaluation: Is the structure of the model compatible with the rules and decision-making process in the system?
- Dimensional compatibility: Are the dimensions of the equations used in the model compatible with each other?

- Parameters evaluation: Are the numerical values of the parameters used in the model compatible with the data in the system?
- Final conditions: In case of sudden changes in some parameters, does the model show appropriate behavior and reaction?
- Integral error: Are the time intervals properly considered and changing the results in a change in the model results?
- Behavior Reproduction: Does it generate a model of the actual behavior in the system?
- Abnormal Behavior: Are some unusual and unreasonable behaviors observed in the model results when some of the model hypotheses are changed or removed?
- Family members: Is the behavior of the model resemble of the other similar systems?
- Strange Behavior: Does it produce the unrecognizable and unobserved behavior?
- Sensitivity analysis: Are there significant changes in numerical values, behavior, and policies with changes in parameters, boundaries, and time intervals?
- System improvement: Has the modeling process been able to change the system improvement?

By considering the above issues and performing validation in modeling, the validity of the model can be granted and its outputs can be considered as appropriate and reliable data. As can be seen below, in this study, two methods of the behavior reproduction and final conditions have been used. Figure 7 shows a comparison of historical and simulation data for the three variables of technology identification rate, number of the acquired technologies and number of technologies in operation. According to the available historical data (in the years 2011, 2012, 2017 and 2019, which is about one of the active companies in the high speed train field), the model has been able to produce the behavior of historical data very well and therefore from this perspective, the model is valid.

Figure 7

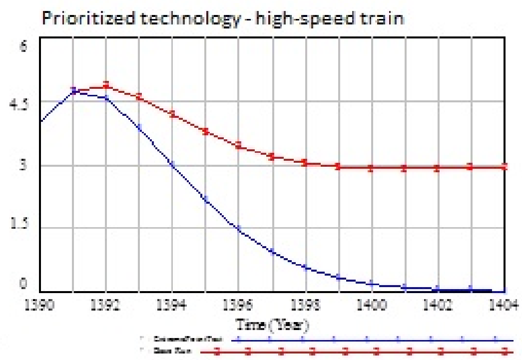
Validation (Behavior Reproduction) Technologies in Operation Variable; Acquired Technologies Variable; Technology Identification Rate Variable



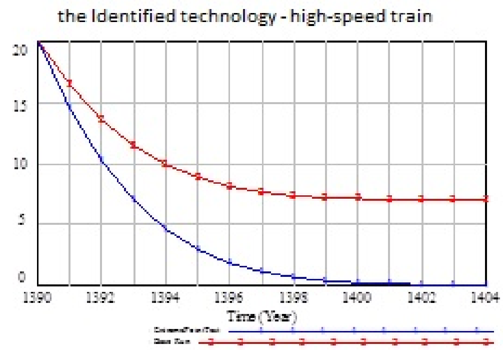
To test the model by the final conditions method, we set the technology identification rate to zero so that we evaluate the behavior of the model. Figure 8 shows the behavior of the 4 state variables including the identified, prioritized, acquired and in-operation technologies. According to the simulation results in comparison with the base mode, by zeroing the input, the mentioned mode variables show the ratio of this reaction change respectively. However, due to the fact that these state variables are interrelated with the rates of prioritization, acquisition, and localization, they have to react to this change with a longer time lag, respectively, and eventually become equal to zero, which the simulation results show this well and also from this perspective, the model is known as valid.

