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Technological Deep Assessment of Automotive Parts Manufacturers

Case of Iranian Manufacturers

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***Abstract*—**In order to develop any strategy, it is essential to first identify opportunities, threats, weak and strong points. Assessment of technology level provides the possibility of concentrating on weak and strong points. The results of technology assessment have a direct effect on decision making process in the field of technology transfer or expansion of internal research capabilities so it has a critical role in technology management. This paper presents a conceptual model to analyze the technology capability of a company as a whole and in four main aspects of technology. This model was tested on 10 automotive parts manufacturers in IRAN. Using this model, capability level of manufacturers was investigated in four fields of managing aspects, hard aspects, human aspects, and information and knowledge aspects. Results show that these firms concentrate on hard aspect of technology while others aspects are poor and need to be supported more. So this industry should develop other aspects of technology as well as hard aspect to have effective and efficient use of its technology. These paper findings are useful for the technology planning and management in automotive part manufactures in IRAN and other Industries which are technology followers and transport their needed technologies.

***Keywords*—**Technology, Technological evaluation, Technology Maturity

I. INTRODUCTION

NOWADAYS, technology plays a crucial role in firms' competitiveness. It needs therefore, like other sources of competition, to be managed based on a strategic point of view [1].Strategic view of technology must consider different aspects of technological capability of the firm and therefore assessing the technological capability will lead to better strategic planning and technology development[2,3]. In addition, the assessment processes, improves quality and broadens existing and potentially new technology bases of a company [4]. The assessment also benchmarks and identifies the strengths and weaknesses in a company [4] and will improve the ability of strategic technology planning and technology development in a company.

Based on this, technological assessment is a critical diagnosis that a firm should do to be survived in today's dynamic environment. So Technological assessment is an important part of technology management [5], that involves decision makings which are critical to the profitability and growth of a company in an increasing competitive global scenario [6]. It is more and more difficult to clarify the right technological plan because the number of technologies is increasing and technologies are becoming more and more complex [7]. As a result, Industrial enterprises are faced with complex and multi criteria decision problems in organization technological assessment and selection [7].

It is clear that Technological assessment processes requires the analysis of a large number of economic (tangible) and analytical (intangible) factors in a decision support environment [6]. According to Yap and Souder [8] several characteristics of technologies should be taken into account in any technology assessment model [9]. There are many published definitions of technology. Examination of these definitions highlights a number of factors that characterize technology, which can be considered as a specific type of knowledge. While technology is often associated with tools and engineering ('hard' technology), the processes which enable its effective application are also important, for example managing processes, together with organizational structures and supporting communication / knowledge networks ('soft' aspects of technology). So technology is a combination of "hardware" (buildings, plant and equipment),"software" (the way to operate the hardware) and "know-how" (skills, knowledge and experience together with suitable organizational and institutional arrangement[10]. according to above definition it is necessary to assess companies based on the all aspects of technology to derive right conclusions in order to plan for future. So that this paper assessed the technological maturity of Iranian auto part makers in all aspects of a technology as well, based on the technology capability the companies should develop their strategies in a way to support their technological maturity. The incorporating technological maturity measures into the TSM[1], assists the decision makers to adopt, adapt, absorb and utilize of the appropriate technologies. From the perspective of technology management, different activities like identification, assessment, selection, acquisition, utilization and protection of technology are very important [2], therefore technology capability assessment will lead to better management of technology.

In the following, at first a revision of technology definitions and different aspects of its nature is provided as a literature

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[1] Technology strategic management

review and then a revision of different models in Technology Capability Assessment with their efficiencies are presented, then a model is developed to analyze the companies technologically with applicable indexes in IRAN, and then in section4, using questionnaire, the capability level of automotive parts manufacturers with 95% of confidence are assessed. Based on the gathered data then the paper in section 5 conclude the level of technology development in Iranian automotive parts industry, by using Freidman test as well as Binomial test to define whether they are technologically Matured. The paper is finished with some suggestions which are prepared to develop the technology capability in these firms.

