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**Review Article**

# A BRIEF OVERVIEW OF TECHNOLOGY COMPETENCY AND MANAGEMENT FRAMEWORKS FOR SMALL AND MEDIUM-SIZED ENTERPRISES

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**ABSTRACT**

It is quite surprising that studies on the relationship between technology competency and technology management skills are still rather scarce. There is a particular lack of studies of technology competency in the specific context of technology management. This paper aims to fill this gap and offers a literature review to examine the technology competency based on the management and technology capabilities of manufacturing enterprises. To begin integrating these various aspects of technology management into a new and systematic framework, joint research–review perspective is considered to prepare an infrastructure to identify competencies of technology for small and medium-sized enterprises. This literature review investigates to define dimensions and decision criteria of technology competency analysis based on seven main perspectives; technology management, technology roadmapping, technological innovation, technology evaluation and entrepreneurship, information and communication technologies, innovation management, knowledge management. This study also contributes to the literature on technology management by examining technology competency.
**Keywords:** Technology management, technology competency, technology evaluation framework, small and medium-sized enterprises, literature review.

## 1. INTRODUCTION

Nowadays, dynamic environment is very crucial that rapid changes in the global environment of business demand changes in the underlying assumptions of technology management. The discipline of technology management (TM) is relevant in any organization with a sizeable investment in technology. Technology Management is concerned with the effective integration of technological considerations into business decision making [1]. Otherwise, ultimate goal of technology management is to advance competencies for creating or improving products, processes or services in the marketplace. Key components of technology management (such as information management, innovation management, entrepreneurship, new product development, intellectual property, etc.) are increasingly recognized as essential for continued corporate and societal well-being [2]. In re cent years, manufacturing industry is one of the main drivers of the

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Turkish economy so that technology and management issues can easily be associated with manufacturing industry. A number of manufacturing sub-sectors in Turkey have been growing in recent years [3]-[4].

Recently, one of the most important subjects for the companies which are profitable and have continuous management principles, is the fact of having targets [5]. Sobanke et al. [6] demonstrate that small and medium-sized enterprises (SMEs) are important to the economy of most developing countries in terms of growth, productivity, technological competitiveness and employment generation. Technological capability index (TCI) is proposed as the dependent variable for regression analysis based on both the internal and external factors in the study. The paper researches on a conceptual framework of factors influencing technological capability. Tabatabaeian et al. [7] study to present a new composite index for technological capability monitoring for evaluating the technological capabilities of countries by using various aspects. 17 indicators are chosen among 37 internationally important indicators to evaluate the technological capability by statistical analyses. De Mori et al. [8] develop a technology capability index model composed of resources, technology upgrade, processes and routines, learning mechanisms, coordination and accessibility dimensions to assess agriculture firms by the Analytic Hierarchy Process (AHP) multicriteria analysis method.

Coombs and Bierly [9] research on a variety of patent statistics and a measure of research & development (R&D) intensity as indicators for technological capability. The aim of the study is to explore the performance framework which is structured on multiple measures of both technological capability and performance. Coombs and Bierly [10] analyze the technological capability and performance relationship in public companies. A variety of patent statistics are used as indicators for technological capability. The aim of this study is to demonstrate the complexity of this relationship by an evaluation framework. Corsatea [11] researches on important innovation parameters to ensure the development of renewable energy in European countries. R & D intensity, promotional activities, strategic planning, incentives, alliances and partnerships, national patent applications, national R & D investment, corporate R & D investment, employment opportunities and market capacity are determined as important components of innovation capacity by the study. Ritala et al. [12] emphasize the need for more research in SMEs about coopetition and innovation issues. The paper demonstrates the positive influence of coopetition on innovativeness for firm performance. Graziadio and Zawislak [13] investigate the role of research and development activities on the product development, process development and process of problem-solving for SMEs of the mechanics industry in Brazil. Unofficial R & D activities (unsystematic R & D) and mechanisms are determination by the study. The paper represents the importance of informal R&D activities in technological capability analyses based on conceptual review. Kim and Park [14] explores communication intensity as a significant moderating effect on the relationship between power asymmetry/information asymmetry and the performance of cooperative R&D for technological knowledge exchanges between SMEs and public research institutes in Korea. Park and Kim [15] research on a conceptual framework for new product development of SMEs based on dynamic capability theory by linear regression analysis. The paper represents that dynamic capabilities have a positive influence on new product development performance.