Figure 8

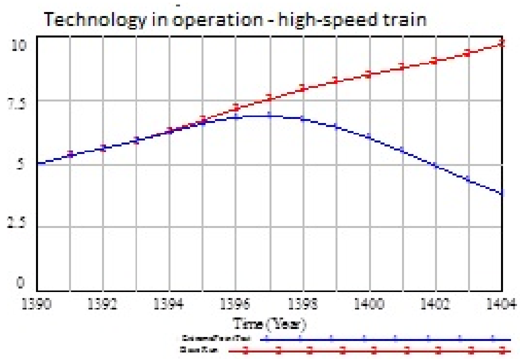
Validation



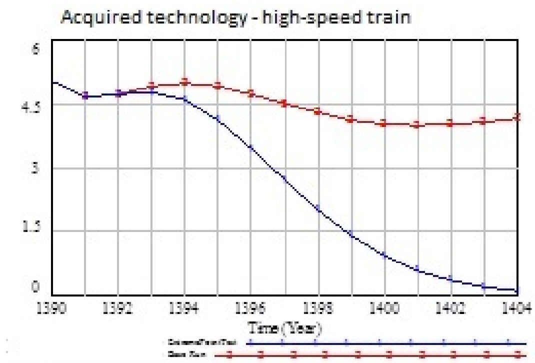
Prioritized technology - high-speed train



the Identified technology - high-speed train



Technology in operation - high-speed train



Acquired technology - high-speed train

Due to the factors affecting the level of technological capabilities in high-tech industries at high-speed train transportation, simulation in this space is always associated with uncertainty. Therefore, it is necessary to define and evaluate different scenarios to examine and evaluate different possible conditions in the future. For this purpose, the two scenarios of optimism and pessimism with the baseline scenario will be compared in table 2. Details of the implementation of this scenario can be seen in the table 2. Therefore, the scenarios definition, according to the expert's opinions, will be as follows:

Possible scenario: In this scenario, it is assumed that based on the past historical trend and its continuation, the data will grow with the current trends, and based on this scenario, the so-called basic scenario which is shown in the diagrams, is considered.

Pessimistic scenario: In this scenario, compared to the baseline scenario, we see no growth or growth equal to half of the baseline scenario.

Optimistic scenario: In this scenario, compared to the baseline scenario, we see no growth or growth equal to at least 2 times of the baseline scenario.

Table 2

Definition of Optimistic and Pessimistic Scenarios (Starting 2020)

No	Variable Name	Possible Scenario (Baseline)	Value in the Pessimistic Scenario	Value in the Optimistic Scenario
1	The technological opportunities evaluation readiness rate	About 10% growth by the end of 2025	About 0% growth by the end of 2025	About 20% growth by the end of 2025
2	The identification and evaluation rate of technological weaknesses	About 30% growth by the end of 2025	About 15% growth by the end of 2025	About 65% growth by the end of 2025
3	Having suitable vision for technology development	About 30% growth by the end of 2025	About 15% growth by the end of 2025	About 100% growth by the end of 2025