II. LITERATURE REVIEW

A. Technology and it's nature

Technology has been defined in many ways. Some authors are defining technology as process of converting inputs into outputs with the aim of facilities and methods [11]. According to Wyk (1988), "Technology is a created capability: it is manifested in artifacts the purpose of which is to augment human skill". Key concepts include:

- *Created.* Technology is not a free gift of nature: it does not come about by itself. It is the product of deliberate action. If technology is to be employed as a resource, it has to be cultivated, nurtured and supported.
- *Capability.* This concept refers to a particular type of skills, namely that of manipulating aspects of the physical world.
- *Artifacts* This is the generic term for all devices, tools, instruments or machines. Artifacts are the repositories of capability.
- *Augment.* This concept is used to convey two meanings: on the one hand enhancing human ability, such as adding instrumentation to human activity, and on the other hand replacing human ability, by substituting it with competent artifacts [12].

With another definition, Smith (1986) mentioned that technology is the application of knowledge, scientifically derived or otherwise, to the creation or modification of things and processes, same as smith, Aldridge's (1990) definition of technology is: "Technology depends on (cannot exist without) knowledge of how to apply other knowledge to create or modify useful things or processes where knowledge has been derived scientifically or otherwise."

Draaijer and Boer (1995) define technology as comprising not only plant and equipment (physical) but also the knowledge and experience (know-how) of the people. In another definition, Technology is a combination of means, such as hardware, software and skill associated with a specific field of technical competence [13].

In one classification, technology can use in different meaning:

- Usage 1: Hardware (or Artifact): Possible denotation: non-natural objects, of all kinds, manufactured by humans.
- Usage 2: Socio technical System of Manufacture. Possible denotation: all the elements needed to manufacture a particular kind of hardware, the complete working system including its inputs: people; machinery; resources; processes; and legal, economic, political and physical environment.
- Usage3: The information, skills, processes, and procedures for accomplishing tasks: Possible denotation: Knowledge, Technique, Know-How, or Methodology in the usual sense of these words.
- Usage4: A Socio Technical System of Use, is a system using combinations of hardware and people (and usually-other elements) to accomplish tasks that humans cannot perform unaided by such systems - to extend human capacities [14].

In the APCTT (1989) definition of technology, there are four elements:

- Techno ware: hard aspect of technology like facilities and machines.
- Info ware: soft aspect of technology that showing the information and explicit knowledge of technology.
- Human ware: soft aspect of technology that showing the tacit knowledge in human activities.
- Orgaware: soft aspect of technology that showing the organizational aspect of technology [15].

Therefore, technology has hard and soft aspects in combination and facilities, skills and knowledge is the most important elements of technology [16]. The nature of technology is not just explicit but it has important tacit elements. The nature of technology has two aspects; the first aspect is explicit in the form of information and can easily move from one place to another place; and second aspect is tacit in the form of Firm-specific Knowledge and can not easily move from one place to another place [17, 18, 19 and 20].

Considering the tacit and explicit elements in organization technologic evaluation, is an important conclusion for the proposed model. Based on these arguments the paper tried to study different approaches of technology assessment and analyzing them from how they consider the tacit and explicit elements of technology. In the following we will address some important aspects of different approaches in technology capability assessment.

B. Technology capability assessment approaches

There are different approaches in organization technological evaluation which is called technology auditing in literature as well. Some of these approaches are broad and encompasses all aspects of technology in the organization, but some of them have narrow approaches about technology in an organization. As a simple definition, technology auditing, evaluates the internal technology status of an enterprise and compares it with the state of the art in the world. It then matches the management capabilities of the enterprise with its technological standing.

APCTT (1989) has a method for technology capability assessment with four dimensions that include technoware, infoware, humanware, orgaware. In this method, first the

complexity of each dimension is assessed then they'll be compared with state of the art of technology. So it has a quantitative approach to technology auditing while it has consideration on all aspects of technology within an organization. In this model both the tacit and explicit aspects of technology are analyzed in technology capability assessment [14].

Phaal et.al (2001) developed a methodology for technology management assessment. They extended the work of Gregory (1995) which presented the five processes model of identification, selection, acquisition, exploitation and protection [21]. They focused on the main functions of technology management and developed a model to assess different levels of technology management in an organization. Their assessment approach consists of three main stages:

I. The strategic overview, defines a framework for linking technology with business objectives and enables selection of areas for more detailed appraisal
II. The process overview, focuses on the business technology area selected in stage (I), mapping and assessing technology management activities (Gregory's five processes model) leading to the identification of specific processes for more detailed assessment.
III. The process investigation focuses on mapping and assessment of specific process areas during stage (II) [2].

