CME LIVE OPEN ACCESS

Archives of
Humanities & Social Sciences Research

Research Article

# Pathology of Factors Affecting the Use of Technology Management Tools and Techniques (Case Study: Iranian Industries)

**Mohammad Taleghani[1*] and Ataollah Taleghani[2]**

*[1*]Associate Professor, Department of Industrial Management, Rasht Branch, Islamic Azad University, Rasht, Iran.*
*[2]Research Assistant, Ted Rogers School of Management, Toronto Metropolitan University, Toronto, Canada.*

**Corresponding Author:** Mohammad Taleghani, Associate Professor, Department of Industrial Management, Rasht Branch, Islamic Azad University, Rasht, Iran.

**Received:** 2024 Feb 02 **Accepted:** 2024 Feb 22 **Published:** 2024 Mar 03

## Abstract

The technology management discipline is silent about presenting a coherent set of tools and techniques that could be used to manage technology. Furthermore, the literature does not attempt to understand how the usage of technology management [TM] tools and techniques could affect firm performance. This study deals with three interrelated questions: 1) what TM tools are used in practice? 2) Do TM tools affect firms' performance and 3) Which factors determine the usage of TM tools? After a short introduction on TM tools and techniques, the paper will present the importance of the subject matter. Next the empirical study will be summarized. Based on a survey of 52 electronic and machinery firms in Iran, the study finds a number of interesting results. The statistical analyses show that there are significant relationships between the number of total TM tools and techniques that a firm uses and (i) the hierarchical level of the chief technology officer (CTO) or the manager who is responsible for the technology in the firm, (ii) the field of education, and (iii) the number of employees, or in other words the size of the firm. More importantly, the findings indicate a significant and linear relationship between the extent to which the firms have reached their growth targets and the number of TM tools and techniques used by them. This relationship is, however, not observed between firm profitability and the number of TM tools and techniques. The findings have important implications for the practice of TM and confirm the role of technology management for firm performance.

**Keywords:** CTO, Technology Management, Technology Management Tools, Performance.

## 1. Introduction

Considering that technological changes are continuously creating new challenges and opportunities for new product, service, process, and organizational development and industrial diversification, these opportunities need to be captured and converted into value through effective and dynamic TM. The effective and dynamic management of technologies require a set of skills and knowledge where the use of TM tools plays a key role. However, the literature is silent about TM tools.

The TM discipline has a history of over 50 years [Roberts; Larson] but it's becoming a self-sustained discipline has been considered to take place in the last 20 years [Allen; Roberts; Ball and Rigby]. This sub-management discipline is still struggling to agree on a few key pillars forming the body of TM. Among these pillars, this study chooses to analyze TM tools that are widely used in practicing TM activities.

In particular, this study aims to understand three critical questions:

- What practitioners are using in their daily operations and perceive as TM tools?
- What is the relationship between the use of TM tools and firm performance?
- What factors determine the effect of the use of TM tools on firm performance?

This paper consists of 5 parts. After this short introduction, section 2 lays down the background for research questions by presenting the results of a literature survey. Then, the methodology of the empirical study is introduced. The results are presented at length in section 4. The conclusion section offers several remarks for strategy and policy makers in developing countries and ends with limitations of the study and a few generalizable comments for advanced countries.

### 1.1. Technology Management Tools and Techniques

TM can be conceived as the development and exploitation of technological capabilities that are changing continuously [Cetindamar et al., forthcoming]. Capabilities might be dynamic or operational [Helfat and Peteraf]. Dynamic capabilities build, integrate, or reconfigure operational capabilities that are defined as 'a high-level routine [or collection of routines] that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type' [Winter]. Defined as such, technological capabilities consist of both dynamic and operational capabilities that are a collection of routines/activities to execute and coordinate the variety of tasks required to manage technology.

Management discipline consists of not only about knowledge but also a wide variety of skills among which the ability to use managerial tools in practice is a critical one. The value of management tools is occasionally brought into question since most of the time it is seen as some form of crutch which managers deploy instead of thinking creatively [Brady et al.,]. Even though the management literature has few exceptions [Powell], in the practice there are many studies investigating what strategic processes and tools are most often used by boards and senior management groups in practice. One such study is conducted by a consultant firm called Bain & Company management whose tools study goes back to 1993. In 2005, Bain & Company surveyed 960 global executives to find out the use of 25 major management tools. Accordingly, the most widely used tool to help run their businesses was strategic planning [79 percent of respondents], while mission and vision statements were reported as widely used by 72 percent and change management programs were reported by 59 percent.

Even though management discipline has been developing both general tools used across sub-disciplines [such as finance and marketing] and specific tools devoted to sub-disciplines, TM literature barely offers such a list of tools relevant to managing technology in companies even though it has been mentioned as a necessity in 1997 [Brady et al.,]. This paper is an attempt to offer such a tentative list to work on. Identifying the major tools that facilitate the development and application of technological capabilities is particularly important to offer practical guidelines to apply and reinforce TM concepts within the business so that managers can incorporate TM into their daily routines.