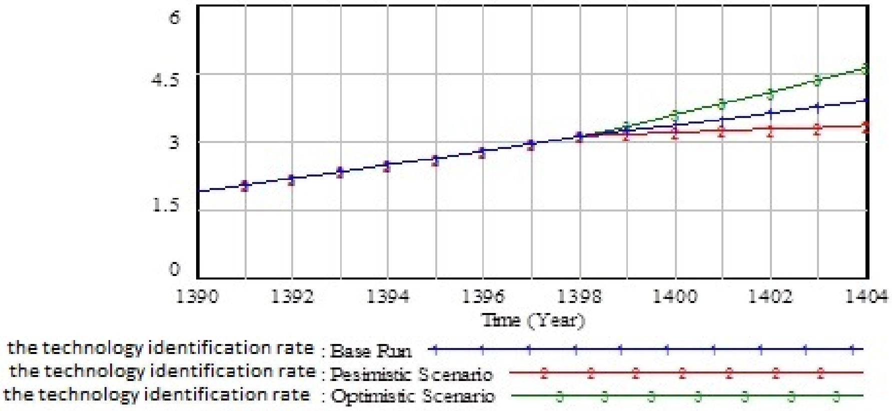
No	Variable Name	Possible Scenario (Baseline)	Value in the Pessimistic Scenario	Value in the Optimistic Scenario
4	The strategic planning capability	About 30% growth by the end of 2025	About 15% growth by the end of 2025	About 40% growth by the end of 2025
5	The basic technological priorities recognition	About 50% growth by the end of 2025	About 30% growth by the end of 2025	About 100% growth by the end of 2025
6	The external and internal technological resources awareness rate	About 20% growth by the end of 2025	About 10% growth by the end of 2025	About 55% growth by the end of 2025
7	The ability to plan, monitor and control design and engineering contracts activities	About 25% growth by the end of 2025	About 0% growth by the end of 2025	About 25% growth by the end of 2025
8	The ability to use and control technology effectively in the main and support processes	About 25% growth by the end of 2025	About 0% growth by the end of 2025	About 75% growth by the end of 2025
9	The ability to learn from one technology to another	About 50% growth by the end of 2025	About 25% growth by the end of 2025	About 125% growth by the end of 2025
10	The ability to improve the existing products and processes	About 40% growth by the end of 2025	About 20% growth by the end of 2025	About 60% growth by the end of 2025
11	The ability to identify, evaluate ,negotiate and finalize the technology acquisition conditions and support facilities	About 50% growth by the end of 2025	About 0% growth by the end of 2025	About 100% growth by the end of 2025
12	The ability to identify customers, announce auction prices and negotiate sales terms and conditions	About 50% growth by the end of 2025	About 0% growth by the end of 2025	About 100% growth by the end of 2025
13	The ability to plan, monitor and coordinate sourcing processes	About 20% growth by the end of 2025	About 10% growth by the end of 2025	About 30% growth by the end of 2025

No	Variable Name	Possible Scenario (Baseline)	Value in the Pessimistic Scenario	Value in the Optimistic Scenario
14	The ability to adapt to the purchased or created technology	About 15% growth by the end of 2025	About 0% growth by the end of 2025	About 15% growth by the end of 2025
15	The ability to reconstruct the purchased technology	About 15% growth by the end of 2025	About 10% growth by the end of 2025	About 30% growth by the end of 2025
16	The networking and information support capability	About 30% growth by the end of 2025	About 15% growth by the end of 2025	About 60% growth by the end of 2025
17	The cooperation with research and academic centers in the important technological projects implementation	About 30% growth by the end of 2025	About 15% growth by the end of 2025	About 40% growth by the end of 2025
18	The ability to plan, monitor and control the research and development projects	About 50% growth by the end of 2025	About 25% growth by the end of 2025	About 75% growth by the end of 2025
19	Having suitable system for technological projects evaluation	About 65% growth by the end of 2025	About 30% growth by the end of 2025	About 100% growth by the end of 2025

In the following the simulation results and comparison between pessimistic and optimistic scenarios with probable (basic) state are presented. The simulation results for the technology identification rate in three scenarios are shown in figure 9. In the base run, we see 25% growth in the technology identification rate from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 19% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 14% lower than the base run in 2025.

Figure 9

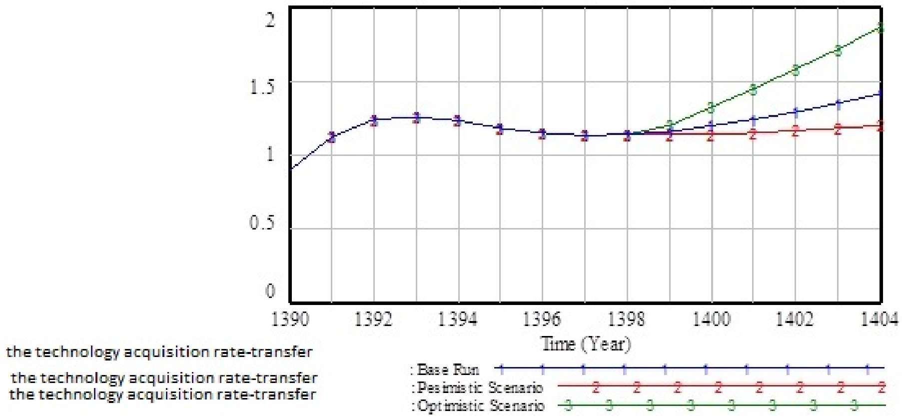
The Simulation Results Based on the Scenario-the Technology Identification Rate



The simulation results for the technology acquisition rate (through transfer) in three scenarios are shown in figure 10. In the base run, we see 24% growth in this variable from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 32% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 15% lower than the base run in 2025.