Panda and Ramanathan [16] represent a model and indicators for technological capability assessment based on the electricity sector. A methodology is demonstrated to evaluate the elements of strategic, tactical and complementary capabilities, all of which together constitute the technological capability of a firm. The study suggests a conceptual framework on types of technological capability as the dimensions; acquisitive, operative, adaptive, innovative, supportive and marketing. Santhanam and Hartono [17] proposed a multidimensional framework to research on relationship between information technology and firm performance. The eight criteria related with cost and profitability are used in regression analyses to assess the impact of IT investments on firm performance. Only, finance and accounting criteria are taken into account for the

evaluation. Özdemir and Gözlü [18] examine that perspectives to model project environment and to study the links between project performance, project success factors and organizational performance by using a conceptual framework. Strategic support, operational support, project performance and organizational success are used as main factors in the structural equation modeling (SEM) method. Baysan and Durmuşoğlu [19] emphasize the potential area of research on designing technology systems for measuring the adaptation of process to humans and processes. Such a system can especially be used as decision support systems for the choice of technology and purchasing issues. Battistella et al. [20] describes the development of a methodology for technological roadmapping specially adapted for SMEs' needs and comprising the role of innovation intermediary with the aim of producing strategic technology roadmaps to support SMEs about decision-making on technology, business and strategy.

Generally, most of the evaluation frameworks on technology competency field in this review paper are designed to present various aspects of technology competency issues to guide firms based on decision criteria; technology policy, technology strategy, strategic plans, technology roadmapping, technological environmental dynamism, sustainable development, competitive strategies, marketing strategies, strategic and tactical marketing activities, strategic management, strategic decisions, corporate culture, intellectual property rights, intellectual property management, technology transfer, technology commercialization, technology investment, technology sourcing, efficient collaboration, quality improvement, technology adoption, technology advancements, technological skills, scenario planning, organizational performance, supply chain performance, research and development management, new product development, information management, open innovation, innovative changes, adaptation of innovations, entrepreneurship activities, human capital, managerial ability, general and policy research as qualitative infrastructures and approaches [1], [21-50].

Although more studies are investigated for technology management issues, some of them, 31 papers are determined to research and analyze the technology competency issues, due to deeply evaluation perspectives of these papers. All of the papers investigated in this study research on different approaches, conceptual assessment frameworks, evaluation frameworks, analysis infrastructures, methods and basic statistical analysis based on technology management and competency issues. Firstly, categories and identifications of the key existing research in technology management literature are considered to determine a new framework for technology competency evaluation of SMEs in this review study. There are *different methods, models and evaluation infrastructures/frameworks* in the technology competency literature, however, the developed framework is available and supportive for qualitative and quantitative variables together by transforming variables into a basic and useful database for enterprises. One of the purpose of this study is to propose a definition of technology management in a "*competency*" form. The remainder of this paper is organized as follows. Section 2 provides a brief overview on the different perspectives of technology management. Section 3 represents classifications of approaches for discussion of the review based statistical analysis results. Finally, Section 4 demonstrates conclusion, limitations, and recommendations for future studies.

## 2. TECHNOLOGY COMPETENCY

In this part, papers are represented and summarized for technology competency evaluation framework based on the important data used in this review study included the contents; authors, publication dates, journal, country, paper application type and dimensions (main criteria). This paper reviews 31 different papers using various technology evaluation infrastructures, frameworks and multi criteria decision making (MCDM) and statistical approaches based on technology competency which are classified into seven categories between 2005 and 2015 years.

The different perspectives for reviewing technology competency of enterprises are emerged for conceptual frameworks and evaluation infrastructures. According to our review the papers are

categorized into seven main fields of technology management issues. For this point of view, we used a systematic approach for defining key points for all papers as goals, origin of the paper, paper types, methods, frameworks, used approaches, application areas, the existence of empirical or real cases for the papers and main decision criteria (dimensions) in our review.

### 2.1. Technology Management Perspective

Under the first perspective, the papers are evaluated on the issues for enterprises' ability to collaboratively exploit existing and new technologies and management capabilities in the industry. There have been several technology management approaches in the papers presented in Table 1.

**Table 1.** The papers related with technology management field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Horwitch and Stohr [1] | 2012 | Hungary | Research | Conceptual framework | This study investigates the major environmental changes that must be addressed by TM. |
| Badawy [21] | 2009 | USA | Research | Conceptual framework | The article propose a definition of management of technology in a conceptual form. |
| Brent and Pretorius [22] | 2008 | South Africa | Review | Approaches | Literature review proposes a conceptual framework of technology management knowledge. |
| Levin and Barnard [23] | 2008 | USA | Research | Conceptual framework | This study offers a cognitive map of the TM routines that technology managers regard as important. |
| Pilkington and Teichert [24] | 2006 | United Kingdom | Review | Conceptual framework | Factor analysis, co-citation and citation analysis are used to organize different concentrations of TM interest. |
| Erensal et al. [25] | 2006 | Turkey | Research | Conceptual framework | Fuzzy Analytical Hierarchy Process (FAHP) method is used to evaluate the key capabilities in TM. |
| Liao [26] | 2005 | Taiwan | Review | Approaches | This study surveys and classifies TM methodologies using the eight main categories. |