There are a variety of terms used interchangeably such as 'tools', 'techniques', 'procedures', 'processes', 'models', 'maps' and 'frameworks. This study will adopt the definition used in Phaal et al.'s study (2006): "in the broadest sense, tools include devices for supporting both action/practical application and frameworks for conceptual understanding".

The literature is highly confusing in terms of supplying TM tool lists. A study [Cetindamar et al.,] has searched eleven of the twelve main TM journals for the period of 1995 and 2005 using the ABI ProQuest and Elsevier ScienceDirect databases to find out articles using phrases of "technology management" and "tool" at the same time. The results indicated 122 articles but the analysis of these articles show that there is no study grouping all TM tools but rather a few studies that group TM tools developed for a particular purpose. For example, the study of Henriksen (1997) classified eight types of tool categories used in technology assessment: economic analysis, information monitoring, technical performance assessment, decision analysis, risk assessment, Systems Engineering/Systems Analysis, market analysis, Technological Forecasting, and Externalities/Impact Analysis.

A recent study [Liao] reviews the literature from 1995 to 2003 on the basis of TM methodologies and applications. Based on the scope of 546 articles of TM, the paper classifies TM methodologies in eight categories:

- TM framework,
- General and policy research,
- Information systems,
- Information and communication technology,
- Artificial intelligence/expert systems,
- Database technology,
- Modelling, and
- Statistics methodology.

These categories are very broad and their connections with actual applications are hard to understand even though some examples are given. To illustrate, the list of applications mentioned for the TM framework category are the followings [Liao]: computer integrated manufacturing, construction project management, business process reengineering, project appraisal, product design, space disaster management, technology assessment, process design, engineering design, and knowledge management.

The confusion on the definition and listing of TM tools also exists in the major TM handbooks [such as Dorf and Gaynor]. There is no clear description and discussion on the methodologies, tools, and techniques published in these handbooks. For example, Gaynor's methodologies section has seven chapters in the following titles: tools for analyzing organizational impacts of new technology [techniques such as checklists]; forecasting and planning technology; knowledge mapping: a tool for management of technology; the process of developing an R&D strategy; decision support systems in R&D project management; enterprise engineering in the systems age; and managing the "technology gradient" for global competitiveness. The lack of systematic gathering of the tool lists makes them difficult to operationalize. Similarly, Dorf's list (1999) in the tools section of the handbook includes financial tools such as cash flow, legal issues [with no tool reference], information systems such as database and decision support systems, and finally decision and simulation methods such as value-focused thinking and uncertainty.

The only comprehensive coverage of TM tools was carried out by an EC project published in 1998. As the outcome of this project, Temaguide had an explicit goal of explaining different TM tools [Cotec] and grouped them under six headings on the basis of their functions in a company:

- tools used for external information analysis such as technology forecast and benchmarking;
- tools used for internal information analysis such as skills and innovation audit;
- tools to calculate workload and resources needed in projects such as project management and portfolio management;
- tools to manage working together such as interface management and networking;
- idea creation and problem-solving techniques such as

creativity and value analysis; and
- tools related to improving efficiency and flexibility such as lean thinking and continuous improvement.

Brown and Farrukh et al. list some principles of good practice for tool design such as: "founded on an objective best-practice model; simple in concept and use; flexible, allowing 'best fit' to the current situation and needs of the company; not mechanistic or prescriptive; capable of integrating with other tools, processes and systems; result in quantifiable improvement; and support communication and buy-in". The base of delineating a toolkit of TM might be simplicity and flexibility of use, degree of availability, and standardisation level. In this study, based on a literature survey [Cotec; Cetindamar and Ansal; Cetindamar, Can and Pala; Phaal et al.,], a preliminary list of TM tools is identified and given at Appendix [DILEK: buraya appendix table yapalım]. As observed in many studies trying to form lists such as the list of innovation management tools [Hidalgo and Albors], the TM list is also inevitably subjective but the authors are confident that the broad scope of tools is appropriate for an initial attempt. There should be a point of start before it becomes possible to list the core TM tools similar to what Straker (1995) does for quality improvement and problem solving. Straker (1995) argues that the toolkit consists of seven tools and interestingly they together can solve 90% of all problems. The TM literature is far behind of even accepting a list of TMs in general.

Measuring the adoption of tools listed in this study is one of the two key tasks set as the goal of this paper. The second task is to find the impact of the use of TM tools on firm performance and final task is the observation of the factors determining the relationship between the use of TM tools and firm performance. Knowing that many tools are used without proper assessment of the evidence supporting their applicability and effectiveness, identifying the right tool to do a job is a necessity for good practice in TM.

The first task of this study is to explore the adoption of TM tools among firms so it is more of an explorative nature. That is why there are no hypotheses. However, the second task aims to observe the relationship between the use of TM tools and performance. Regarding this relationship, the study holds a hypothesis.