Figure 10

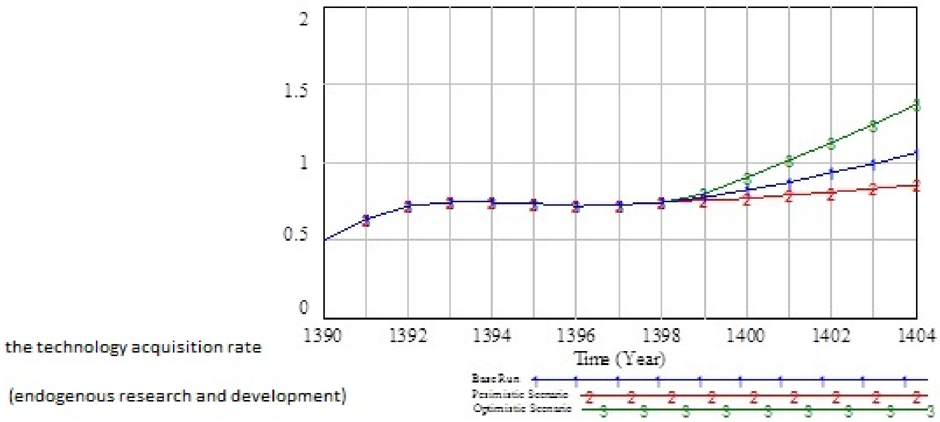
The Simulation Results Based on the Scenario-the Technology Acquisition Rate (Transfer)



The simulation results for the technology acquisition rate (through the endogenous research and development) in three scenarios are shown in figure 11. In the base run, we see 43% growth in this variable from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 29% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 19% lower than the base run in 2025.

Figure 11

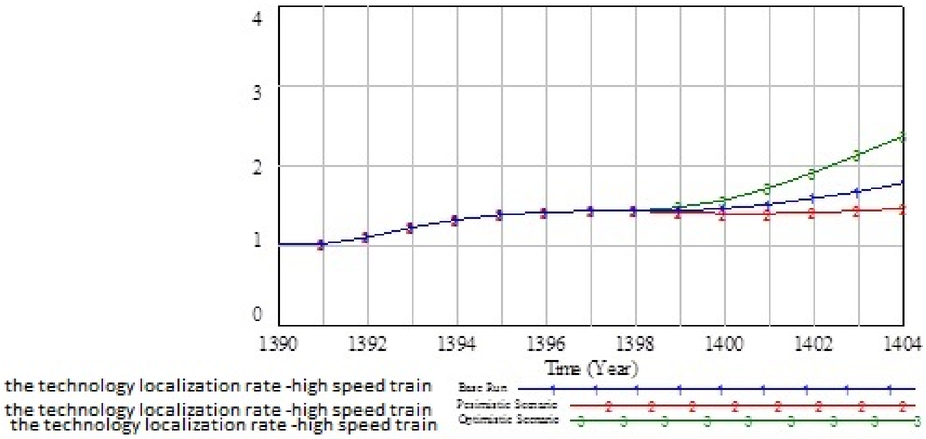
The Simulation Results Based on the Scenario-the Technology Acquisition Rate (Endogenous Research and Development)



The simulation results for the technology localization rate of high speed train variables in three scenarios are shown in figure 12. In the base run, we see 24% growth in the high speed train technology localization rate from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 33% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 18% lower than the base run in 2025.