Horwitch and Stohr [1] analyze transforming technology management education as value creation-learning in the early twenty-first century. Researchers examines the major environmental changes that must be addressed by Technology Management and the skills that future graduates will require. This paper proposed a definition for TM as the discipline to which all technology-intensive firms must turn when they seek new talent. The research paper suggests a conceptual framework for Technology Management Education based on twelve dimensions; Innovation Management, Entrepreneurship, R&D, Information Technology (IT) Management, New Value Creation, Customer-Oriented Services, Productivity, Knowledge Management, Intellectual Competence, Corporate Strategy, Value Creation and Risk analysis. Badawy [21] examines technology management simply defined as a tweet plus two characters. The purpose of the article is to propose a definition of management of technology in a "twitter" form. The research article suggests a technology management framework based on four dimensions; Technology and innovation, Technology utilization, Technology advancements, Internet technology and eight criteria; Strategic investments, e-commerce, Social media networks, Online networks, Social

networking tools, Technology transfer, Utilization of innovation and Competitive advantage. Brent and Pretorius [22] research on sustainable development as a conceptual framework for the technology management field of knowledge and a departure for further research. This paper reviews technology management knowledge approaches based on five dimensions; Management of technology, Sustainable development, Competitiveness, Technology management methodology and External life cycle system. Levin and Barnard [23] address the fragmentation in the technology management field by identifying and organizing the routines used by managers of technology. This research paper is structured on a framework based on four dimensions; scientific and technological knowledge, transforming knowledge into working artefacts, Matching artefacts with user requirements and providing organizational support. Pilkington and Teichert [24] research on management of technology as themes, concepts and relationships. This paper empirically investigates the issues arising from the struggle to establish TM by examining its literature using citation and co-citation data obtained from Technovation. The review paper proposed a conceptual framework by using bibliometric (co-citation analysis) and social network analysis techniques for investigating technology management discipline. The paper is structured on four dimensions; R&D Management, Technology strategy, Competitive strategies and Knowledge management. Erensal et al. [25] represent determining key capabilities in technology management using fuzzy analytic hierarchy process as a case study of Turkey. The paper proposes a model to understand the links between competitive advantages, competitive priorities and competencies of a firm in the context of the technology management. The paper uses Fuzzy Analytical Hierarchy Process (FAHP) approach for technology evaluation based on six dimensions; Competitive advantages, Competitive priorities, Technological resource skills, Technological competencies, Technological developments and Strategic plans. Liao [26] presents a comprehensive study on the technology management methodologies and applications as a literature review from 1995 to 2003. This paper examines technology management development and issues on eight important features or dimensions; Technology management framework, General and policy research, Information systems, Information and communication technology, Artificial intelligence/expert systems, Database technology, Modeling and Statistics methodology.

### 2.2. Technology Roadmapping Perspective

Under this viewpoint, the papers are deeply analyzed on the technology roadmapping by representing the assessment frameworks, infrastructures and evaluation approaches. Table 2 presents the details of technology roadmapping approaches based on evaluation infrustructures.

**Table 2.** The papers related with technology roadmapping field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Kawazoe and Abetti [27] | 2014 | USA | Research | Conceptual framework | Strategy, marketing, R&D and new product development policies are examined by the case study. |
| Rehn and Abetti [28] | 2013 | USA | Research | Conceptual framework | This article is a depth case study that uses findings of interviews. |
| Grover and Pretorius [29] | 2008 | South Africa | Research | Conceptual framework | Technology roadmapping is used in electrical power generation and Mining industry as a case study. |
| Phaal et al. [30] | 2006 | United Kingdom | Research | Conceptual framework | Matrix management tools and technology portfolio matrix are used to examine TM issues. |

Kawazoe and Abetti [27] demonstrate an in-depth case study of the transition of strategy, R&D and new product development procedures after the acquisitions of a small entrepreneurial

US high-tech company, SuperPower Inc., first by Philips of the Netherlands, and then by Furukawa Electric of Japan. Rehn and Abetti [28] represent an in-depth case study of the transition of R&D and product development procedures after the acquisition of a small entrepreneurial US high-tech company, Intermagnetics General Corporation (IGC), by a leading multinational, Philips of the Netherlands. Grover and Pretorius [29] examine the technology assessment of demand side bidding in the South Africa. This research paper represents a conceptual framework for technology balance sheet and technology roadmapping in electrical power generation and mining industry based on two dimensions; Power supply capacity and Demand side bidding. Phaal et al. [30] show technology management tools as concept, development and application. This research paper describes the development of a technology and general management tool catalogue. The paper uses Interval type-2 fuzzy sets approach for technology evaluation based on five dimensions; Markets, Business areas, Products, Competences and goals and Technology.