TM might be seen a sub-field similar to Total Quality Management [TQM]. Both of them are trying to increase the competitiveness of firms either by using technology as a resource or by using quality as a source, respectively. As a study on TQM shows, if a resource does produce economic value, firms that have more of that resource should outperform the firms that have less resource overall [Powell]. Therefore, the following hypothesis acts as an initial test of the economic value of TM:

Hypothesis 1: Firms engaged more with TM tools outperform firms using less tools.

Analyzing the relationship between the use of TM tools and performance brings another interesting question into mind: what are the factors influencing the contributions of TM tools?

Management literature is overwhelmed with the analysis of CEO and firm performance [Finkelstein and Hambrick; Jayaraman et. al; Wood and Vilkinas]. However, the performance impact of other executives such as CIOs or Chief Operation Officers [COOs] is not generally studied with few exceptions [Smaltz et. al; Hambrick and Cannella]. To our knowledge, there is no study carried out to observe the relationship between CTOs and performance. Therefore, by using the studies analysing CEO and firm performance, we will make some analogies for our study.

Accordingly, it is expected that top management's demographic effects are likely to be strongest under conditions of high uncertainty [Yan et. Al.,]. This is particularly important for technology managers that deal with new and radical technologies in a dynamic environment. Further, the influence of executives on their organizations is assumed to be a product of their experiences and educational background as well as age, socioeconomic roots, financial position, and functional tracks [Hambrick and Mason]. In other words, human capital is the key determinant in generating value to their firms [Mayo]. Here, human capital is defined as "the knowledge, skills, competencies and other attributes embodied in individuals that are relevant to economic activity" [OECD, 1998].

This paper concentrates on educational background and experiences of a CTO or a CTO-proxy manager as the main human capital traits [Hitt et.al.,]. Higher levels of education are associated with a manager's ability to generate and implement creative solutions to complex and new problems in organizations [Kimberly and Evanisko; Yan et. al.,]. Technology management will necessitate to deal with complex problems demanding innovative and highly technical solutions, so any technical education will help to improve the performance. In addition, Carpenter and Fredrickson's study (2001) show that diversity may help top management in overcoming the information overload, complexity, and myopia. This is particularly important for technology managers. So, the hypothesis is:

Hypothesis 2: Educational background in technology fields will positively influence the relationship between the use of TM tools and performance.

Another significant characteristic is CTO's or CTO-proxy manager's experience in the company, namely tenure. The years of inside service by a manager is negatively related to strategic choice involving new terrain such as innovation and technology [Hambrick and Mason]. A number of studies also suggest that managers tend to make fewer changes in strategy as their tenures increase because of their commitment to status quo [Yan et. al.,] Keeping status quo might be good for a cost-based strategy but it might not be a good to pursue new opportunities and bring new technology applications into firm as expected from a CTO [Kathuria and Port]. By taking these concerns, the second hypothesis related to human capital becomes:

Hypothesis 3: Experience in the company will negatively influence the relationship between the use of TM tools and performance.

However, it is important to consider that a CTO might have skills and experience, but his/her use of TM tools might not affect firm performance unless a CTO is influential at the top management that will help him/her to carry out CTO functions effectively. Smaltz et. al. particularly emphasized how the hierarchical level of the CTO within the organization influences the firm performance. Thus,

Hypothesis 4: Hierarchical level will positively influence the relationship between the use of TM tools and performance

To achieve these three key tasks of the study and analyses four hypotheses, a survey is sent to CEOs in order to observe the degree of their adoption and how these tools influence performance. The survey is conducted in Turkey particularly for two reasons. Turkey is a developing country with the majority of technologies imported from abroad. If the use of TM tools and their effectiveness can be measured, it might become possible to develop strategies for managers how to improve their skills and knowledge. Managing boards need to be well-informed and aware of the pitfalls of adopting novel and unproven methods of decision-making while managing technology. In addition, policy makers might contribute to the development and adoption of the most useful tools that will increase productivity of technology use in companies.

**1.2. Empirical Study**

Data: In Iran finding the actual number of firms in an industry or the addresses of such companies is highly difficult. Therefore, one reasonable source of data is business associations that keep track of their members. The research team approached two business associations: The Association of Machine Manufacturers and the Iranian Electronics Industrialists' Association, who both kindly agreed to share their information with the team. The members of these two associations were chosen mainly due to their representative power of their industries and because the directors of these associations argued that their members accounted for more than 80% of local sales in their respective industries. Thus, the members of these associations constituted the population, consisting of 267 firms. The data was collected using a questionnaire developed by the authors based on two separate questionnaires: one developed by the European Institute for Technology and Innovation Team [EITIM] [Herstatt et. al.,] and one used in another empirical study [Cetindamar and Ansal]. Prior to sending the survey by post, semi-structured interviews were conducted with 15 firms in order to refine the questionnaire. Six of the pilot firms were from the machinery industry and the remaining nine were from the electronics industry. While identifying companies to interview, the two business associations guided the research team towards companies believed to have good technology management practices.