Figure 12

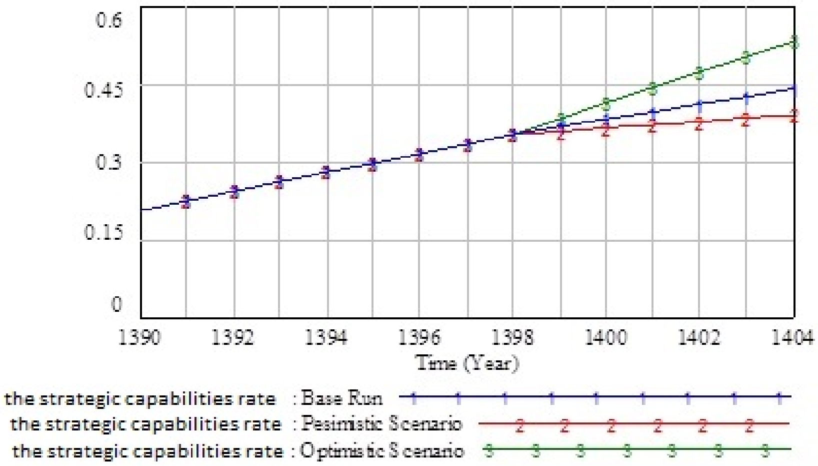
The Simulation Results Based on the Scenario-the Technology Localization Rate



The simulation results for the strategic capabilities rate variables in three scenarios are shown in figure 13. In the base run, we see 25% growth the strategic capabilities rate from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 21% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 11% lower than the base run in 2025.

Figure 13

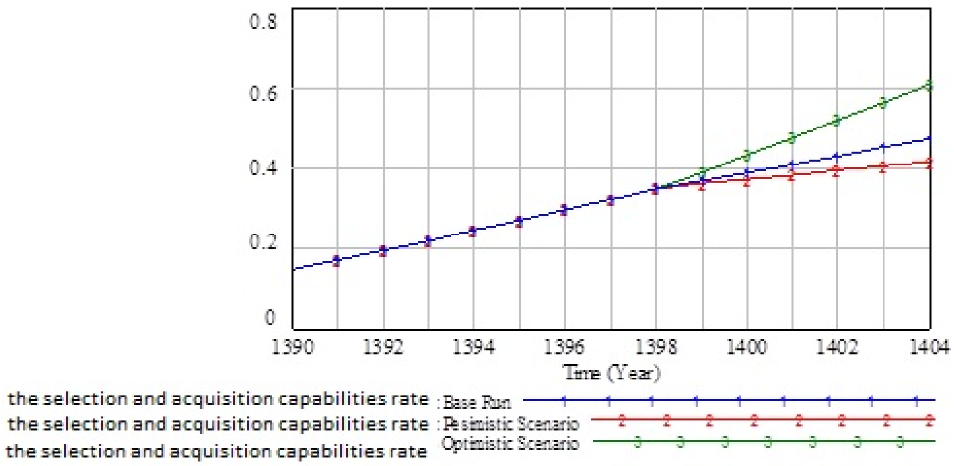
The Simulation Results Based on the Scenario-the Strategic Capabilities Rate and Extent



The simulation results for the selection and acquisition capabilities rate variables in three scenarios are shown in figure 14. In the base run, we see 36% growth of selection and acquisition capabilities rate from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 29% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 12% lower than the base run in 2025.