The aim of this approach is to undertake a structured evaluation of a firm's technology management practices and to identify areas for improvement. This approach is qualitative, it is not focusing on the content of technology but it focuses on the functions of technology management and its strengths and weaknesses as a tool, in order to develop key technologies in organization.

Another approach that has similarity with Phaal's approach is Ford's approach (1996). In this approach, technology capability of an organization is equal to technology management capabilities in selection, acquisition, utilization, development and diffusion of technologies. This approach is very qualitative and it doesn't focus on the content of technology but focuses on the functions of technology management [22].

Panda and Ramanthan (1996) suggest a model with five-step in conducting technological capability assessment. The steps are:

I. identification of value addition stages
II. identification of the technological capability needed to perform the necessary value addition
III. development of a set of indicators for assessing each technological capability
IV. benchmarking of technological capability of the firm for the state-of-the art company, finding the existing level of technological capability
V. Determination of the gaps in technological capability [4].

This model is based on the evaluation of organizational capability in value creation and assesses technology according to these main criteria. It is both qualitative and quantitative approach for technology capability assessment and it considers all aspects of technology in an organization. In this model both the tacit and explicit aspects of technology are analyzed in technology capability assessment.

Porter (1985) with considering organizational value chain, proposed some implications for technology assessment in organization. Technologies are divided into two categories with respect to organizational value chain: core technologies and support technologies. In this model, based on the process approach, assessment of technologies will lead to performance assessment of whole organizational value chain. This approach is qualitative and it considers all aspects of technology in an organization but it does not consider the content and complexity of technology and just focuses on the output and performance of technology. In this model just the explicit aspect of technology is analyzed in technology capability assessment and tacit aspect is not considered [11].

Chiesa (2001) considers the technology assessment and selection in the process of technology strategy and R&D strategy. This approach will lead to prioritization of technologies and provide the condition for technology selection and development. It is very qualitative and has not a broad approach for technology capability assessment in an organization [23].

Wet (2002) suggests a 3-dimensional matrix, which is hierarchy, fundamental functions and business cycles. The important steps in the technology assessment are:

- identify the current technologies in the various sublevels,
- characterize each technology in terms of people, processes and system requirements,
- map the different technologies in the framework according to the characteristics of the fundamental functions, life cycle and hierarchy,
- do a projection of the technology map onto the process map; this projection indicates which technologies are empowered by which processes,
- Quantify the impact of the technology on the company, using various analytical techniques [12].

It is both qualitative and quantitative approach for technology capability assessment and it has a broad approach about assessment of technology in an organization. With respect to these approaches, we can design an integrated model based on holistic approach to technology capability assessment in organization and considering both qualitative and quantitative indicators with analyzing both the tacit and explicit aspects of technology. As a conclusion, When we observe the typical outcomes of technology management and investments in technology appraisal, There is still a wide variation in how evaluation of technology is carried out and the results that are achieved [24, 25]. What has been learnt so far however, is that as organizational goals and circumstances change, so should the appraisal process [26]. However, the process and nature of evaluating and making technology

decisions requires continual experience and applied knowledge in order to succeed.

III. Survey Methodology

A. Conceptual model

In this section we propose a conceptual model for assessing the Technological Capability of Manufacturers. The proposed Model has a holistic approach to technology capability assessment within organization and considers both qualitative and quantitative indicators with analyzing both the tacit and explicit aspects of technology. The proposed model is shown in the figure 1. Based on the variety of approaches reviewed in the Literature, different aspects of the conceptual model are developed.

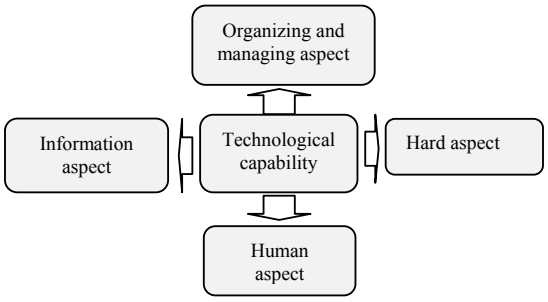

Fig.1: conceptual Model for Technological Capability Assessment

Managing and human aspects of technological capability have more tacit knowledge, But hard and information aspects of technological capability have more explicit knowledge. Based on these arguments, we prepared our conceptual model and different indicators were selected to assess different aspects of technological capability in Automotive Parts Manufacturers.