Measures: The final questionnaire, by and large, consisted of questions with 5-point Likert scales; however, there were a few binary response questions and open-ended questions. Considering the fact that the CTO position does not exist in all companies, the questionnaires were directly sent to the firm CEOs and they were asked to direct the questionnaire to the most senior executive responsible for technology management practices within the company. In cases where no senior manager existed, the CEO was requested to fill out the questionnaire. Since 15 firms were interviewed, the questionnaire was sent to the remaining 252 firms twice by regular mail with a time interval of a month between the two mailings. The package sent included both the questionnaire and a prepaid envelope by which the completed questionnaires could be returned.

Excluding the interviews, there were responses from 37 companies, with a 15% response rate. The 15 interviewed companies were then re-contacted to fill the missing questions that were not included in the initial interviews but were later added to the postal survey instrument. The resulting database thus had 52 companies, increasing the response rate to 20%.

In this study, our objective is to study the factors affecting the number of TM tools and techniques used by firms and the nature of the relationship between the firm performance and the number of these tools and techniques used by firms. Therefore, the primary dependent variable in this study is the number of TM tools and techniques used by the firm. This dependent variable, in turn, will be used as the independent variable for two other dependent variables, namely, the growth performance, and the profitability performance of the firms.

Fifty different TM tools and techniques are listed for eleven fields of TM activities in the questionnaire [the list of tools and techniques and their field(s) of TM activity is given in Appendix A]. As shown in Table 3.1, while the average number of TM tools and techniques per firm is 17.13, the TM activities with a higher average number of TM tools and techniques are "R&D management", "technology strategy," and "knowledge management, organization of technological activities".

**Table 1: Number of TM tools and techniques used under each TM activity.**

| TM activities | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| R&D management | 0 | 7 | 2.48 | 2.03 |
| Technology strategy | 0 | 7 | 2.42 | 1.41 |
| Knowledge management, organization of technological activities | 0 | 6 | 2.37 | 1.27 |
| Technology planning and forecasting | 0 | 6 | 1.87 | 1.55 |
| Technology acquisition, transfer, dissemination | 0 | 6 | 1.85 | 1.59 |
| Total | 1 | 45 | 17.13 | 10.33 |

This study uses the most global financial performance criteria: profitability and growth. The respondents are asked to rate the profitability or growth of their company in the last five years on a 5-point Likert scale. No actual data is asked since firms' reluctance to openly provide their profitability or growth rate was observed during the interviews. The study thus relies on the respondents' accuracy, since the majority of firms are private companies and no secondary data exists to confirm their data. However, subjective performance measures are widely accepted in organizational research [Powell].

Thus, to measure a firm's performance, two variables are used: the extent to which the firm has reached its growth and profitability targets in the last five years. In the original EITIM questionnaire, the profitability and growth targets are coded as 5 for "far more than expected," 4 for "more than expected," 3 for "about what is expected," 2 for "less than expected," and 1 for "far less than expected." The mean value of the firm growth performance is 3.33 out of 5 and that of firm profitability performance is 2.81 out of 5. This indicates that while firms in our sample perform slightly better than their expected growth target, their profitability performance is a bit lower than what they expected (Table 3.2).

**Table 2: Descriptive statistics on firm performance.**

| | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| Extent to which firm reached its growth target in the last 5 years | 1 | 5 | 3.33 | .90 |
| Extent to which firm reached its profitability target in the last 5 years | 1 | 5 | 2.81 | .89 |

The independent or explanatory variables used in this study can be divided into two groups. The first group includes variables related directly to the human capital of CTO or, in other words, her/his field of education and her/his length of experience in the current firm and in other firms. The second group of independent variables aim to measure the level of hierarchy in the firm. We use two proxy measures for this:

- title in the firm, meaning her/his being a CTO or a manager responsible for technology related issues and
- her/his level in the firm administration as shown in Table 3.3.

Company performance might change due to context. Many studies investigating the performance of firms take into consideration the size as a control variable, since large firms are expected to have plenty of resources compared to small firms influencing their range of activities [Hambrick et. al.,]. Since there are only two industries and the sample are small, only one firm level control variable, the size of the firm [proxied by the number of employees] will be used for the analyses. Size is measured by a four-level scale to measure the firm size, namely "less than 25 employees", "25-49 employees", "50-249 employees" and "more than 250 employees".