Figure 14

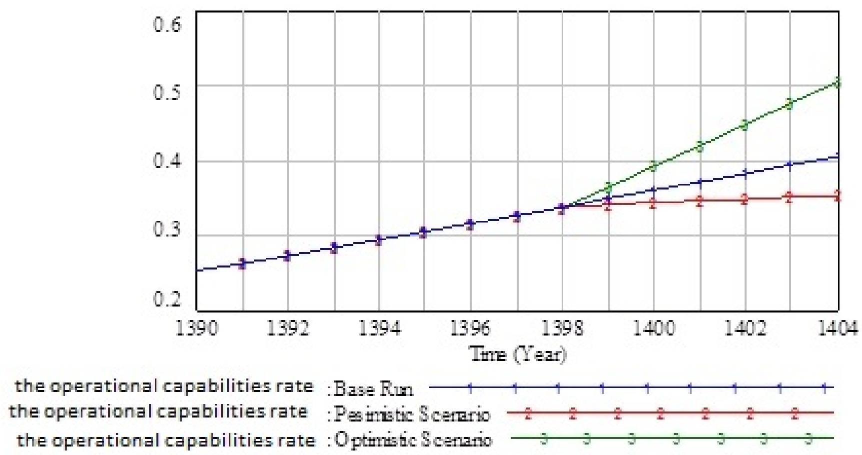
The Simulation Results Based on the Scenario-the Selection and Acquisition Capabilities Rate and Extent



The simulation results for the operational capabilities rate variables in three scenarios are shown in figure 15. In the base run, we see 20% growth of the operational capabilities rate from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 25% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 13% lower than the base run in 2025.

Figure 15

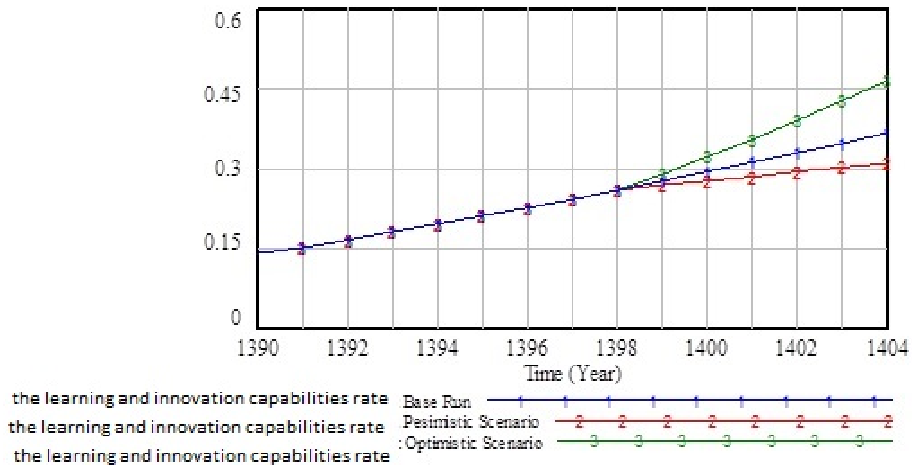
The Simulation Results Based on the Scenario-the Operational Capabilities Rate and Extent



The simulation results for the learning and innovation capabilities rate variables in three scenarios are shown in figure 16. In the base run, we see 41% growth of the learning and innovation capabilities rate in these industries from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 27% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 16% lower than the base run in 2025.

Figure 16

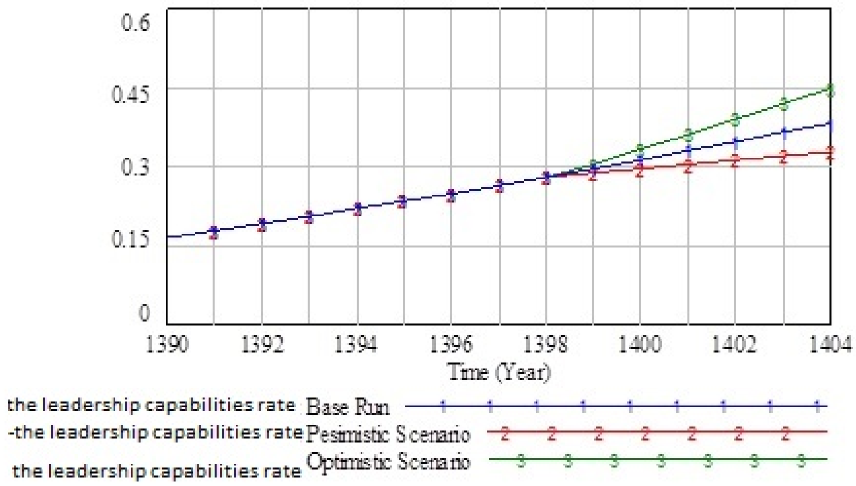
The Simulation Results Based on the Scenario-the Learning and Innovation Capabilities Rate and Extent



The simulation results for the leadership capabilities rate variables in three scenarios are shown in figure 17. In the base run, we see 37% growth of the leadership capabilities rate in these industries from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 18% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 14% lower than the base run in 2025.

