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Prioritizing Technological Capabilities of Cycle Power Plants (Case Study: Fars Combined Cycle Power Plant)[1]

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Abstract

In the new era that can be called the era of rapid technological changes, organizations in order to develop policies and strategic plans, require careful and clear examination of the technological aspects, along with other strategic factors. Using the technological capabilities evaluation process, we can evaluate solutions and strategies proposed in the technology strategy, in terms of capabilities. In the present study, based on the model proposed by Panda and Ramanathan, technological capabilities of Fars combined cycle power plants is evaluated and prioritized. This research, in terms of objective, is functional and is put among the descriptive researches. The sample consists of 135 experts that are selected in a systematic random way, among experts, managers and engineers in the areas of research and operational power industry. To collect the data, library research method and past achieves of the organization is used. To complete the process of extracting the capabilities different tools are used including interviews with experts, questionnaire, and paired comparisons matrix based on AHP method and spider diagram to represent profile. The results show that from 20 major extracted technological capabilities, 9 capabilities DEC2, DEC3, DEC4, PRC2, SEC2, SUC1, SUC3, ACC4 and ACC5 have low and medium levels of capabilities and low final relative number. PRC1 has high level of capacity and low final relative number. Four capabilities DEC5, SEC1, SEC4 and ACC1 have a low or moderate level and high final relative number. Six capabilities DEC1, PRC3, PRC4, SUC2, SUC5 and ACC2 have high level of capability and high final relative number. The annual and periodic assessment process is also offered.

Keywords: *Technological Capabilities, Technological Capability Assessment, Panda and Ramanathan Model*

1. Introduction

One of the important steps in the formulation of every plan and strategic decision-making is indoor recognition or identifying the strengths and weaknesses of the organization's internal environment. In general, in order to plan strategically, given the objectives and overall strategy of the organization, we should recognize what capabilities and capacities are required. After the planners got aware of the required skills and abilities for the organization, they must look for the presence or absence of these skills in their organization; and in the case of the existence of these abilities, recognize their existing and desired level. In other words, they need to know in what capability are strong and in which of them are weak. Technology is also one of the strategic important variables that identifying its strengths and weaknesses is essential for the organization. In this era that can be called the era of rapid technological change, Organizations in order to develop policies and strategic plans, require careful and clear examination of the technological aspects, along with other strategic factors. This requires an assessment of technological capabilities and determination of the technological strengths and weaknesses in organizations. If the process of evaluating the technological capabilities is done to a technology, the organization's ability to create that technology (internal R & D or transfer of technology) and the development and optimal utilization of technology (technical knowledge, skilled manpower, management infrastructure and appropriate structure, etc.) can be detected. If the organization, had any shortcomings and weaknesses in any of the above cases, due to the amount of strategic capabilities' attraction, can apply different policies. If the organization had shortcomings and weaknesses in any of the above-mentioned cases, due to the amount of strategic capabilities' attraction, can apply different policies. Since the firms under the control of the electricity industry, compared to other industries have a relatively high diversity, evaluating the technological capabilities of each of these firms, using the existing models that have general criteria, may not provide useful information for managers and planners in the industry. Thus, relying on a comprehensive model in this case is necessary.

Fars Combined cycle power plant in Akbarabad of Fars province, 19 kilometers from Shiraz, is one of the combined cycle power plants in Iran. The nominal capacity of this power plant in 1388 was about 1050 MW. The employer of this power plant is Iran Power Development Company. Combined cycle power plant is a

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power plant that consists of some gas turbine and steam turbine. In these types of power plants, using the recovery boiler, the heat from the exhaust gases from the gas turbines is used for producing steam for the steam turbine. If the gas turbine is not a combined cycle type, the exhaust gases, which can have up to 600 degrees Celsius, will directly get into the air, and the remaining energy will be wasted. While this is being used in combined cycle power plant, and the boiler of steam turbine, without fuel, produces water steam. Thus, using this method, the cycle efficiency is increased. [5]

This research is intended to provide a method that can be applied in all of the companies under the control of Iran electric industry and using the obtained information, studied the company's strengths and weaknesses due to the required capabilities for technology management. The criteria used in this study have previously been used to compare the two big electric companies, one in France (EDF)[2] and the other in Thailand (EGAT)[3]. However, it is for the first time that these standards are used in Iran in the field of companies producing vital energy of electricity. Therefore, we can say that the main objective of this research is to provide a tool to demonstrate the technological capabilities in the field of power generation that can provide Strategic Directors and Chief Technology Officer of Power Industry with a suitable tool for benchmarking and decision-making. Finally, through the proposed tool and the collected data, we can assess technological capabilities of every large company in the power industry that deals with power generation and transmission technologies and then visualize them in spider diagrams.

2. Review of Literature

A glimpse of the definitions in magazines, books and specialized texts in the field of technology management, the following definitions can be presented about this research:

2.1 Assessment of Technological Capabilities

Assessment of technological capabilities is a process in which the current level of technological abilities and capabilities in the organization is measured so that we will be able to identify the organization's technological strengths and weaknesses and compare technological capabilities of the organization with competitors or ideal level in order to compensate for the adverse action. In order to have a better investigation, the definition of technological capabilities is offered: technological capability is a set of functional abilities that affects the performance of organization through various technological activities and cannot be simply followed and its ultimate goal is to create value added and improve the organization's position .According to the above definition, the assessment of technological capabilities is the process by which an organization or industry examines its technological abilities and capabilities with regarding the long-term objectives [4].