**Table 3: Descriptive statistics for the independent and control variables.**

| Qualitative variables | Percentage | Minimum | Maximum | Median | Mode |
|---|---|---|---|---|---|
| **Respondent has CTO title** | | | | | |
| Yes | 21.6% | 0 | 1 | 0 | 0 |
| No | 78.4% | | | | |
| **Title of the CTO or responsible manager** | | | | | |
| Operational (lower level) | 7.8% | 1 | 5 | 4 | 5 |
| Operational (higher level) | 7.8% | | | | |
| R&D (lower level) | 7.8% | | | | |
| R&D (higher level) | 31.4% | | | | |
| General management | 45.1% | | | | |
| **Field of education of respondent** | | | | | |
| Electronics | 26.7% | 1 | 5 | 2 | 1& 2 |
| Machinery / automotive | 26.7% | | | | |
| IT / software / telecommunication | 11.1% | | | | |
| Other technical / engineering fields | 17.8% | | | | |
| Other non-technical fields | 17.8% | | | | |
| **Level in the firm administration** | | | | | |
| 0-The top manager herself / himself | 11.4% | 0 | 3 | 2 | 2 |
| 1-CEO or the member of the board of directors reporting to the top manager | 25.0% | | | | |
| 2-General manager, director or equivalents who report to the CEO or the board of directors | 56.8% | | | | |
| 3-Managers who report to the general manager, director or equivalents (R&D managers; engineering managers, etc) | 6.8% | | | | |
| **Firm size** | | | | | |
| Less than 25 employees | 11.5% | 1 | 4 | 3 | 3 |
| 25-49 employees | 15.4% | | | | |
| 50-249 employees | 50.0% | | | | |
| More than 250 employees | 23.1% | | | | |
| **Industry** | | | | | |
| Machine manufacturing | 48.1% | 1 | 2 | 2 | 2 |
| Electronics | 51.9% | | | | |

| Quantitative variables | Measurement unit | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Respondent's work experience (total) | Month | 7 | 480 | 244.25 | 117.171 |
| Respondent's work experience (in current firm) | Month | 2 | 468 | 151.67 | 120.292 |

## 2. Results

### 2.1. The Use of TM Tools

According to the study, the most frequently used TM tool/technique is the "market analysis". Its frequency is higher than the others because it is listed under four different technology management activities. For example, firms in our sample used the "market analysis" tool/technique mostly in the field of "technology strategy"; followed by "technology planning and forecasting", "new product management," and "technology commercialization, marketing" activities. The second most frequently used TM tool/technique is "creativity". This tool/technique is also listed under two different TM activities; "R&D management" and "knowledge management, organization of technological activities". Finally, "benchmarking" is found as the third most frequently used TM tool/technique. Like the previous ones, "benchmarking" is also listed under two different TM activities, which are "technology strategy" and "technology acquisition, transfer, dissemination". Table 4.1.1. shows the most frequently used TM tools/techniques, the TM activities for which they are used, and their frequencies.



**Citation:** *Taleghani, M., Taleghani, A. (2024). Pathology of Factors Affecting the Use of Technology Management Tools and Techniques (Case Study: Iranian Industries). Archives of Humanities & Social Sciences Research. 1(1), 1-13.*

**Table 4: The most frequently used TM tools and techniques.**

| TM tools and techniques | Number of TM fields | TM activities | Usage frequency | Non-user firms |
|---|---|---|---|---|
| Market analysis | 4 | Technology strategy | 100 | 7 |
| | | New product management | | |
| | | Technology planning and forecasting | | |
| | | Technology commercialization, marketing | | |
| Creativity | 2 | Knowledge management, organization of technological activities | 52 | 18 |
| | | R&D management | | |
| Benchmarking | 2 | Technology strategy | 45 | 16 |
| | | Technology acquisition, transfer, dissemination | | |
| Continuous improvement | 1 | Knowledge management, organization of technological activities | 42 | 10 |
| Modelling | 3 | R&D management | 33 | 33 |
| | | New product management | | |
| | | Technology planning, forecasting | | |
| Team working | 2 | R&D management | 31 | 33 |
| | | Project management | | |
| Marketing research | 1 | Technology acquisition, transfer, dissemination | 30 | 22 |
| Brainstorming | 2 | Technology strategy | 30 | 34 |
| | | R&D management | | |
| Technology foreseeing | 1 | Technology planning, forecasting | 29 | 23 |
| SWOT analysis | 1 | Technology strategy | 28 | 24 |

The first 10 firms that use the highest number of TM tools and techniques and the share of R&D in the firm's budget are given in Table 4.1.2. The list indicates that firms in the electronics sector use a higher number of TM tools and techniques than those in the machinery sector. The average number of TM tools and techniques used by the firms in the electronics sector is 19.07 whereas it is 15.04 among firms in the machinery sector.

**Table 5: First 10 firms with the highest number of TM tools and techniques, their R&D over budget ratio and sectors**

| Firms | Number of TM tools and techniques being used | R&D/budget ratio | Sector |
|---|---|---|---|
| Firm A | 45 | 2 | Consumer electronics |
| Firm B | 41 | 8.5 | Mechanical fabrication |
| Firm C | 38 | 50 | Robotic automation |
| Firm D | 38 | 5 | Electronics |
| Firm E | 33 | 1 | Information |
| Firm F | 31 | 20.5 | Electronics |
| Firm G | 30 | 1.7 | Machinery production |
| Firm H | 28 | 1 | Automobile electronics |
| Firm I | 27 | 5 | Medical electronics |
| Firm J | 26 | 2.1 | Construction equipment |

### 2.2. Analysis of Factors Affecting the Usage of TM Tools and Techniques

Regression analyses are conducted to investigate the factors determining the number of total TM tools and techniques, Since the number of TM tools and techniques used in a firm is an integer, a Poisson regression technique is preferred for these analyses. The results derived by using STATA 9.1 program package are given Table 4.2.1.