Figure 17

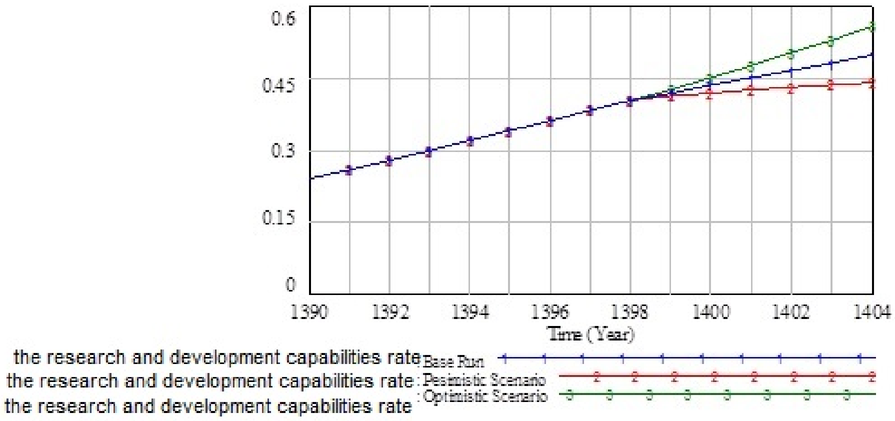
The simulation Results Based on the Scenario-the Leadership Capabilities Rate and Extent



The simulation results for the research and development capabilities rate variables are shown in three scenarios in figure 18. In the base run, we see 23% growth of the research and development capabilities rate in these industries from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 12% higher than the base run in 2025 and in the pessimistic scenario, this variable rate will be 11% lower than the base run in 2025.

Figure 18

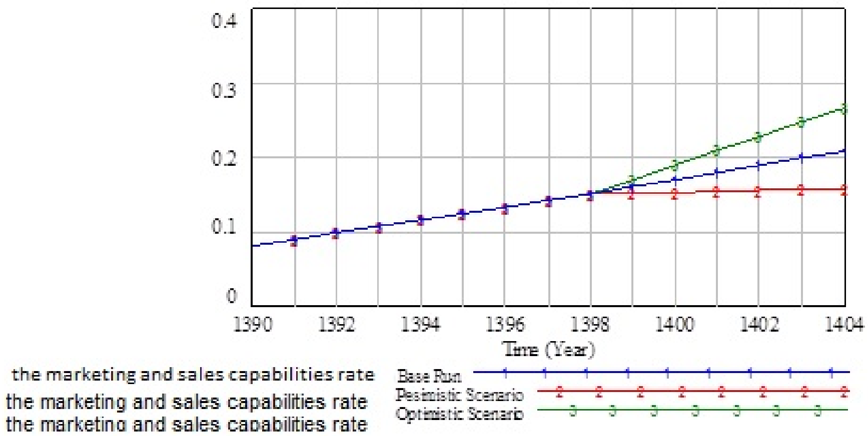
The Simulation Results Based on the Scenario-the Research and Development Capabilities Rate and Extent



The simulation results for the marketing and sales capabilities rate variables shown in three scenarios are shown in the figure 19. In the base run, we see 38% growth of the marketing and sales capabilities rate in these industries from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 28% higher than the base run in 2025 and in the pessimistic scenario this variable rate will be 24% lower than the base run in 2025.

