

# Technological Innovation Capabilities: A Critical Review

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**Abstract:** Innovation's importance has continuously increased and aligns with global business growth, these days every organization focuses on how they will enhance their technological innovation capability. Today challenges are: speedy development of digital world and automation in every filed. The emergence of the intense global competition, considerable technological and knowledge economy and human resources advance have seen innovation become increasingly central to compete. Innovation is the mechanism by which organizations produce the new processes, products and systems required for adapting to changing technologies, markets and modes of competition. Numerous studies have been done in the literature in this context but still there is gap in literature about how any real estate firm can increase their capabilities related to technological innovation. The main objective of this study is do a proper literature review on technological innovation capability evaluation factors and do citation of each factors. To do critical review, the studied 1998 to 2016 have been reviewed.

**Keywords:** Innovation Capability, Knowledge Resources Capability, Strategic Planning Capability, Social Capital, Research and Development Cooperation.

## I. INTRODUCTION

Innovation's importance has continuously increased and aligns with global business growth. But the innovation in the context of Technological as well as Human Resources Innovation are required. In competitive environment combination of both the factors are important for an organization to grow. Technological Innovation Capabilities (TICs) play a crucial part in the initiation of firms' competency and as the source of sustainable competitive advantage stated by Bessant et al., (2005), and Huang (2011) clearly but we cannot avoid human resources factors also. The enterprises, thus, are strongly required the periodical monitoring their HIRs and TICs, have to continuously strengthen their weak capabilities in order to facilitate the competitive advantage.

The emergence of the intense global competition, considerable technological and knowledge economy and human resources advance have seen innovation become increasingly central to compete. Innovation is the mechanism by which organizations produce the new processes, products and systems required for adapting to changing technologies, markets and modes of competition (Dougherty et al, 1996). Innovation is a core renewal process within organizations and

a cornerstone of competitive strategy. It is a new technology defined as the development and implementation of a new idea, product organizational process, or arrangement (Rishiksha et al, 2011). Also, Innovation is a main strategic tool to have a competitive advantage in such complex environments and it is a necessity for long-term success, growth, sustainable performance, and to survive as the firm's industry. For this reason, firms accept that innovation is a strategic necessity and innovation is generally introduced as the key factor for competition in various markets (Gul et al, 2008).

## II. LITERATURE REVIEW

TICs was defined as an enterprises' ability to improve their technological innovativeness in order to create new customer value through the introduction of new products and services, the exploitation of new technologies and the exploration of new skill and competencies (Perdomo-Ortiz et al., 2009, Wang et al., 2008, Huang, 2011). TICs assessments were also included the aspects of multi-dimensionality, complexity, interactive innovation activities with resource allocation to enhance competitive advantage (Wang et al., 2008, Chiesa et al., 1996).

The technological innovation framework, approaches and components are developed by various researchers to evaluate a firm's technological or innovation capabilities as followings:

Burgelman et al. (1988) found in the study that TIC is a series of elements in supporting the firm's strategy, including comprehension of the industry development, comprehension of the technology development, configuration and culture of the firm and strategic management. Adler and Shenbar (1990) defined that the capacity of developing new products satisfying market needs, the capacity of applying appropriate process technologies to produce these new products; the capacity of developing and adopting new product and processing technologies to satisfy the future needs, and the capacity of responding to accidental technology activities and unexpected opportunities created by the competitors is innovative capability. In the same year, Adler and Shenbar (1990) defined that TIC is the capability of developing new products, applying appropriate process technologies, developing and adopting new technologies and the capacity of responding to unexpected technological changes.

Lall (1992) defined that to effectively absorb, master, and improve existing technologies, and to create new ones, TIC is the skills and knowledge needed. In same year, Barton (1992) said that the core of TIC was made up of expertise, technical systems, management systems and the values and norms of the firm.

Afuah and Bahram (1995) proposed that three uncertainties, namely, technological, market and enterprise-based uncertainties are involved in technological innovations. There are numerous sources of uncertainty, and E-mail ambiguities are embedded within each phase of the technological innovation process. The authors argued that radical, incremental and architectural aspects are applied to innovation at different stages in the innovation value-added chain and also proposed changes in high-tech firms. Most of the literature discussing innovation system failure tends to focus on perceived weaknesses in structural composition.