We found that the "CTO's field of education", "the level of the [CTO] or the manager is responsible for the technology in the firm management", "the size of the firm", and finally "work experience of the CTO in the current firm" are the major determinants of the number of TM tools and techniques used in the firms. As shown in Table 4.2.1, among the models, the first one seems to have more explanatory power, not only due to its comparatively higher pseudo $R^2$, but also due to the significant coefficients of all explanatory variables. In Models 1, 2 and 3, the signs of the manager's field of education are significant and negative. This sign indicates that if the manager's field of education is related to electronics or mechanics, it is expected that the number of technology management tools and techniques used by the firm will increase. This implies that CTOs having deep knowledge on the core technologies of the sector, electronics and mechanics in our case, might increase the total number of TM tools and techniques used in the sample firms.

The level of the CTO in the firm administration is also one of the significant determinants of the total number of TM tools and techniques used in the firms. Since the values taken by this explanatory variable is getting smaller while the CTO is getting more closer to the "top manager" (see Table 3.3), the positive association revealed in the table indicates that the CTO's closeness to the top management decreases the number of total TM tools and techniques in the firms. This might be because of the fact that CTOs who are much closer to the top management have a wide range of responsibilities and therefore they do not allocate enough time for the management of technological activities (Table 4.2.2). On the other hand, CTOs who are mainly responsible for technical or operational units and who are at comparatively lower levels in the firm hierarchy can be more eager to improve the technological activities in the firm and be more focused on the technology management activities. Models 1 and 2 produce significant and positive coefficients for "the level of the CTO in the firm administration".

Model 3 differs from the previous two models in one respect; it investigates the impact of the title of the CTO instead of the level in the firm administration on the number of TM tools and techniques. The interesting finding of Model 3 is that the use of TM tools is influenced from power rather than the "title". In other words, whether or not the person who manages technology related activities in a firm has a formal title such as the CTO is not important. What determines the use of TM tools is that person's hierarchical status.

Model 1, 2, and 3 separately measure the impact of the CTO's work experience on the total number of TM tools and techniques used by the firms. The results indicate that the length of the work experience of the CTO at the current firm has a significant (p0.01) but negative effect on the total number of TM tools and techniques, as confirmed with the findings in the literature. On the other hand, CTO's having experience in different firms, as shown in Model 1, increases the total number of TM tools and techniques, this might be because CTOs who are less experienced (and maybe younger) or have worked for different firms might be more open to new TM tools and techniques and more eager to develop their knowledge on the management of technology. This may also indicate that managers who are new to the firm are more motivated to introduce new TM tools and techniques.

As the control variable, the firm size is also positively and significantly associated with the total number of TM tools and techniques used by the sample firms. This implies that larger firms with a higher number of employees use a higher number of TM tools and techniques than the smaller ones.


Citation:Taleghani, M., Taleghani, A. (2024). Pathology of Factors Affecting the Use of Technology Management Tools and Techniques (Case Study: Iranian Industries). Archives of Humanities & Social Sciences Research. 1(1), 1-13.

**Table 6: Factors determining the total number of TM tools and techniques used.**

| | (1) | (2) | (3) |
|---|---|---|---|
| Field of education | -0.164 | -0.174 | -0.125 |
| | (3.83) *** | (3.90) *** | (2.98) *** |
| Level in firm administration | 0.206 | 0.136 | |
| | (2.48) ** | (1.81) * | |
| Title of the CTO | | | -0.073 |
| | | | (1.15) |
| Firm size | 0.188 | 0.192 | 0.172 |
| | (1.61) | (2.33) ** | (2.01) ** |
| Respondent's work experience (current firm) | (1.68) * | | |
| | | -0.002 | -0.002 |
| Industry | | (3.05) *** | (3.40) *** |
| | | | -0.052 |

Robust z statistics in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

Apart from the total number of technology management tools and techniques used by the firms, the number of TM tools and techniques used for each of the technology management activities asked in the questionnaire were analyzed. The results are summarized as follows:

To test whether firms with different income levels in our sample are significantly different from each other according to the number of tools and techniques they use for each of TM activities, we use two different statistical methods: one-way ANOVA to compare the mean values, and Kruskal-Wallis to compare the median values of the number of tools and techniques between groups. We found that the firms, initially categorized into four according to their income levels,

are significantly different in terms of the number of tools and techniques they use for the TM activities of "technology strategy", "technology acquisition, transfer, dissemination", "R&D management", "new product management," and "commercialization of technology, marketing". In other words, the number of TM tools and techniques used to carry out these five technology management activities by the firms differ significantly according to the firm's income at the 10% or 5% confidence levels. This implies that the firm's income level plays a significant role in decisions about how many TM tools and techniques would be employed to carry out aforementioned five TM activities.