### 2.3. Technological Innovation Perspective

Under this perspective, papers largely characterize the disciplines of innovation and technology, technological innovation is used to further the stated goals of the organization. The papers focus on different innovation fields and conceptual views of technology issues based on the enterprises.

The technological innovation issues are also investigated by the evaluation frameworks of technology competency and they are presented in Table 3.

**Table 3.** The papers related with technological innovation field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Krishnaswamy et al. [31] | 2014 | India | Research | Conceptual framework | Cognitive maps This case study is based on to bring out the relationship between innovation and growth of sales revenue. |
| Hameed et al. [32] | 2012 | United Kingdom | Review | Approaches | Theoretical models of IT innovation adoption are investigated in the study. |
| Amadi-Echendu et al. [33] | 2011 | South Africa | Research | Conceptual framework | Scenario planning and trend analysis are preferred approach for technology planning and forecasting. |
| Cetindamar et al. [34] | 2009 | Turkey | Research | Conceptual framework | The dynamic capabilities theory is used for technological changes to explore the topic of TM. |

Krishnaswamy et al. [31] examine technological innovations and its influence on the growth of auto component SMEs of Bangalore as the case study approach. The case studies consisted of three SMEs in the auto components industry of Bangalore in India with the objective of understanding the processes of innovation in a SME, and the role of the entrepreneur in this process. The assessment framework for technological innovation is based on ten dimensions; Technological innovation, Technological capability, Entrepreneurial motivation, SME growth, External environment, Customer focus, Incremental innovation, Reverse engineering, Market competition and Flexibility. Hameed et al. [32] propose a conceptual model for the process of IT innovation adoption in organizations. The paper aims to theoretically construct an integrated model for IT adoption process in an organization. Based on the literature search, the study combines the most suitable innovation theories, models and frameworks that depict IT innovation

adoption in organizations. This review paper examines approaches in technology and innovation adoption field. The paper is structured on six dimensions; Innovation adoption, Information technology (IT), Technological innovation, Technology acceptance, Organizational performance, Organizational and individual level analysis. Amadi-Echendu et al. [33] examine case studies of technology roadmapping in mining. This study briefly describes three case studies of how mining firms tackle the issues of technology planning and forecasting especially in the context of depleting ore grades and new legislation. The paper suggests a conceptual framework in technological innovation field. Technology roadmapping framework is formed by five dimensions; Technology planning and forecasting, Strategic business objectives, Technological competences, Markets, products and technologies and Scenario planning. Cetindamar et al. [34] research on understanding technology management as a dynamic capability by a framework for technology management activities. The study explores the topic of technology management considering the dynamic capabilities theory. This research paper offers a conceptual framework for technological changes and technology management based on five dimensions; Innovation management, Project management, Technology management, Knowledge management and Technological capabilities.

### 2.4. Technology Evaluation and Entrepreneurship Perspective

Under this perspective, technology assessment, methods and entrepreneurship issues are analyzed to represent the goals of the organization based on the view. Table 4 represents technology evaluation and entrepreneurship approaches based on available methods.

**Table 4.** The papers related with technology evaluation and entrepreneurship field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Martín-Rojas et al. [35] | 2013 | Spain | Research | Method | Hierarchical regression model is used for evaluating structured hypotheses on corporate entrepreneurship. |
| Dereli and Altun [36] | 2013 | Turkey | Research | Method | Interval type-2 fuzzy sets and systems are used for investigating trendiness of the technologies. |
| Xu et al. [37] | 2012 | China | Research | Conceptual framework | Regression and factor analysis are used to test the influence of technology sourcing and appropriability regimes. |

Martín-Rojas et al. [35] study influence of technological support, skills and competencies, and learning on corporate entrepreneurship in European technology firms. The paper analyses the influence of corporate entrepreneurship on organizational performance in the context of technology firms. The hypotheses studied are empirically confirmed by using a hierarchical regression model. The research paper focused on corporate entrepreneurship based on six dimensions; Top management support (TMS) for technology, Technological skills, Technological competencies, Organizational learning, Corporate entrepreneurship and Organizational performance. Dereli and Altun [36] research on technology evaluation through the use of interval type-2 fuzzy sets and systems. This study proposes a novel technology evaluation framework based on an advanced/improved version of fuzzy logic, namely; interval type-2 fuzzy sets and systems (IT2FSSs). This research paper uses Interval type-2 fuzzy sets approach for technology evaluation based on two dimensions; Science and technology and Trendiness of the Technologies. Xu et al. [37] study technology sourcing, appropriability regimes, and new product development.