Panda and Ramanathan (1996) studied the important information were obtained from technological capability assessment, which carried out the inputs or the indicators of what requirements firms needed to do in order to enhance more competitiveness and to support its strategic decision making. A medium and high level rate of firms' supporting capability and steering capability could be pointed out as firms' strategic plan found through the results. In the same year, Oyelaran-Oyeyinka et al. (1996) emphasized that in order to gain competitiveness, firms need a certain capability to exploit technology sources and this capability is embedded in the skills and capabilities of the firms.

Guan and Ma (2003) said that TICs are a special asset of an enterprise. This comprises different key areas, such as technology, production, process, knowledge, experiences and organization. They considered the role of the seven innovation capability dimensions i.e. learning, research and development (R&D), organizational, manufacturing, marketing, resource allocating and strategy planning and the three firm characteristics i.e. domestic market share, size and productivity growth rate in determining the export performances for a sample of 213 Chinese industrial firms. The empirical analysis of this research found out that 1) Export growth is closely related to the total improvement of innovation capability dimensions, except for the manufacturing capability. Burgelman et al (2004) studied that TICs are a comprehensive set of characteristics of an organization that facilitates and supports its technological innovation strategies. TICs are the capability to modify the existing technology and create new technology found in study for Romijn and Albaladejo (2007). Yam et al. (2004) introduced a study framework reflecting the relevance of seven TICs to building and sustaining the competitiveness of Chinese firms. Two most important TICs are verified in the findings i.e. R&D and resource allocation capabilities. The study shows that a resource allocation capability would enhance the sales growth in small firms while a strong R&D

capability could safeguard the innovation rate and product competitiveness in large and medium-sized firms.

Woolthuis et al. (2005) indicated that all of the four types of innovation failures identified in their recent synthesis are related to structural components: infrastructure, institution, interaction and capability failures. The study shows that without referring to its effects on the innovation process to evaluate the implementation and performance of a particular structural element, is very difficult. Jacobsson and Lauber (2006) studied that there is need to be identified the elements such as the planning and commitment of the management. Generally, firms compete not only in the market but also over the nature of the institutional set-up so this work needs to be aligned with a new technology.

Garcia-Muina and Navas-Lopez (2007) defined that the phrase "degree of uncertainty", which refers to each phase of a technological growth trajectory to which successful technological innovation requires increased amounts of information. The required information regards a firm's organizational innovation decisions and its research and development (R&D) capability to fully represent the firm's TIC. Wang et al. (2008) presented the evaluation based on multiple criteria. For this study authors used the criteria such as R&D, innovation decisions, marketing, manufacturing and capital capabilities. Because the TICs of a firm are typically subjective and because measurements are typically imprecise, this construct increases the complexity of the implementation and performance evaluation process.

Chang and Lee (2008) explored the effect of knowledge accumulation capability on organizational innovation. This study also attempts to find if interaction between external environment or organizational culture and knowledge accumulation ability will influence organizational innovation. They employed a quantitative research design was employed. The research results indicated that the capability to obtain knowledge can positively and significantly affect knowledge administrative and technical innovation. Knowledge expansion capability can positively and significantly affect administrative innovation. In addition, external environment and organizational culture have significant interaction effects with knowledge accumulation capability on organizational innovation. They followed some research limitations/implications such as they discussed only some organizational layers like knowledge accumulation, external environment and organizational culture without any further research efforts aimed at any other facets. For Practical implications that said that with the rapid change of markets and the intense industry competition, business management is deeply affected by any change in the external environment.

Wang et al. (2008) examined that Technology innovation capability (TIC) is a complex, elusive, and uncertainty concept that is difficult to determine. Measuring TICs requires simultaneous consideration of multiple quantitative and qualitative criteria. This study evaluates the performance of

synthetic TICs in hi-tech firms by adopting a fuzzy measure and non-additive fuzzy integral method. The non-additive fuzzy integral is an effective, simple and suitable method for identifying the primary criteria influencing TICs at hi-tech firms, especially when evaluation criteria are interactive and interdependent are indicated by the analytical results of the study. For assessing the TICs of a firm and obtains useful information regarding hierarchical TIC frameworks, the proposed approach is an effective method.

Mothe et al. (2010) provided evidence of the major role of non-technological activities in the innovation process. It seeks to highlight the effects of marketing and organizational innovation strategies on technological innovation performance. They tested theoretical hypotheses on a sample of 555 firms of the Fourth Community Innovation Survey (CIS 4) in 2006 in Luxembourg. A generalized Tobit model is used for data analysis. Evidence is found to support the impact of innovation in the marketing and organization fields on a firm's capacity to innovate, but not on the innovative performance. The effects of non-technological innovation differ depending on the phase of the innovation process are statistically shown in the paper.