Secondly, there are significant associations between the title of the CTO or the manager who is responsible for technology in a firm and the total number of TM tools and techniques used by the firm for some TM activities. As shown in Table 4.2.2, except for the technology commercialization and marketing activity, the number of tools and techniques significantly differs among groups of firms where CTOs have different titles. It seems that the R&D management activity is where most of the tools are used. Furthermore, lower level operational and R&D managers actively use TM tools, with an average of 4.67 and 5.00 tools, respectively. In all cases, people who have general management titles use less TM tools compared to R&D managers.

**Table 7: Association between number of tools and techniques used for some TM activities and the titles of CTOs (median values in parentheses).**

| | Operational (lower level) | Operational (higher level) | R&D (lower level) | R&D (higher level) | General management | Δ (t-stat) | Δ (K-W) |
|---|---|---|---|---|---|---|---|
| | Mean | Mean | Mean | Mean | Mean | | |
| Knowledge management, organization of technology activities | 1.67 | 1.50 | 3.25 | 2.75 | 2.35 | * | * |
| Technology acquisition, transfer, dissemination | (2) | (1.5) | (3.5) | (2) | (2) | | |
| | 1.67 | 2.25 | 3.50 | 2.44 | 1.13 | ** | ** |
| R&D management | (1) | (2) | (4) | (2) | (1) | | |
| | 4.67 | 2.25 | 5.00 | 2.50 | 1.87 | ** | ** |
| New product management | (5) | (2) | (4.5) | (1.5) | (1) | | |
| | 2.67 | 1.25 | 2.75 | 1.50 | .61 | ** | ** |
| Technology utilization and integration | (2) | (1,5) | (2.5) | (1) | (0) | | |
| | 1.00 | 1.00 | 3.00 | .94 | .87 | ** | * |
| Technology commercialization, marketing | (1) | (1) | (2.5) | (1) | (0) | | |
| | .33 | .50 | 2.00 | 1.19 | .57 | ** | ns |
| | (0) | (.5) | (2.5) | (1) | (0) | | |

* Significant at 10%; ** Significant at 5%.

No significant relationship could be found between the R&D expenditure as a percentage of firm budget and the total number of TM tools and techniques used by the firms in the sample. The only significant association between R&D expenditure and the number of tools and techniques used for individual TM activities is found for project management activities. This indicates that the firm's usage of TM tools and techniques does not mainly differ according to the R&D expenditure, but rather according to the variables related to firm size or those related to the CTO's title and his/her power in the firm.

2.3. Analysis of the Relationship between Performance and the Usage of Technology Management Tools and Techniques

To analyze the association between the number of TM tools and techniques that a firm uses and the extent to which this firm has reached its growth targets, we ran a bivariate correlation analysis using SPSS, allowing us to simultaneously see the strength and the direction of the relationship. As given by Table 4.3.1, there is a significant (p0.01) and positive relationship between the total number of TM tools and techniques used by a firm and its growth performance.

**Table 8: Correlation between the total number of TM tools and techniques and performance**

| | | Number of TM tools and techniques used | Firm's growth performance |
|---|---|---|---|
| Total number of TM tools and techniques | Pearson Correlation | 1 | 0,399** |
| | Sig. (2-tailed) | | 0,003 |
| | N | 52 | 52 |
| Firm's growth performance | Pearson Correlation | 0,399** | 1 |
| | Sig. (2-tailed) | 0,003 | |
| | N | 52 | 52 |

** Correlation is significant at the 0.01 level (2-tailed).

 

As a separate analysis, the firms were clustered into three significantly different (p ≤ 0.01) groups according to the total number of TM tools and techniques they use using the SPSS 13.0 statistical program package. In the first cluster, there are 25 firms with less than 15 TM tools and techniques, in the second group there are 20 firms using between 15 and 28 TM tools and techniques. Finally, in the third group there are only 7 firms which use more than 30 tools and techniques. One-way ANOVA (Figure 4.3.1) indicates a significant difference (p<0.05 /0.028) in the mean value of performance between the firms that are clustered according to the number of TM tools and techniques they use. The Kruskal-Wallis test produces the same result [1-3].