This study helps us to revisit and to examine the emerging theories of technology and innovation management and provides empirical evidence for these developing concepts. The research paper uses regression and factor analysis to evaluate conceptual framework of technology sourcing and appropriability regimes based on manufacturing sector. The paper is structured on eight dimensions; Technology sourcing, Appropriability regimes, Legal appropriability regimes, Strategic appropriability regimes, Technology protection, Competitive advantages, Open innovation and Intellectual property rights.

### 2.5. Information and Communication Technologies Perspective

Under this viewpoint, papers characterize conceptual frameworks of information and communication technologies (ICT) and information systems (IS) for the enterprise performance and technology competency. ICT are also examined as important infrastructures of technology competency for firm performance so that remarkable papers in this field are presented in Table 5.

**Table 5.** The papers related with information and communication technologies field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Rampersad et al. [38] | 2012 | Australia | Review | Conceptual framework | The article is based on a case study on the adoption of an innovation application. |
| Dyerson et al. [39] | 2009 | United Kingdom | Research | Method | Basic statistical analysis is applied to the data of a structured questionnaire on ICT. |
| Ashrafi and Murtaza [40] | 2008 | Oman | Research | Conceptual framework | Basic statistical analysis is used for evaluation of ICT adoption. |

Rampersad et al. [38] investigate the use of information technology in managing innovation as a case study from a university technology transfer office. This study contributes to the innovation and TM literature concerning technologies for managing innovations. The review paper proposed a conceptual framework for the adoption of information technology and innovation management based on ten dimensions; Technology acceptance, Innovation process management, Innovation application, Knowledge management, R&D, Marketing, Administration, Collaboration, Competitive advantage and University research commercialization. Dyerson et al. [39] examine national survey of SMEs' use of information technologies (IT) in four sectors. The research paper uses basic statistical analysis in information and communication technologies field based on three key dimensions; Information and communication technology, Technology adoption and e-commerce. Ashrafi and Murtaza [40] research on use and impact of information and communication technologies on SMEs in Oman. This research paper offers a conceptual framework in information and communication technologies field based on four key dimensions; Technology policy, ICT, Usages and effects of ICT and Information technology infrastructure.

### 2.6. Innovation Management Perspective

Under this perspective, the disciplines of innovation management and technologic changes are investigated to further the stated objectives of the firms. Innovation management is an important requirement for organizational survival. This field especially offers several insights for managers

of technology-oriented companies by introducing new products, processes or services to market. There have been several innovation management approaches and evaluation frameworks in presented papers in Table 6. Innovation management literature has been expanded to be analyzed in the context of SMEs. There have been considerable articles and vital suggestions on collaboration, open innovation and management perspectives studied by researchers of developed and developing countries.

**Table 6.** The papers related with innovation management field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Cruz-González et al. [41] | 2015 | Spain | Research | Method | Hierarchical regression analysis is used for investigating the degree of openness on firms' innovation performance. |
| Oliveira et al. [42] | 2015 | Brazil | Research | Method | DeBK method is used to evaluate the innovation performance of two companies. |
| Othman et al. [43] | 2012 | Canada | Research | Method | Cluster analysis and logistic regression model are used to classify and evaluate the firms based on degree of openness. |
| Yang [44] | 2012 | USA | Research | Conceptual framework | Structural equation model and factor analysis are utilized to examine a conceptual framework and corresponding hypotheses on innovation capability. |
| Shih [45] | 2012 | Taiwan | Research | Conceptual framework | Regression analyses and autocorrelation models are used to research on dynamics of innovation adoption. |

Cruz-González et al. [41] research on open search strategies and firm performance by the different moderating role of technological environmental dynamism. The study searches and focuses on innovation and management field for high-technology manufacturing Spanish firms. Hierarchical regression analysis method is used to evaluate firm performance based on four dimensions; External knowledge search, Innovation activities, Knowledge source and Open innovation. Oliveira et al. [42] demonstrate that decision making at the front end of innovation by the hidden influence of knowledge and decision criteria. Evaluation of decision making process is studied on two projects from consumer electronics sector and print industry. This research paper suggests a new method called decision making based on knowledge (DeBK) in innovation management field to explore technology investment projects based on five dimensions; Innovation management, Level of the knowledge of information, Process assessment, Applicability and Roadmapping for management. Othman et al. [43] represent a study of enterprise evaluation clusters SMEs based on their degree of openness for the case of manufacturing industries. Cluster analysis, analytical model and logistic regression model are developed to show variables such as national and regional proximities in the study. The research paper shows internal and external contexts characteristics as nine important dimensions; R&D employees, Engineers and technicians, internal obstacles to innovation, Firm size, Firm age, External obstacles to innovation, Technological intensity, Regional proximity and Provincial and national. Yang [44] researches on innovation capability and corporate growth as an empirical investigation in China. This study developed a conceptual framework and corresponding hypotheses. The paper analyses the innovation capability framework based on twelve dimensions;

Competitive advantage, Innovation capability, Sustainable growth, Entrepreneurship, Dynamic capability approach, Knowledge-based view, Intangible asset, Corporate performance, Strategic decisions, Incentives, Intellectual assets and Organizational learning. Shih [45] researches on the dynamics of local and interactive effects on innovation adoption as the case of electronic commerce. The research paper is structured for the conceptual framework on innovation adoption based on six dimensions; Electronic commerce, Information technology, Innovation adoption, Local effects for corporate, Interactive effects and Information technology intensity.