2.2 Internal and External Investigation

In our evaluation, research on the evaluation of the technology level was conducted. These researches are classified in the field of external and internal researches that due to the limited number of pages are presented in two tables of 1 and 2:

2.2.1 External Researches

Table 1: External Researches Conducted in the Field of Technological Capabilities

The Centrality of theIissue	***Year***	***Published***	***Authors***	***Row***
Assessment of technological capabilities in the electrical industry and related industries	1996	Technovation , vol. 16, no. 10, pp. 561-588	H.Panda and K.Ramanathan	1
Technological capability assessment of a firm in the electricity sector				
Predictor variables of technological capabilities	2011	J. Technol. Manag Innov. 2011,Volume 6, Issue I p.14-25	Fernanda Reichert and etal.	2
Technological capability assessment				
Technological capability assessment as a basis for strategic planning	1997	Technovation , vol. 17, no. 7, pp. 359-390	H.Panda and K.Ramanathan	3
Technological Capability Assessment as input for Strategic Planning				

[2] Électricité de France
[3] Electricity Generating Authority of Thailand

Table 1: External Researches Conducted in the Field of Technological Capabilities

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The centrality of the issue	*Year*	*Published*	*Authors*	*Row*
Technological capabilities and economic efficiency of enterprises in low and medium technology	2014	. Technol. Manag Innov. 2014,Volume 9, Issue 4 p.20-35	Fernanda Reichert and etal.	4
Technological Capability and Firm Performance				
Technological capabilities and efficiency of firms in emerging economies	2014	J. Technol. Manag Innov. 2014,Volume 6, Issue 4 p.70-89	Paulo Antonio Zawislak and etal.	5
The Relationship between Technological Capability and Firm Performance in Emerging Economy				
Assessment of technological capabilities as a strategic tool	2001	J. Manage. And Eng. And	Wei Jiang	6
Technological Capability Assessment as an Strategic Tool				

2.2.2 Internal Researches

Table 2: Internal Researches Conducted in the Field of Technological Capabilities

The centrality of the issue	*Year*	*Published*	*Authors*	*Row*
Assess the level of technology in the industry relying on the Atlantic Technology	2003	Industrial Management Institute	Industrial Management Institute	1
Measurement of technology in the country's industry				
Assess the level of technology in the industry relying on the Atlantic Technology	1999	Proceedings of the seminar on technology and industry renovation, pp. 178- 169	Mohamad Hosein seyed Kanani and Jafar Pashaian	2
Evaluation of Technology in Iran Tractor Manufacturing Company				
Evaluation of the technology in the automotive industry (A Case Study of Bahman Group)	2004	Proceedings of the International Conference on Automotive Industry 180-170 p.	Aliakbar Tavakoli and Ali Valimohammadi	3
Evaluation of the technology in the automotive industry				
Assessing the level of technology in Iran Ferrosilice company with the approach of technology assessment by Atlantic Technology method	1997	Thesis MSc in Business Management Supervisor: Dr. Ranjbarian	Seyed Mohammad ali Ekrami rad	4
Assess the status of technology in Iran Ferrosilice company				
Assessing the level of technological capabilities using technology Atlantic method	2011	First International Conference and Fifth National Conference on Management of Technology	Maghme Taleb Tabrizi	5
Assessing the level of technological capabilities using Technology Atlantic method in Poura Food Factory				
Assessing the level of technological capabilities in the automotive industry relying on the Panda and Ramanathan model	2011	First International Conference and Fifth National Conference on Management of Technology	Reza Radfar And etal	6
Assessing the technological capabilities of the automotive industry (case study: Pars Khodro company)				

Table 2: Internal Researches Conducted in the Field of Technological Capabilities

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Table 2: Internal Researches Conducted in the Field of Technological Capabilities

The centrality of the issue	*Year*	*Published*	*Authors*	*Row*
Evaluation of technological capability of innovation in rolling and pipe industries relying on the Panda and Ramanathan model	1393		Abas Khamse and Siamak Sasani	7
Assessment of Technological Innovation Capabilities in IRAN's Rolling and Pipe Mills Industries: Case Study of Ahwaz Rolling and Pipe Mills Co.				
Presenting an effective model based on data analysis to evaluate technological capabilities (Case study: SAPCO)	1388	Thesis MSc in Technology Management Supervisor: Dr. Radfar	Marzie Jalali Farahani	8
Providing a mathematical model for the selection of an efficient method to evaluate the capabilities of the technology				

2.3 Conceptual model

Technological capability assessment process:

Panda & Ramanathan in 1996 provided a process for the assessment of technological capabilities. By extracting some parameters, they applied this process in the electric industry in France and Thailand and compared the obtained results in 1997.

The proposed process is as follows:[6]

Step One: Identifying the steps to create value added given by company

Technological capability evaluation process begins by identifying the steps of creating value in the company. Since a company is not fully involved at all stages of creating the value added of a good or service, therefore, a comprehensive analysis of the value added that the company is undertaken, is necessary. This analysis can examine the dynamics of the steps of the value added compared to the total generated value added.

Step Two: Identifying the required technology capabilities

Any activity that a company does requires a certain level of technological capabilities. Therefore, by finding certain activities that are done by the company in steps of value adding, the company's requirements can be identified in terms of technological capabilities.