B. Tools and validity

Above model consists,11 indicators in Human aspect as well as 6 indicators in Information aspect and 53 indicators in organizing and management aspect and 33 indicators in hard aspect.

In order to implement the model, we need to develop data gathering tools, so both of the questionnaire and the interview are used in complement of each other to gather the data of indicators in four dimensions as well. Seven point Likert's scale is used to the questionnaire. In order to compare the various indicators with each other, the gathered data were normalized within zero and one. Zero represents the lowest in capability and one represents a highest in capability.

After developing the questionnaire it was evaluated by 30 experts and managers of Automotive Parts Manufacturers as a content analysis with the Delphi method, With respect to their comments modifications have done to some of the indicators and the final questionnaire developed. So the proposed model validated with the expert opinions, and Cronbach's Alpha was used for reliability analysis, which was about 73%.

C. Case study

Automobile industry actually is one of the most important manufacturing industries in IRAN, which is supported by the government as well as the private sector. It has a critical role in Iranians national economy and job creation. Within this, Automobile parts Manufactures as the main suppliers play a significant role in this production process. Therefore, focusing on their capabilities and developing strategies especially in technology management will enhance their effectiveness and efficiency and plays a crucial role in developing economy.

After developing model of technological assessment for the Manufacturers in order to test the validity, it was implemented in 10 Automotive Parts Manufacturers in IRAN. We assessed the quantitative and qualitative indicators of this model, with questionnaire and deep interview and the real data from these companies. The results were suitable in comparison to the mental models of the managers, so the model was valid in their view.

In addition to implementing model to technological assessment of the case firms, we used some nonparametric statistical techniques in order to generalize the results to other Iranian Automotive Manufacturers. So the following hypothesizes are developed in order to deep understanding of the technology maturity in Automotive parts industry in Iran and at the end to enable the ability of developing suitable technology management strategies at Business level.

Hypothesize1:The technology dimensions (in the conceptual model) are proportionally developed in IRAN Automotive parts industry.

Hypothesize 2:The overall technology is matured in IRAN Automotive parts industry.

$H_{2.1}$: The Hard dimension in technology is matured in IRAN Automotive parts industry.

$H_{2.2}$: The Human Dimension in technology is matured in IRAN Automotive parts industry.

$H_{2.3}$: The Management Dimension in technology is matured in IRAN Automotive parts industry.

$H_{2.4}$: The Information dimension in technology is matured in IRAN Automotive parts industry.

IV. Research Findings

A. Case results

After gathering the Data and analyzing them, the final results of the implementation of model in 10 Automotive Parts Manufacturers as an overall technology maturity is shown in the figure2. At the following, we conclude the result of assessing Iranian automotive parts Manufacturers. As it mentioned before, one represents the highest maturity and zero represents the lowest maturity. It's clear that X_1 has the higher technological capability within these 10 manufacturers. Due to Confidentially reasons, the case names are not mentioned here.

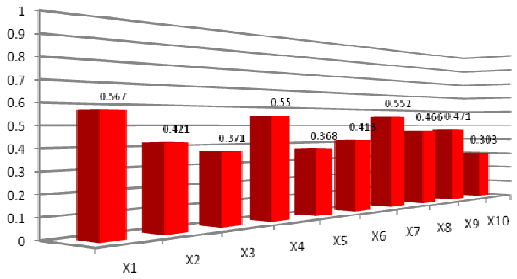

Fig. 2: Overall technological capability of 10 Manufacturers

In addition to that Table 1 exhibits the capability scores of each Manufacturer in four dimensions of technology. Based on the conceptual model four dimensions are: Hard aspect of technology, Human aspect of technology, Management aspect of technology, Information aspect of technology. Each of these dimensions refers to an important aspect in technology management and its productivity.

TABLE I TECHNOLOGICAL CAPABILITY OF THE MANUFACTURERS IN FOUR ASPECTS

Technology dimensions		N	Subset for alpha = .05	
		1	2	1
Tukey B(a)	Management	10	.3873	
	Human	10	.4217	
	Information	10	.4366	
	Hard	10		.5527

Table 1 shows that within these Manufacturers, organization and management aspect of technology is so poor (0.387) and Hard aspect which is related to machinery and tools is the highest (0.553) in comparison to the other aspects. Human aspect (0.422) is not matured as well as Information aspect (0.437). In addition to that we can analyze the table.1 for each automotive manufacturer, for instance X_1 has a great capability in information and hard aspects but has weakness in Human aspect or X_{10} has weakness in all aspects as a whole.