### 2.7. Knowledge Management Perspective

Under this viewpoint, the disciplines of knowledge management and conceptual frameworks for TM and competency are examined to evaluate the enterprises. Intellectual property rights (IPR), R&D strategy and technological assets (tangible and intangible) are utilized as considerable issues on this field. Knowledge management has intricate relationships of technology competency management issues which are presented in Table 7.

**Table 7.** The papers related with knowledge management field

| Author | Year | Country | Paper Type | Application | Method |
|---|---|---|---|---|---|
| Ayerbe et al. [46] | 2014 | France | Research | Conceptual framework | An assessment framework for management of IPR is proposed in the case study. |
| Kukko [47] | 2013 | Finland | Research | Conceptual framework | An assessment framework for knowledge sharing barriers is examined in an empirical case study. |
| Lee et al. [48] | 2012 | South Korea | Research | Conceptual framework | Existing techniques and software systems are used to propose a document mining framework in this study. |
| Mearns [49] | 2012 | South Africa | Research | Conceptual framework | Knowledge management framework is used to manage operational and strategic decisions in a specific area. |
| Lee and Lai [50] | 2007 | Taiwan | Research | Method | Balanced scorecard method is used to evaluate the performance measurement systems for knowledge management. |

Ayerbe et al. [46] research on the new challenges of organizing intellectual property in complex industries as a discussion based on the case of Thales. This study researches on the issue of protecting innovations and their exploitation. This paper analyses managing intellectual property rights (IPR), evolutions and the new organizational arrangements. The research paper proposed an assessment framework for intellectual property based on eleven dimensions; Intellectual property (IP), IP management, IP consultancy, IP strategy, Management strategies, Outsourcing, Innovation management, Strategic and technological decisions, Competitive advantage, Open innovation and R&D activity. Kukko [47] represents knowledge sharing barriers in organic growth as a case study from a software company. As a case study, this study aims to increase the understanding of the biggest potential knowledge sharing barriers that an organically growing software company may face. The case study examines whether the assumed barriers can be supported empirically. The conceptual framework for knowledge management is based on nine

dimensions; Organic growth, Knowledge management, Knowledge sharing levels, Knowledge sharing barriers, The software business, Innovativeness, Competitiveness, Managerial ability and Management communication. Lee et al. [48] suggest a study researches on analysis of document-mining techniques and tools for technology intelligence by discovering knowledge from technical documents. The research output is expected to support intelligence operatives in finding suitable techniques and software systems for getting value from document-mining and thus facilitate effective knowledge management. Mearns [49] researches on knowing what knowledge to share for collaboration for community, research and wildlife in Tembe Elephant Park of South Africa. This research paper is structured on the assessment framework in knowledge management field based on seven dimensions; Innovation, Efficient collaboration, Effective knowledge management, Organizational intelligence, information management, Knowledge sharing culture and Competitive advantage. Lee and Lai [50] suggest a performance measurement systems for knowledge management in high technology industries by a balanced scorecard framework. The dimensions of the framework are considered as four perspectives; financial, customer, internal business process and learning and growth.

Fernández-Olmos and Ramírez-Alesón [51] investigate the technology collaboration networks which are becoming increasingly important in creating technological knowledge for firms. Ruiz-Jiménez and del Mar Fuentes-Fuentes [52] propose that top managers can implement techniques, programs, and systems that drive development of innovations in the organization's products and services to encourage proposing ideas and creating new products or services for technology-based SMEs. Bolukbas and Guneri [53] utilize the TM literature and related approaches and propose an evaluation framework for technology competency of SMEs in Turkey.

## 3. CLASSIFICATION OF THE PAPERS

Technology evaluation framework is obtained on the basis of a review of technology competency and management literature. The potential capabilities and dimensions for technology competency issues most relevant to a manufacturing enterprise suggested by the literature review. Hotness of topics is shown as follows respectively; technology management, innovation management, knowledge management, technological innovation, technology roadmapping, information and communication technologies and technology evaluation and entrepreneurship. Number of papers published on technology competency in different areas is presented in Figure 1.