Zhou and Wu (2010) examined the role of technological capability in product innovation. Building on the absorptive capacity perspective and organizational inertia theory, technological capability has curvilinear and differential effects on exploitative and explorative innovations are proposed by authors. The findings support the proposition that though technological capability fosters exploitation at an accelerating rate, it has an inverted U-shaped relationship with exploration. That is, a high level of technological capability impedes explorative innovation. Strategic flexibility strengthens the positive effects of technological capability on exploration, such that when strategic flexibility is high, greater technological capability is associated with more explorative innovation.

The effects of various dimensions of customer relationship management (CRM) on innovation capabilities investigated by Lin et al. (2010). Five dimensions of CRM i.e. information sharing, customer involvement, long-term partnership, joint problem-solving, and technology-based CRM and five aspects of innovation capability i.e. product, process, administrative, marketing, and service innovations are identified. The one-to-one associations between the two constructs are developed and verified. For study the data is collected from 107 Taiwanese computer manufacturers. To examine the effects of CRM on innovation capabilities multiple regression analysis is employed. The study found out that computer manufacturers in Taiwan perform various levels of CRM and, consequently, display different levels of effects on each of the five innovation capabilities. Generally, firms are able to increase their innovation capability by ad hoc CRM; the relationship between customer involvement and process innovation; customer involvement and administrative innovation; and long-term partnership and marketing

innovation are not significant; and technology-based CRM has positive effects on all five types of innovation. Not all CRM activities contribute to innovation programs, which clearly indicates the need for applying other mechanisms, such as supplier integration, to form a complete innovation program, is suggested by them. Managers should align the development of their supplier management and CRM practices with the desired innovation capability.

Depends on determining multiple criteria and depends on building a performance and implementation plan. Lin et al. (2013) defined that the evaluation of Technological Innovation Capabilities (TICs). There are intensive studies on the issues of TICs, which have been dealt with extensively by practitioners and academicians but studies on the implementation and performance evaluation are few identified by the authors. The approach of adopting trapezoid fuzzy numbers and extending a technique for ordering performance by similarity to address the evaluation of TICs is proposed by them. The hybrid method is a suitable and effective method for identifying and analyzing the competitiveness in the context of uncertainty.

Sumrit and Anuntavoranich (2013) analyzed the technology innovation capabilities (TICs) evaluation factors of enterprises by applying the Decision Making Trial and Evaluation Laboratory (DEMATEL) method. They extracted six main perspectives and sixteen from literature reviews. The innovation management capability perspective was the most important perspective and influenced the remaining perspectives shown by the authors. The significant criteria for each perspective presented in the study.

Innovation depends heavily on knowledge is examined by Xiaobo and Sivalogathan (2013). In a knowledge-based economy Intellectual capital is a vital asset of an organization. For Innovation capability in advance of motivation the intellectual capital should be lead to superior performance. The impact relationship of intellectual capital on innovation capability and organizational performance of the Apparel industry in Sri Lanka for long-term survival is found in the study. As a research instrument to collect the data using simple random sampling technique the quantitative method is adopted and the structured questionnaires were administered. To test the relationship between the components of intellectual capital, innovation capability and the performance of Apparel Industry Pearson Correlation was used. The component of intellectual capital has significant positive relationship with innovation capability and the organizational performance found in the results. For Apparel Industry to understand and apply intellectual capital to create innovation in their organizations findings of this research will be useful.

A comparative case study of innovation capability in Australian manufacturing companies is done by Samson and Gloet (2014). For the study six case studies were undertaken with organisations having a degree of variance across company size, ownership type and industry sector. A history

of successful innovation is reflected from all the cases and the managers were interviewed about the attributes of innovation and the ways in which sustained innovation was manifested in their organisations. A model of innovation capability was developed based on the interview data, with a view to identifying attributes common to systematic and sustained innovation. The implications of the model for manufacturing organizations in general, and their managers in particular, are subsequently discussed.

Kafetzopoulos and Psomas (2015) explained the role of organisational learning as an antecedent to non-technical innovation comprising organisational and marketing innovation. This is also the aim of authors in this study to analyzing the influence of these dimensions of non-technical innovation on customer satisfaction. Based on a comprehensive literature review the authors formulate research hypotheses. For testing hypotheses 226 Greek small and medium-sized enterprises (SMEs) are selected and

structural equation modelling (SEM) is used on collected data. The results confirm that organisational learning capability favors the development of organisational innovation and marketing innovation. Both dimensions of non-technical innovation promote the achievement of customer, is shown by the results of the study.