B. Generalization to IRAN's Automotive Manufacturers

In this section by using statistical techniques like Binomial Test and Friedman Test as well as One way ANOVA the paper try to whether accept or reject the Hypothesizes developed in section 3.3. The first hypothesize was: Hypothesize 1: The technology dimensions (in the conceptual model) are balanced developed in IRAN Automotive parts industry. These hypothesize means that whether the Manufacturers developed the four aspects of technology in balance way or they concentrate on some aspects more than others. To test this hypothesizes ANOVA and Friedman test is used. The results are exhibited in Table 2.

TABLE II COMPARING THE MATURITY IN TECHNOLOGY DIMENSIONS

ANOVA test	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.155	3	.052	4.319	.011
Within Groups	.429	36	.012		
Total	.584	39			
Freidman test	N		Df	χ^2	Sig.
Between Groups	10		3	13.149	0.004

Based on results we reject the idea of having the same mean between groups. So Technology dimensions are not developed in a balance way. At least one dimension is different from the others. In order to define the differences the Tukey test is applied. The results are shown in table 3, concludes that the Hard aspect is different and in higher maturity level within the four dimensions at investigated industry in IRAN.

TABLE III TUKEY TEST RESULTS

Technology aspects	Average	S.D	X_1	X_2	X_3	X_4
Hard	0.55	0.07	0.64	0.61	0.59	0.60
Human	0.42	0.07	0.47	0.37	0.30	0.49
Management	0.39	0.11	0.56	0.35	0.31	0.54
Information	0.44	0.15	0.68	0.35	0.30	0.66
Hard	X_5	X_6	X_7	X_8	X_9	X_{10}
Human	0.50	0.51	0.50	0.62	0.56	0.40
Management	0.40	0.43	0.53	0.46	0.45	0.32
Information	0.35	0.30	0.50	0.36	0.40	0.20
Hard	0.18	0.48	0.50	0.43	0.45	0.35

In order to test the hypothesize 2 and its minor hypothesizes, the Binomial test is used. This test is done for each dimension separately, H_0 represented the immaturity and the H_1 represented the maturity of each dimension in technology. By rejecting H_0, results show maturity in that dimension.

$H_0: \mu \leq 0.5$
$H_A: \mu > 0.5$

The results are represented in table 4. Based on these results it can be concluded that the whole Technology is not matured, human and Management and Information aspects of technology are not matured as well but the hard aspect is matured in IRAN Automotive Industry.

V. CONCLUSION

In this paper a conceptual model is developed to assess the companies technologically. Based on the developed model the automotive parts manufacturers in Iran are evaluated by using the questionnaire and deep interview. Gathered data are normalized to scale of 0 to 1 in order to compare the various scales within the gathered data. These manufacturers' technologies are evaluated in four dimensions in comparison to each other. Also the validity and reliability analysis on the research tools and the proposed model have been done.

TABLE IV THE BINOMIAL TEST

		Category	N	H_0	Exact Sig. (1-tailed)	Decision
Technology overall	Group 1	<=0 .5	7	$\mu \leq 0.5$	.650	Accept
	Group 2	>0 .5	3			
Hard	Group 1	<=0 .5	4	$\mu \leq 0.5$	.047	Reject
	Group 2	>0 .5	6			
Human	Group 1	<=0 .5	9	$\mu \leq 0.5$	.149	Accept
	Group 2	>0 .5	1			
Management	Group 1	<=0 .5	8	$\mu \leq 0.5$	.383	Accept
	Group 2	>0 .5	2			
Information	Group 1	<=0 .5	8	$\mu \leq 0.5$	.383	Accept
	Group 2	>0 .5	2			

Statistical techniques like Binomial Test and Friedman Test as well as One way ANOVA are used in order to analyze the gathered data. Findings show that Iranian automotive parts Manufacturers have not right understanding of technology, they concentrate on that technology as a hardware (i.e. machinery) instead of considering all aspects in technology. According to the results mentioned above it is clear that these manufacturers have got problem in their technology roadmap and they need to improve their understanding of technology if their strategy is being competitive. Shortcomings of looking at technology just as a hardware is significant in Iranian's manufacturers specially in Auto Industry. This survey's main idea is to magnify the soft dimension of technology and it's role, in technology management which is ignored in the case studied here.

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