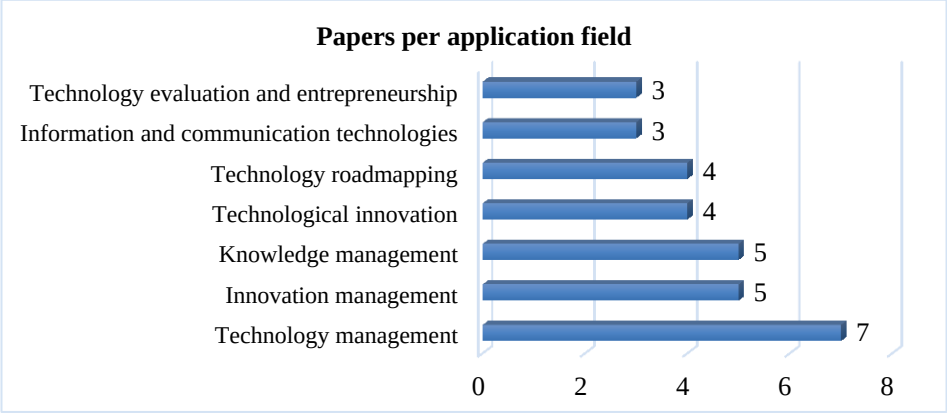


**Figure 1**. Distribution of application areas for investigated papers

Number of papers published in top journals is presented in this part. Especially, technology management and competency issues are the trend topics in the Journal of Engineering and Technology Management, Technovation, International Journal of Technology Management. Table 8 shows the number of the papers which are related with single and hybrid approaches.

**Table 8**. The number of reviewed papers

| Distribution of the journals | The number of articles |
|---|---|
| Journal of Engineering and Technology Management | 8 |
| Technovation | 7 |
| International Journal of Technology Management | 5 |
| Electronic Journal Information Systems Evaluation | 2 |
| South African Journal of Industrial Engineering | 2 |
| Computers & Industrial Engineering | 1 |
| Expert Systems with Applications | 1 |
| Information Sciences | 1 |
| Journal of Technology Management and Innovation | 1 |
| R&D Management | 1 |
| Technology in Society | 1 |
| The Journal of High Technology Management Research | 1 |

Distribution of the investigated papers per journal is demonstrated in Table 8. Thirty one papers are classified in two categories as twenty one real case studies and ten empirical case studies, however, some of the papers can be evaluated for both cases.

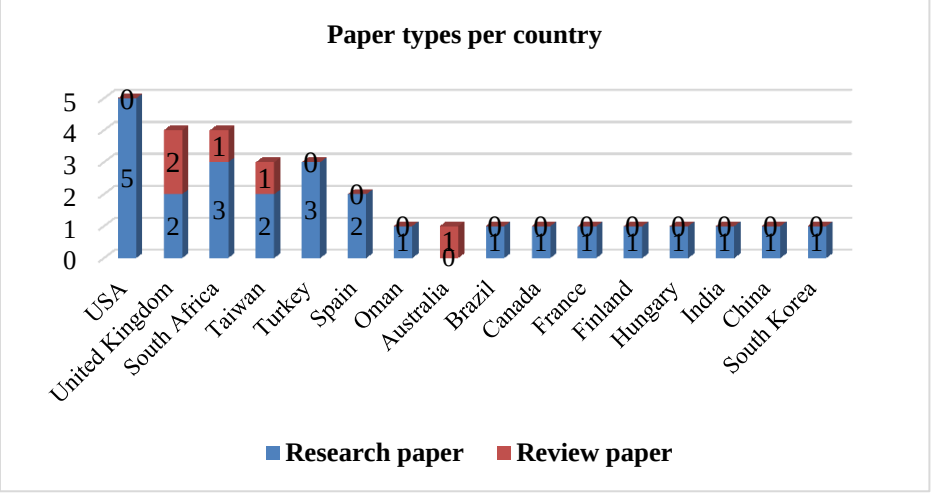


**Figure 2**. Distribution of papers by country origin

In the Figure 2, as distribution of country, technology competency issues are mostly dealt with and evaluated in USA, United Kingdom, South Africa, Taiwan, Turkey and Spain. Seventeen papers are published by the institution of these developed and developing countries. Given the remarkable importance of technology management for enterprise growth, the lack of studies exploring sources of technology competency and management capability and empirically examining the link between technology competency and enterprise performance in the context of the transition economy is an important research gap.