Step Three: Developing criteria for evaluating each of the technological capabilities

The third step in assessing the technological capabilities requires developing a set of criteria that can be measured. Some objective and subjective indicators can be used for modeling in the components of technological capabilities. These indicators should show the following criteria:

- Having the ability to monitor the basic results instead of evaluation of Intermediate processes performance and individual programs
- Objectivity and fairness
- The ability to apply and possibly ability to easily collect the data
- The ability to create a vision or concept, without the need to have complete knowledge of the actions and plans of factories

In addition, the use of these criteria must ensure the following:

- The results must help setting goals
- Focus on improving the value of the index should not lead to adverse action
- The results only reflects function of the areas under the control or influence the management of the factory
- The results of capability should have broad application

Since the evaluation of some components of technological capabilities can be direct, such measurements are difficult. Therefore, indicators have to be developed that can surrogate these capabilities.

Step Four: Benchmarking or patterning of technological capabilities.

In a world of increasing globalization and global growth, a company cannot operate in a vacuum. Therefore, evaluation of technological capabilities, without knowing the current ability compared to its best situation, would never be perfect. Using the same and specific set of parameters to a developed company and an under investigation company, we can achieve the results that show the strengths and weaknesses.

It is not necessary that always a leading company in the industry and the world be selected as a modern company, rather, a company that is technologically advanced can be chosen as a model. Even this company may be in another industry, but does the same technological activities. At this stage of the technological capabilities process assessment, if we could not find a company as a modern or pattern company, experts within the company can be used as a consultant. These experts through practical experience, training and knowledge to new developed areas, can develop appropriate criteria for the model parameters.

Step Five: Gap analysis

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The last step in the evaluation of technological capabilities is determining the gap between the capabilities of the model company and the company under study. This would provide a useful perspective on the strengths and weaknesses of the company and show the parts that require corrective measures.
In what follows, you can see the divisions of technological capabilities that are introduces by these two researchers.

Table3: Technologic strategic capabilities classified by Panda and Ramanathan

Strategically Technologic Capability		
Carrying out improvements in existing products and processes and the development of new products and processes	CRC1	Creation Capability
capability to create new organizational structures	CRC2	
Capability to plan, monitor and control research and development projects	CRC3	
Capability in evaluation of projects based on technical, economic, financial, environmental criteria and social impacts	DEC1	Design & Engineering Capability
capability to perform detailed engineering and common drawings in processes and products	DEC2	
Capability to adapt with purchased or created technology	DEC3	
Capability of restructuring or reorganization of a purchased technology	DEC4	
Capability to plan, monitor and control the activities of design and engineering and contracts	DEC5	
capability to support feasibility studies and estimates of the parameters and the ability to perform value engineering and sites engineering	COC1	Construction Capability
capability of civil engineering and construction	COC2	
capability of commissioning activities for mechanical and electrical items and control equipment	COC3	
capability to plan, monitor and control the construction and commissioning	COC4	

Table 4: Tactical technological capabilities classified by Panda and Ramanathan

Tactically Technologic Capability		
Capability to apply and control the effectiveness of technologies in the main and auxiliary processes	PRC1	Production Capability
Capability to perform quality assurance, inspection and inventory control	PRC2	
Capability of Troubleshooting and capability to perform common and preventive repair and maintenance and fixing failures	PRC3	
Capability to perform production planning and scheduling equipment and maintenance repair	PRC4	
capability to identify customers, announcing the prices or (bid) and the negotiations on the sale conditions of goods or services	MSC1	Marketing & Selling Capacity
Capability to provide product / service to the customer with each contact (either individually or in coalition)	MSC2	
Capability to plan, monitor and coordinate marketing and sales activities.	MSC3	
capability to detect problems, perform corrective actions (including maintenance and repair, replacement or exchange) and helping out the product	SEC1	Servicing Capacity
capability to provide technical recommendations to clients	SEC2	
capability to conduct researches in order to determine and monitor the needs and wants of the customer and to determine satisfaction levels for determination of service standards	SEC3	
capability to plan, monitor and coordinate the capacity of service, service activities and timing equipment and services personnel	SEC4	

Table 5: Leadership skill capabilities classified by Panda and Ramanathan

Steering Capability	
Routing Capabilities	STC1
Decision-making and implementation capabilities	STC2
capability to integrate the activities of the organization	STC3

Table 6: Complementary technological capabilities classified by Panda and Ramanathan

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Supplementary Technologic Capability		
capability to identify, evaluate, negotiate and confirm the conditions for acquisition of technology	ACC1	Acquisition Capability
capability to identify, evaluate, negotiate and confirm the conditions for acquisition of raw materials, supportive facilities, spare and consumable parts	ACC2	
capability to identify, evaluate, negotiate and confirm the conditions for acquisition of funding	ACC3	
capability to identify, evaluate, negotiate and confirm the conditions of human resources acquisition	ACC4	
capability to plan, monitor and coordinate processes of resources acquisition	ACC5	
capability to provide training	SUC1	Supporting Capacity
Strategic planning capabilities	SUC2	
Networking and information supporting capabilities	SUC3	
Technology sales capabilities	SUC4	
capability to maintain a high level of safety and security	SUC5	

Panda and Ramanathan provided indicators for each of the capabilities that using them we can measure the level of each of the capabilities in companies active in the electricity industry. These two, categorized the companies in the electricity industry into ten categories and offered a combination of capabilities for each category. The categories are as follows: [6]