Huimin and Bin (2015) studied that Technological innovation is a key ingredient in building high performance organizations and the proper evaluation of technological innovation capability (TIC) is very important for decision makers. The objective of this paper is to introduce an analytical network process (ANP) model for technological innovation capability evaluation. The paper presents a report on an application of proposed methodology related to large and medium-sized industrial enterprises in China. The analysis aims at proper evaluation and improvement of TIC for enterprise or region. After doing extensive literature Table 1 is showing the citation of Technological Factors.

Table 1 Technological Factors with Citations

Criteria	Support References
Innovation Management Capability	Burgelman et al. (1988), Adler and Shenbar (1990), Cohen and Levinthal (1990), Damanpour (1991), Lal (1992), Afuah and Bahram (1995), Panda and Ramanathan (1996), Oyelaran-Oyeyinka et al. (1996), Romijn and Albaladejo (2002), Xu, Lin, and Lin (2008), Guan and Ma (2003)Burgelman et al (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014), Samson and Gloet (2014), Kafetzopoulos and Psomas (2015), Huimin and Bin (2015).
Collective Learning Capability	Xu, Lin, and Lin (2008), Guan and Ma (2003)Burgelman et al (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014), Samson and Gloet (2014), Kafetzopoulos and Psomas (2015), Huimin and Bin (2015).
Organizational Innovation	Damanpour and Evan (1984), Damanpour (1991), Damanpour (1992), Damanpour (1996), Zamantili et al. (2014), Svante Schriber and Jan Löwstedt. (2015),
Technology Commercialization Capability	Burgelman et al. (1988), Xu, Lin, and Lin (2008), Guan and Ma (2003)Burgelman et al (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Serrano García and Robledo Velásquez (2013), Samson and Gloet (2014), Kafetzopoulos and Psomas (2015), Huimin and Bin (2015).
Strategic Planning Capability	Burgelman et al. (1988), Adler and Shenbar (1990), Cohen and Levinthal (1990), Damanpour (1991), Lal (1992), Afuah and Bahram (1995), Panda and Ramanathan (1996) Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014), Samson and Gloet (2014), Kafetzopoulos and Psomas (2015), Huimin and Bin (2015).
Innovation Decision Capabilities	Xu, Lin, and Lin (2008), Burgelman et al (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo

	Velásquez (2013), Zhu and Xu (2014)
Marketing Capabilities	Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013),
Robustness Product & Process Design Capability	Burgelman et al. (1988), Adler and Shenbar (1990), Cohen and Levinthal (1990), Damanpour (1991), Lal (1992), Afuah and Bahram (1995),Panda and Prašnikar et al. (2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014), Samson and Gloet (2014), Kafetzopoulos and Psomas (2015), Huimin and Bin (2015).
Innovation Sourcing Capability	Burgelman et al. (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013).
Network Linkage Capability	Oyeleran-Oyeyinka et al. (1996), Romijn and Albaladejo (2002), Xu, Lin, and Lin (2008), Guan and Ma (2003)Burgelman et al (2004), Yam et al. (2004), Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), Prašnikar et al. (2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014), Huimin and Bin (2015)
Technology Acquisition Capability	Woolthuis et al. (2005), Jacobsson and Lauber (2006), Guan et al. (2006), Perdomo-Ortiz et al. (2006), (Prašnikar et al., 2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Zandhessami and Jalili (2014).
Product Structural Design and Engineering Capability	Burgelman et al. (1988), Adler and Shenbar (1990), Cohen and Levinthal (1990), Damanpour (1991), Lal (1992), Afuah and Bahram (1995),Panda and Prašnikar et al. (2008), Garcia-Muina and Navas-Lopez (2007), Wang et al. (2008), Akman and Yilmaz (2008), Chang and Lee (2008), Wang et al. (2008), Bo Wu et al (2010), Mothe et al. (2010), Zhou and Wu (2010), Lin et al. (2010), Yam et al. (2011), Forsman and Annala (2011), Lin et al. (2013), Sumrit and Anuntavoranich (2013), Xiaobo and Sivalogathan (2013), Serrano García and Robledo Velásquez (2013), Zhu and Xu (2014), Huimin and Bin (2015).

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