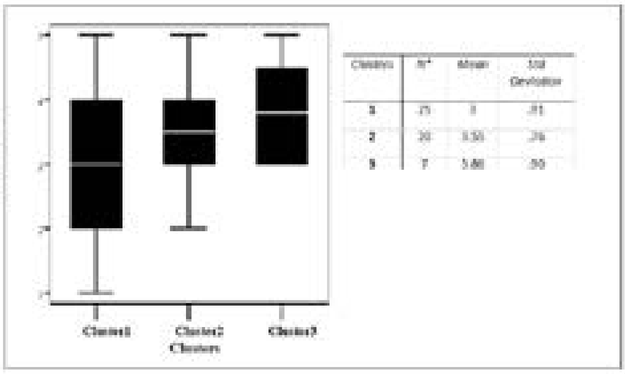


**Figure 1:** Growth performance and firm clusters

**Table 9: Descriptive statistics for clusters (Std. deviations in parentheses)**

| | Cluster 1 | Cluster 2 | Cluster 3 | Δ |
|---|---|---|---|---|
| Firm has CTO | .13 | .3 | .29 | ns |
| | (.34) | (.47) | (.49) | |
| Respondent's work experience (current firm) | 176.79 | 148,45 | 74,71 | ns |
| | (130.49) | (114.38) | (66.45) | |
| Respondent's work experience (total) | .79 | .85 | .86 | ns |
| | 1.39 | 1.6 | 1.57 | |
| CTO's level in the firm hierarchy | 1.38 | 1.72 | 2 | ** |
| | (.86) | (.75) | 0 | |
| Size (number of employees) | 2.64 | 3.05 | 3 | ns |
| | .86 | .89 | 1.15 | |
| Firm income | 1.96 | 2.7 | 2.3 | * |
| | .79 | 1.17 | 1.37 | |
| R&D/total budget | .13 | .13 | .15 | ns |
| | .23 | .2 | .19 | |

## 3. Concluding Remarks

### 3.1. Limitations/further research

## Acknowledgements

This study was carried out with the spiritual support of the National Industries Organization of Iran.

**Table 10: Technology management tools / techniques and technology management activities for which they are used.**

| TECHNOLOGY MANAGEMENT TOOLS / TECHNIQUES | TECHNOLOGY MANAGEMENT ACTIVITIES |
|---|---|
| Expected value-success matrix | Technology evaluation and assessment |
| Brain storming | Technology strategy |
| | R&D management |
| Copyright | Technology protection, license/patent acquisition |
| CPM | Project management |
| EDI (Electronic Data interchange) | Knowledge management, organization of technological activities |
| Training | Technology utilization and integration |
| Excel | Project management |
| Utility model | Technology protection, license/patent acquisition |
| IPR (Intellectual property rights) | Technology commercialization, marketing |
| | Knowledge management, organization of technological activities |
| Observation, tracking | Technology acquisition, transfer, dissemination |
| Hierarchical decision trees | Technology evaluation and assessment |
| Relationship management | Knowledge management, organization of technological activities |
| Statistical decision models | Technology acquisition, transfer, dissemination |
| | Technology planning and forecasting |
| Quality circles | Technology utilization and integration |
| Decision trees | Technology strategy |
| Cost-profit analysis | Technology acquisition, transfer, dissemination |
| Resource planning | R&D management |
| Benchmarking | Technology acquisition, transfer, dissemination |
| | Technology strategy |
| License | Technology protection, license/patent acquisition |
| Brand registration | Technology protection, license/patent acquisition |
| Mathematical programming | Technology planning and forecasting |
| Matrix analysis | R&D management |
| Modeling | R&D management |
| | New product management |
| | Technology planning and forecasting |
| Customer reports | Technology utilization and integration |
| Patent | Technology protection, license/patent acquisition |
| Patent analysis | R&D management |
| TECHNOLOGY MANAGEMENT TOOLS / TECHNIQUES | TECHNOLOGY MANAGEMENT ACTIVITIES |
| Market analysis | New product management |
| | Technology commercialization, marketing |
| | Technology strategy |
| | Technology planning and forecasting |
| Marketing research | Technology acquisition, transfer, dissemination |
| PERT | Project management |
| Portfolio management | New product management |

| | |
|---|---|
| | Technology utilization and integration |
| Project assessment | Technology evaluation and assessment |
| Competition analysis | New product management |
| Competitive position-industry maturity matrix | Technology strategy |
| Risk-return analysis | New product management |
| | Technology evaluation and assessment |
| After sales services | Technology commercialization, marketing |
| Scenarios | Technology planning and forecasting |
| Intuitive method | Technology acquisition, transfer, dissemination |
| Continuous improvement | Knowledge management, organization of technological activities |
| SWOT analysis (Strengths/weaknesses/opportunities/ threats) | Technology strategy |
| Organizational culture | Knowledge management, organization of technological activities |
| Team working | R&D management |
| | Project management |
| Technology foreseeing | Technology planning and forecasting |
| Technology acquaintance techniques | Technology acquisition, transfer, dissemination |
| Technology efficiency analysis | Technology utilization and integration |
| Technological portfolio management | R&D management |
| Reverse engineering | R&D management |
| Expert opinion (such as Delphi) | Technology planning and forecasting |
| Product- technology matrix | Technology evaluation and assessment |
| | Technology strategy |
| Creativity | Knowledge management, organization of technological activities |
| | R&D management |
| Road maps | Technology planning and forecasting |

## References


1. Corso, M., Giacobbe, A., Martini, A., & Pellegrini, L. (2007). Tools and abilities for continuous improvement: what are the drivers of performance? International Journal of Technology Management, 37(3-4), 348-365.
2. Chou, A. Y., & Chou, D. C. (2007). Knowledge management tools adoption and knowledge workers' performance. International Journal of Management and Decision Making, 8(1), 52-63.
3. Drew, S. A., & Kaye, R. (2007). Engaging boards in corporate direction-setting: strategic scorecards. European Management Journal, 25(5), 359-369.