- **Energy services companies**: service providing, acquisition, supporting and guidance capabilities
- **Electricity distribution companies**: marketing and sales, service providing, acquisition, supporting and guidance capabilities
- **Manufacturers of power plants**: capabilities for construction, acquisition, supporting and guidance
- **Power plants consulting companies**: design and engineering, acquisition supporting and strategic capabilities
- **Generation and transmission companies**: manufacturing, marketing and sales, acquisition, supporting and guidance capabilities
- **Electricity distribution and services providing companies**: service providing, marketing and sales, acquisition, supporting and guidance capabilities
- **Production and consulting company**: production, design and engineering, acquisition, supporting and guidance capabilities
- **Transmission and distribution of electricity and service proving Companies**: manufacturing, marketing and sales, service providing, acquisition, supporting and guidance capabilities
- **Generation and transmission companies and the manufacturer of power plants and the power plants themselves**: building, designing and engineering, manufacturing, marketing and sales, acquisition, supporting and guidance capabilities
- **A to Z companies**: capabilities for creating, design and engineering, construction, manufacturing, marketing and sales, service providing, acquisition and operational support

Looking into this category, we can observe the following points: [1]

- Complementary technological capabilities must exist in all companies
- Operational capability even if is not a technological capability, has the role of infrastructure in all its companies
- Some of the indicators are in the general category of capabilities, but are specific to a particular company, for example, the number of packages obtained from the decomposition of a power plant has been considered to belong to the design and engineering capabilities but is special for electric power plants.
- In the classification provided by Panda & Ramanathan, there is no a company that is solely responsible for the power transmission.
- It also should be noted that this method has another weakness. This method does not provide any specific strategy to strengthen the technological capabilities that have been identified as weak capabilities.

In this research, from the capabilities offered by the two above-mentioned researchers, some capabilities have been selected for transport companies and has been evaluated by proposed technique. [6]

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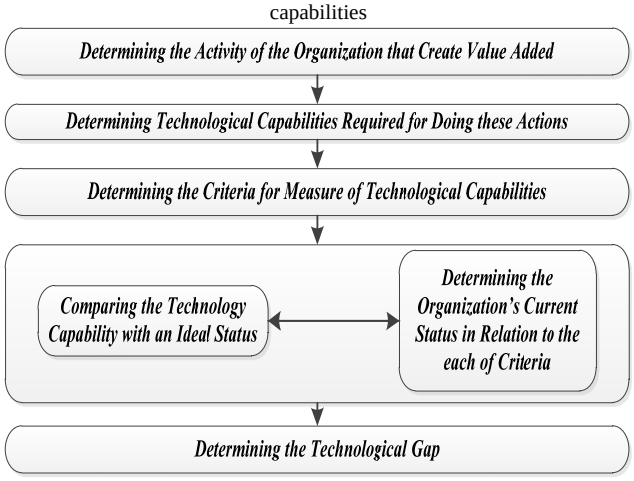
Figure 1: Model of Panda and Ramanathan to assess technological capabilities



3. Research Method

The present study, regarding its aim, is practical because a method is presented that develops the application of AHP[4] and Web Decision decision-making tools in technological capabilities evaluation process and on terms of the method of data collection, is regarded a field and library research. Statistical population of this research consists of transmission company managers, experts in Energy Research Center and Managers and experts from the Ministry of Energy Research Department (former Deputy Minister for Research and Technology) who were in charge during the time that research was being performed 1392-1393. The sample contains 135 people that have been selected using systematic random sampling from 850 total populations. Methods of data collection are as follows: [6]

- At the completion of the research theoretical primary library sources are used. These resources include books and articles in English and the ones translated into Persian.
- In determining the weights of the capabilities, a questionnaire is used to complete matrix of pairwise comparisons (prerequisite for AHP technique)
- In determining the capabilities of the surveyed company using the method of structured interview, a number of technological capabilities were selected from the list.
- In order to collect indicators to measure the capabilities, the method of referring to documents of organizations and interviews with managers and experts is used.

[4] Analytical Hierarchy Process

3.1 Steps of performing the research

3.1.1 In the first phase, a series of studies were undertaken to identify and evaluate the theoretical foundations of the research that this step was performed through four other detailed steps. The steps are as follows:

- Studies related to determination of the nature of technological capabilities assessment and technological evaluation and their place in the strategy formulation process.
- Study and investigate in the researches done in Iran on this subject.
- Introduction and investigation of methods for assessing the technological capabilities.
- The results related to the studies on identification and familiarity with transmission companies in Iran.

3.1.2 Identification of experts familiar with transport companies; at this stage, experts among university professors, directors of transport companies, experts in Energy Research Center, Managers and experts from the Ministry of Energy Research Department (former Deputy Minister for Research and Technology) were identified to fill the questionnaire and to be interviewed.

3.1.3 Interviews with some of the directors and experts to determine the composition of the capabilities needed to transport companies from the list of capabilities offered by Panda & Ramanathan.

After this stage, from the strategic and tactical capabilities, 3 sets of capabilities including design and engineering capabilities (DEC) and production capabilities (RRC) and service capabilities (SEC) were selected for transfer companies. Since according to the ideas of Capabilities List (Panda & Ramanathan) complementary capabilities are required in every company, two other capabilities including acquisition capabilities (ACC) and support capabilities (SUC), are also added to the previous ones. Since, according to Panda and Ramanathan strategic capabilities do not belong to technological capabilities, and plays the infrastructure role and has a managing role in organization, in this paper the author did not consider them and just technological capabilities are evaluated.