Figure 19

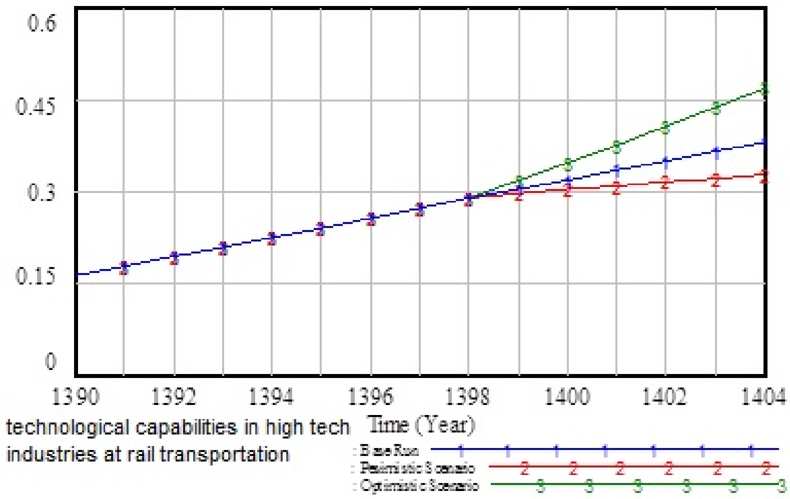
The Simulation Results Based on the Scenario-the Marketing and Sales Capabilities Rate and Extent



Finally, the simulation results for technological capabilities extent variable in high tech industries at high speed train in three scenarios are shown in figure 20. In the base run, we see 32% growth of technological capabilities in these industries from 2019 to 2025. Also, in the optimistic scenario the rate of this variable is 23% higher than the base run in 2025 and in the pessimistic scenario this variable rate will be 14% lower than the base run in 2025.

Figure 20

Simulation Results on the Scenario Basis-the Technological Capabilities Measure and Extent



Discussion and Conclusion

The purpose of this paper is to present a systematic model for investigating the effective factors for technological capabilities enhancement in high tech industries at the high speed train transportation. After literature review and conducting several sessions with experts, the conceptual and qualitative structure of the subsystems and how they relate in this field were obtained. Then in order to identify the effective dynamics in enhancing the technological capabilities at high tech industries in high speed train transportation, the causal loops were drawn and its modeling was performed in VENSIM software. Then by using the simulation model based on the developed structure, the technology development process was modeled. Finally, in order to consider the uncertainty space, based on the experts opinions two scenarios of optimism and pessimism were considered. According to the obtained results, the variables such as having suitable vision for technology development ,recognizing basic technological priorities, ability to use and control technology in main and support processes effectively, ability to learn from one technology to another, ability to identify, evaluate, negotiate and finalize the technology acquisition and support facilities, the ability to identify the customers, announcing the auction prices and negotiating about the sales conditions, the ability to plan, monitor and control the research and development projects and having the appropriate system for evaluating the technological projects are so effective. Given the model structure, enhancing the marketing and sales capabilities with the aim of increasing financial capabilities for investment in technology development (which in turn leads to the enhancement of technological capabilities in high tech industries in high speed train transportation filed) in one hand and the effective relationship with market and the stakeholders needs on the other hand are so important (which leads to recognition of more technologies). If this cycle is managed effectively and strategically, synergy would be created and eventually with increasing the mentioned capabilities, the enhancement of technological capabilities in high tech industries in the field of high speed rail transportation would be achieved. Also, the final step of technology development which is the localization of high speed railway technology shouldn't be forgotten because until this step is completed, it wouldn't be possible to exploit the revenue potential of this process.

In this regard, practical suggestions are presented as follows:

- Increasing the ability of business negotiation, pricing and mastering on the different technology revenue generation models
- Increasing R&D management capability (from project definition to contract management)

- Enhancing networking and mastery on the information resources related to the technologies
- Enhancing the effectiveness of technology development orientation and its strategy formulating

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