This study purposes a bridge for the gap by defining the dimensions presented in Figure 3. Small and medium-sized enterprises are analyzed with respect to technology evaluation surveys in which processes management, product competitiveness, information and communication technology, marketing strategies, innovation and entrepreneurial activities and research and development (R&D) issues are investigated. After literature review is accomplished, ten experts from university and technology transfer office evaluated the technology competency framework based on the level of knowledge of information, availability and usefulness by considering survey research and multi criteria decision making approaches. The issues recorded previously in section 2 and summarized in Figure 3 will be used as a framework to study the technology competency and management empirically.

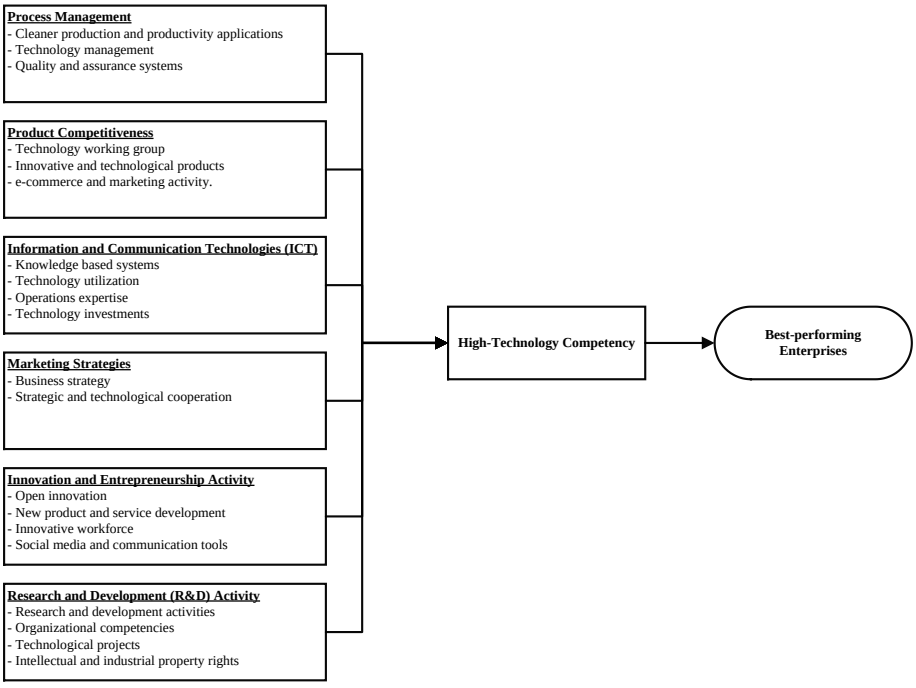


**Figure 3**. A new conceptual framework for technology competency analysis

Figure 3 shows the developed framework by examining the papers both in research and review studies. The purpose of this study is to determine a new evaluation framework in the special context of technology competency and management of technology. Figure 3 visualizes how the typical characteristics of the technology competency and management of technology affect enterprise performance on a theoretical level. This kind of categorization also makes it

easier to understand the whole model. However, despite this categorization, many of the dimensions and criteria are interlinked in the framework.

## 4. CONCLUSIONS AND FUTURE WORKS

This review paper demonstrates results of an exploratory study carried out to learn about the use and impact of the technology competency infrastructures and management capabilities on SMEs in manufacturing industry. Firstly, this review paper basically investigates research and review papers in the field of technology management and competency together to develop a new framework for evaluating performances of the enterprises. It is the choice for our review not to focus on Ph.D. or master thesis, institution reports, books, conference papers (excluding extended versions) and the chapter of books.

In the technology competency and management literature, there is a gap of systematic approaches and frameworks for SMEs. On the other hand, there are few models of technology evaluation to illustrate quantitative methods based on the decision criteria so that the developed conceptual framework in this study is different and innovative for technology competency analysis as providing a hybrid approach based on the literature. The framework is also flexible to consider all types of qualitative and quantitative variables used together for bridging the gap in technology competency literature. The evaluation model for technology competency can be used for multi criteria decision making approaches and basic statistical analysis; cross tables, figures, diagrams and radar charts in which many assumptions can be tested and interpreted easily. The case study for this new framework investigates SMEs by the critical decision criteria and variables shown in part 2, for this reason there is no limitations to claim the generalization of the findings for the new evaluation framework and survey research. Both research and practical implications are derived from the evaluation framework for further researches and analysis on technology management. The developed framework of technology competency is formed by literature review and views of ten academic experts.

Technology competency evaluation framework is structured on six main dimensions; process management; product competitiveness, information and communication technologies (ICT), marketing strategies, innovation and entrepreneurship activity, research and development activity and twenty decision criteria based on the technology competency literature in the review paper. In the future, the number of applications and approaches of technology competency will rise due to the complexity and fertile issues in technology management problems for different kind of enterprises. Multi criteria decision making approaches can be applied to evaluate and comparison the performance of small and medium-sized enterprises by using the developed model for different sub-sectors of manufacturing sector.

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