3.1.4 collecting questionnaire data:

At this stage, the data on the level of technological capabilities and the data related to tables of capabilities paired comparisons were collected to determine the weight of each Capability. The stage was divided into two parts; first, a questionnaire containing items needed to assess the capability of each of the introduced capabilities in the previous stage was given to the organization under study and then in order to weigh strategic and tactical capabilities, four types of Paired comparisons questionnaires were distributed to the experts. For weighting the complementary capabilities (the capability

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to acquire and support), 3 types of paired comparisons questionnaires were distributed between experts. (Figure 2) shows segmentation of technological capabilities in this study.

3.1.5 in the fifth stage, after the data stages 3 and 4 is collected, the number of each capability element, a number of technological capability, as well as the number of types of technological capability will be calculated.

- To calculate the number of each capability elements, first the number obtained from the data collected for each element will be calculated and then will be multiplied by the weight of the element.

$$DEC1 = \frac{(DEC_{11} + DEC_{12} + DEC_{13})}{3} . W_{DEC1}$$

- to calculate the number of each technological capabilities, the sum of the numbers related to each technological capabilities elements (i.e., the average weight of capability), was multiplied to the capability's weight. For example, the calculation of design and engineering capability (DEC) is performed as follows:

DEC= (DEC1+DEC2+ DEC3 + DEC4 + DEC5) * WDEC

- to calculate the number of each type of technological capabilities (strategic, tactical or complement) numbers related to technological capabilities that are obtained in the second stage are summed up. For example for a number related to the strategic and tactical capabilities, the procedure will be as follows:

Strategic and tactical capabilities = DEC+ PRC+ SEC

- At this stage, the numbers obtained in the fifth stage must be shown by appropriate diagrams so that all components of capabilities would be comparable.

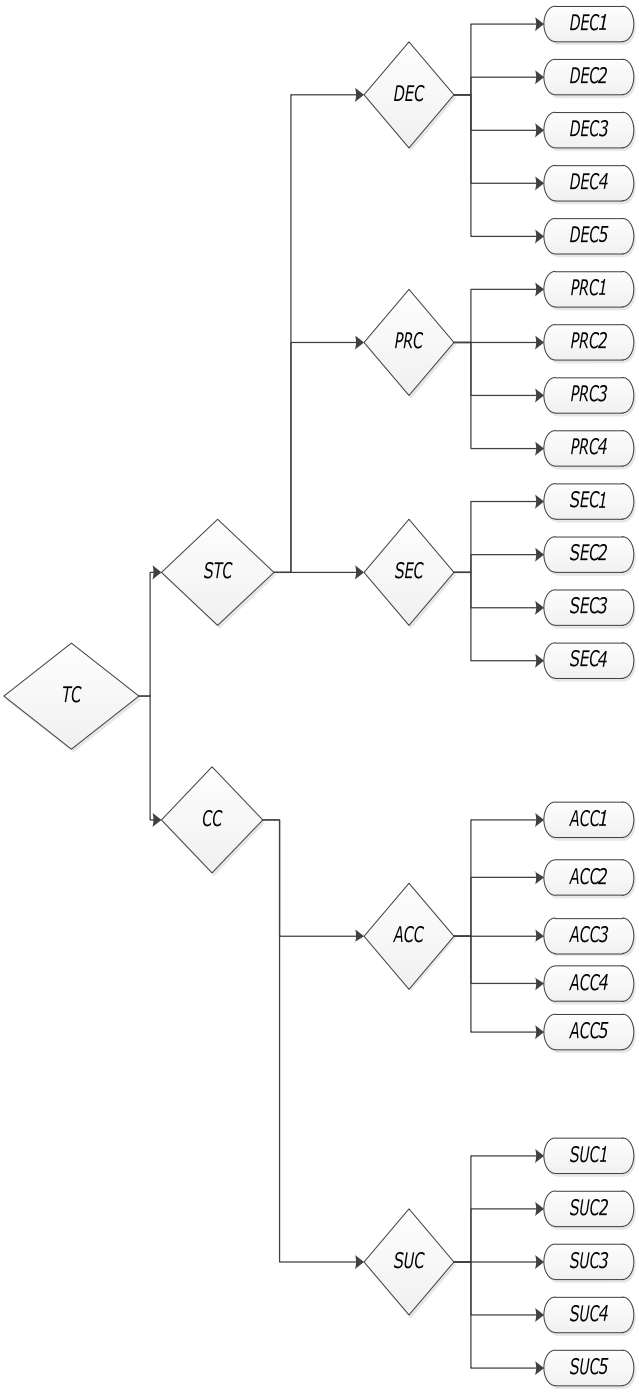

Figure 2: The classification of technological capabilities of the research.

The numbers of each level can be used to rank the same company. In other words, the same companies can be ranked based on any of the numbers related to capabilities. The following table, the charts used for transfer companies is listed. It should be noted that the mentioned figures are used for comparing capabilities and their components with a template company. [3]

Table 7: Capabilities address diagram findings

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Use the chart ...	*To show ...*
5 branch figure of Decision Web	Design and engineering capabilities (DEC)
5 branch figure of Decision Web	Production capacity (PRC)
5 branch figure of Decision Web	Service capabilities (SEC)
5 branch figure of Decision Web	Strategic and tactical capabilities
5 branch figure of Decision Web	Acquisition capabilities (ACC)
5 branch figure of Decision Web	Support capabilities (SUC)
Histograms	Complementary capabilities

4. Research Findings

4.1 Prioritizing Technological Capabilities:

After interviews with experts, design and engineering, manufacturing and service providing capabilities were selected as strategic and tactical technological capabilities used in transfer companies. During the next phase, first, the questionnaires containing two paired comparison matrixes were distributed for weighting the strategic, tactical and complementary capabilities that the respective weights are then calculated as follows:

Table 8: weights of strategic and tactical capabilities
And for the complementary capabilities the following weights were obtained:

weights	*Technological ,strategic and tactical capabilities*	*row*
0.414	Design and engineering capabilities	1
0.323	Production Capabilities	2
0.254	Service providing Capabilities	3
CR: 0.0138		

Table 9: weights of complementary capabilities

weights	*complementary technological capabilities*	*row*
0.25	Support capabilities	1
0.75	Acquisition capabilities	2
CR: 0.0000		

Since the calculated adaptation rate for both the results is less than 0.1, then the paired comparisons and weighting are accepted.
It should be noted that the amount of adaptation ratio should be less than or equal to0.05 for a 3 into3 matrix, for a matrix of four into four smaller or equal to 0.09 and for other matrices less than or equal to 0.1. The amount of adaptation ratio for a 2 into 2 matrixes is zero.

4.2 Prioritizing the Elements of each Capability

In this step, a questionnaire containing 5 paired comparisons matrixes was distributed among experts. Then though collecting and calculating the weight of each matrix, prioritization of elements of each capability was obtained. At this stage, the experts were asked to complete matrix of paired comparisons based on the strategic importance of each of the capabilities elements. The priority of each of these elements was as follows: [6]

Table 10: the elements of design and engineering capabilities

rank	*Elements of design and engineering capabilities*		*row*
2	Capability of evaluating the projects in terms of technical, economic, financial, environmental criteria and social impacts	DEC1	0.211
5	Carrying out detailed common and engineering designs in processes and products	DEC2	0.149
4	Capability to adapt to the purchased or created technology	DEC3	0.162
3	Capability of restructuring or reorganization of a purchased technology	DEC4	0.176
1	capability to plan, monitor and control the design and engineering activities of and contracts	DEC5	0.302
CR=0.027			

Table 11: Producing capability elements

rank	*Producing capability elements*		*row*
4	Capability to implement and monitor the effectiveness of converting technology in the main and auxiliary process	PRC1	0.154
3	Carry out quality assurance, inspection and inventory control	PRC2	0.198
1	Troubleshooting and capability of performing preventive and common repair and maintenance, and fixing failures	PRC3	0.351
2	Carrying out production planning and equipment scheduling and maintenance repair	PCR4	0.297
CR= 0.063			

Table 12: Service providing capability elements

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rank	*Service providing capability elements*		*row*
1	capability to detect problems, perform corrective actions (including repair, maintenance, replacement or exchange) and helping out the product	SEC1	0.295
3	capability to provide technical proposals to customers	SEC2	0.238
4	Capability to conduct research to determine the needs and demands and monitor the customers' needs and setting standards for determining levels of satisfaction with services	SEC3	0.203
2	capability to plan, monitor and coordinate the capacity of service providing, service providing activities, equipment scheduling and service personnel	SEC4	0.264
CR= 0.048			

Table 13: Elements of acquisition capabilities

rank	*Elements of acquisition capabilities*		*row*
2	capability to identify, evaluate and negotiate and finalize the acquisition of technology	ACC1	0.238
3	Capabilities to identify, evaluate, negotiate and finalize the acquisition of raw materials, supporting facilities and consumable and spare parts	ACC2	0.334
4	capability to identify, evaluate, negotiate and finalize the terms of finances	ACC3	0.112
5	capability to identify, evaluate, negotiate and finalize the terms of manpower	ACC4	0.102
3	capability to plan, monitor and coordinate processes and resources	ACC5	0.214
CR=0.039			

Table 14. Supporting capability elements

rank	*Supporting capability elements*		*row*
4	capability to provide training	SUC1	0.192
1	Strategic planning capabilities	SUC2	0.247
3	Networking and information supporting capabilities	SUC3	0.214
5	Technology sale capabilities	SUC4	0.123
2	capability to maintain a high level of safety and security	SUC5	0.224
CR= 0.019			

In addition to complete information, the sub- elements of each capability is separately prioritized.

4.3 Final results

In what follows, the research results with proposed graphs in the method of Ramanathan and Panda is depicted:

Figure 3: Results of the design and engineering capabilities

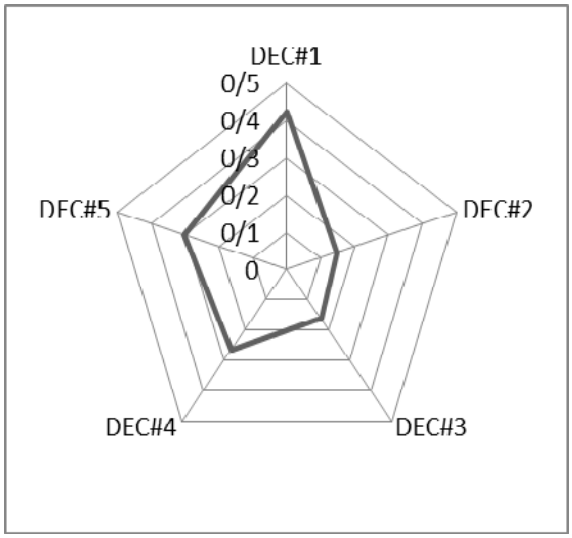

Figure 4: Results of the production capabilities

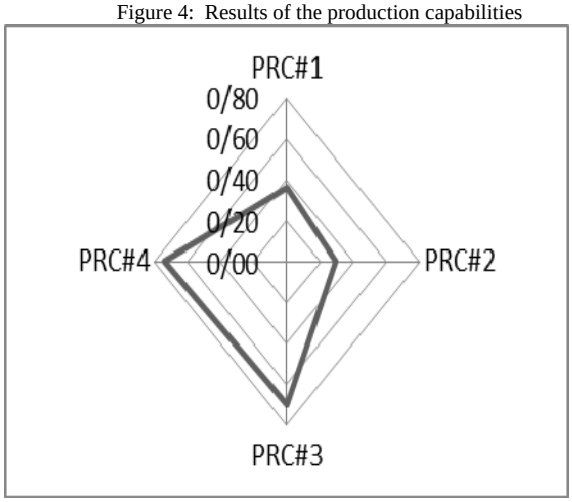

Figure 5: Results of the service proving capabilities

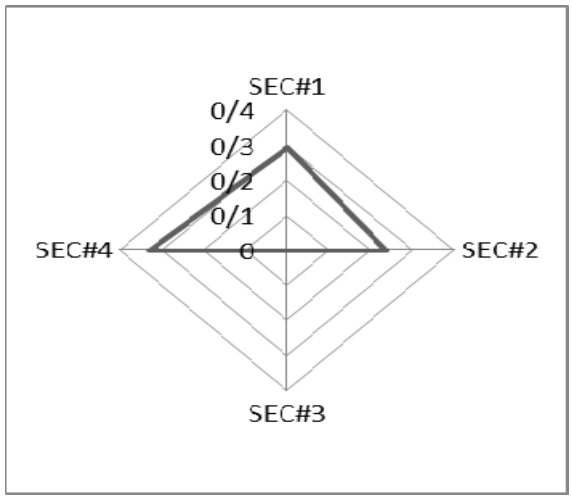

Figure 6: Results of the supporting capabilities

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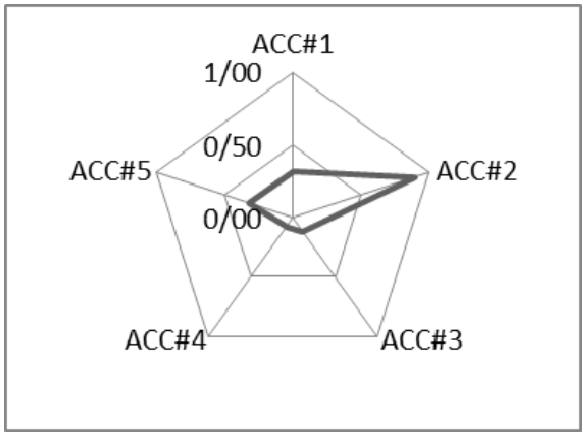


Figure 7: Results of the strategic and tactical capabilities

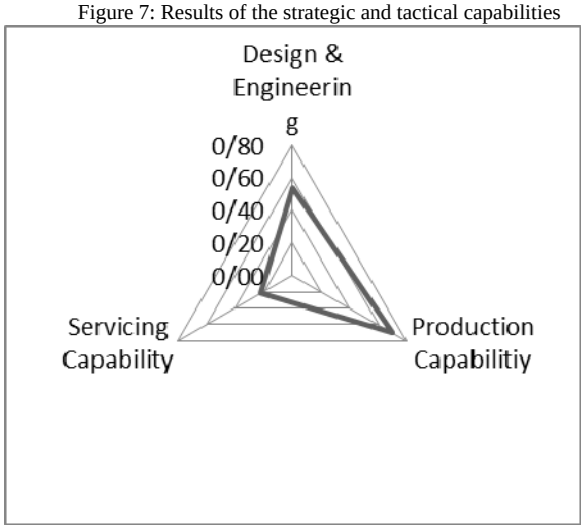
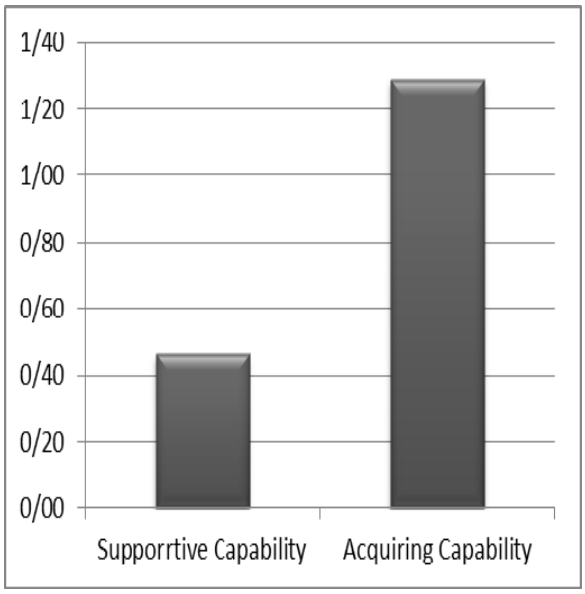


Figure 8: Results of the complementary capabilities



5. Conclusion

To conclude from the information obtained through the methodology presented in this study the following should be noted:

5.1 The capability level from 0 to 2 is considered to be low and moderate, and greater than 2 can be considered high.

5.2 The final score representing every capability that is relatively compared to the other numbers from the same class of capabilities.

5.3 through checking the above conditions, the followings can be seen:

- The low or medium existing capability level and the relatively low final number
- High existing level and the relatively low final number
- The low or medium existing level and the relatively high final number
- The high existing level and the relatively high final number

We now explain each of the above:

1. In the A status, strategic capability attraction is not that much significant that affect the number corresponding to the current level. The company can undertake activities related to this capability to other contractors and companies (Outsourcing).
2. In B status, the low final number comparing to other numbers, represent that the weight of this capability (or in other words its strategic attraction) is low. However, the number related to the current level, shows the number higher than

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2. In these cases, the company is better by new targeting, increase strategic priority of capability. In other words, either boosting or investment was done regardless of the target, or the goal related to the capability was set incorrectly.
3. In C status, we should try to strengthen capabilities, because contains a high relative final number. However, its existing level is low. Therefore, the strategic attractiveness of this capability is high and should be strengthened.
4. In D status, the level of existing capabilities is ideal and the final number too is among the high numbers. These capabilities must be exploited effectively and efficiently; and if possible, in order to gain competitive advantage and revenue, use them in other activities that are not among the main of company's work.

5.4 With respect to the above description s and figures 3 to 8, the following results can be deduced:

In the surveyed company, the capabilities are in A status (low or medium level of existing capabilities and the relatively low final number).

Table 15: Low or medium existing capabilities level with relatively low final number

Description	*Capabilities element*	*row*
Carry out detailed common and engineering designs in processes and products	DEC2	1
Capability to adapt to the purchased or created technology	DEC3	2
Capability of restructuring or reorganization of a purchased technology	DEC4	3
Carry out quality assurance, inspection and inventory control	PRC2	4
capabilities of providing and presenting technical offers to customers	SEC2	5
Capability to provide training	SUC1	6
Networking and information supporting capabilities	SUC3	7
capability to identify, evaluate , negotiate and finalize the terms of manpower	ACC4	8
capability to plan, monitor and coordinate processes of resource acquisition	ACC5	9

The company also regarding the following capability is in B status (its existing capability level is high but the relative final number is low). [2]

Table 16: The existing capabilities level is high with a relative low final number

Description	*Capabilities element*	*row*
Capability to utilize and control the effectiveness of converting technologies in the main and auxiliary processes	PRC1	1

The following capabilities are in C status (low or intermediate existing levels, relatively high final number)

Table 17: The capabilities of the existing level is low or medium with high relative final number

Description	*Capabilities element*	*row*
capability to plan, monitor and control the activities of design and engineering and contracts	DEC5	1
capability to detect problems and take corrective action (repair, maintenance, replacement or exchange) for customers	SEC1	2
capability to plan, monitor and coordinate the capacity of the service providing, service providing activities, equipment scheduling and service providing personnel	SEC4	3
Ability to identify, evaluate , negotiate and finalize the acquisition of technology	ACC1	4

Finally, the following capabilities are in D status (the existing level is high and the relative final number is high).

Table 18: Existing capabilities in level are high with a relatively high number

Description	*Capabilities element*	*row*
Capability of evaluating the project in terms of technical, economic, financial, environmental criteria and social impacts	DEC1	1
Troubleshooting and capability of performing preventive and common repair and maintenance, and fixing failures	PRC3	2
Carrying out production planning and equipment scheduling and maintenance repair	PRC4	3
Strategic planning capabilities	SUC2	4
capability to maintain a high level of safety and security	SUC5	5
capability to identify, evaluate , negotiate and finalize the acquisition of raw materials, supporting facilities, consumable and spare parts	ACC2	6

6. Suggestions

6.1 practical suggestions

- Activities related to the capabilities that are in group A, it is better to be funded from external sources. (Outsourcing)
- Activities related to the use of converting technology in the main and auxiliary process is of

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the little strategic importance, but the company has high capability in them. In the surveyed company, it is better to use the activities related to this capability in a better way. The company can use this capability as a factor to gain side incomes and provide services related to this capability for other companies and organizations.

- Those capabilities that the company is not strong in them, but they are high in weight, or in other words, are in the class C, should be strengthened in different ways. These methods can include investment, training of employees and managers, the use of new technologies in the activity related to these capabilities, promoting the culture of collaboration and coordination from the management.
- Ultimately, the Company should make use of its capability in class D in the best way and try to use these capabilities more effectively and efficiently.
- the method proposed in this study is better to be repeated in an annual process in a long-term planning period and it is better to compare the results of each year to the next (by the use of figures provided in the method). This increases the better understanding of the implications of technological decisions by managers.
- We can calculate the numbers related to each capability and the final number representing each category of the capabilities in each period, and show them ,with the numbers related to the next periods, in curves. This can result in useful information in decisions' evaluation and organization's performance, in long-term.

6.2 Research Suggestions

- It is suggested that the method presented in this study, be used for the ranking of several companies in terms of technological capabilities. In a way that, first we compare the numbers derived from this method with the numbers resulting from the implementation of this method with each other and then do the rankings on the same basis.
- The second suggestions are related to the determination of indicators to measure and perform this method in other industries. Developing indicators for measuring each of the capabilities presented by Panda & Ramanathan in other industries can also help application and development of technology management in industry and can provide indicators to measure the effectiveness of the technology strategy.
- Third suggestion refers to further studies on the nature and the identification of technological capabilities and competencies in organizations including the competitive organization. According to the resource-based viewpoint, identification and detection of capabilities and core competencies can help the organization to achieve and maintain a sustainable competitive advantage. Providing conceptual and systematic approaches and step on this issue could help organizations strategists in the formulation of strategies in various levels, including technology strategy.

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