

COMPETENCY DEVELOPMENT IN TECHNOLOGY MANAGEMENT FOR ENHANCING COMPETITIVENESS

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Abstract: There is an increasing interest to understand role of sub-domains within technology management function. The competencies within the sub-domains determines the competitiveness of technology based firms which vary across firms dependent on their level of technology dependence, competitive position, evolving technologies which can affect its position and country specific influences. The competitive sustainability of firms in future is most likely dependent on awareness of relative importance of sub-domains of technology management and efforts to gear up accordingly. The study examines the literature to figure out major frameworks and important sub-domains of technology management and relevance in terms of competencies. Competency in corporate technology strategy, technology acquisition and transfer, creativity and innovation, knowledge management, R & D management, technology protection, audit, financing and human resource management are doing to be major determinants of sustainability for technology intensive manufacturing firms.

Key Words: Technology Management, Technology Management Practices, Competencies

1.0 Introduction

There is untiring race amongst the nations to win international market positions. There has been growing interest in emergent technologies and effective technology management driven by competition and societal requirements. Technology is a major competitive factor for the countries at macro level and for individual firms at micro level (BIS, 2014). But, most of the developing and newly emerging economies, due their weak R&D, are not at par with the advanced countries in achieving competitive advantages in technological excellence, and hence their manufacturing sectors are less competitive. To combat these challenges, technology management competencies, are perceived as effective in achieving competitiveness (Ram Khilari, 2014). Competitiveness is a dynamic and multidimensional construct. The extant literature on technology management has been mostly around its definition, dimensions, factors which determine the competitiveness at various levels, measurement, contextual questions, technology transfer, R&D, spill overs societal and policy interfaces. Also associated inter firm collaboration and cooperation as the primary analytical units (Robber Huggis and

HiroIzushi, 2015). These characteristics are relevant in view that it is the firms, not the nations which compete in the international market, nations can compete if their firms can compete (Porter, 1998). The company/firm competitiveness is its ability to design, produce and/or market products or services superior to those offered by competitors, considering the price and non-price qualities (Momaya, 2008). Competitiveness has been studied based on firms' performance mainly on quality, productivity, cost, market share, market capitalization, growth, introduction of new products in the market, customer delight, export and technological wellbeing. There is a very high positive association between technology management practices and firm performance and higher level of technology management capability leads to higher competitive advantages (E. Unsal and Cetindamar. D, 2015, Ram Khilari and O.P.Wali, 2015). But, there is lack of validated agnostic indicators of effective technology management or scientifically proven generic models for technology management. There are evidences of contextual models in use by business practitioners in firms. This paper an effort to present a representative broad technology management framework which can drive competitiveness of technology based manufacturing firms.

This paper presents definition of technology and technology management, an overview on various technology frameworks, including a technology management framework developed in the specific context of manufacturing of auto component in India, and brief literature on competencies related questions for managing various contemporary and evolving sub-domains of technology management.

2.0 Definition of Technology and its Management

Depending on context, situation and its uses, technology has been defined in varied ways by scholars and practioners from institutes and organizations. Technology is 'a system of knowledge, techniques, skills, expertise and organization used to solve a problem, produce goods or services or serve some purpose' (BIS, 2014). It considers products such as machinery, equipment, and material, as well as processes and organization methods, all linked by the common factor of enhancing efficiency, improved utility and productivity (Global Competitiveness Report, 2015-16).

The basic aim of technology management is to achieve competitive advantage (White and Bruton, 2007), and its objective is enhance the competitiveness of enterprises; its scope is perceived to be the people, knowledge, competence, architectures, products, tools and methods, software, and IT systems (Sahlman and Haapasalo, 2012). Hence, 'Technology management is a set of policies and practices that enable entities to manage their technologies and technology related processes to create competitive advantage' (BIS, 2014). If the application of technology is from the strategic management and operation management point of view of the enterprises, it is termed as strategic technology management.

3.0 Technology Management Frameworks at Manufacturing Firm Level

There are no commonly or universally accepted theoretical and practical framework for technology management (Phaal et.al., 2004; Brent and Pretorions, 2008; Certindamar et.al, 2009.b). Complexity of the subject and lack of comprehensive frameworks give rise to managerial challenges in all sizes of enterprises. Common perceptions of technology management are not well suited for coping with the complexity of the field (Levin and Barnard, 2008). Therefore, a consistent framework with insights on the elements of technology management has been necessitated. The framework should represent at least a partial solution to the problem of what are the elements of strategic technology management link technology as a resource for reaching business objectives or to manage technology specifically as part of innovation or new product development processes.

The literature lists a number of technology management frameworks. A few of them with their key characteristics/elements are presented in Table-1

Table-1
Elements/Characteristics of Technology Management Frameworks at Firm Level

Type of Framework	Elements/Characteristics	References
Generic Process Framework	Five Processes are :Identification, Selection, Acquisition, Exploitation and Protection (ISAEP) of technology.	Gregory (1995)
Universal Technology Management Framework	Technology Audit, Corporate Technology Strategy, Technology Acquisition, R&D Management, Technology Marketing, Finance for Technology, Creativity and Innovation, Pricing of Technology, Protection of Technology, and Technology Measurement.	Kumar and Bhatt 2000
Technology Management Activity and Business Process Framework	Framework is based on: (i) RBV theory of the firm, (ii) Use at the firm-level of analysis, and (iii) Business environment where the firm operates. TM processes i.e. Identification, Selection, Acquisition, Exploitation and Protection (ISAEP)are distributed and existed within the core business processes and are important for the sustainability of the firms. Understanding the relationships among Technology Management processes, business processes, pull/push mechanisms and the commercial and technological perspectives in the businesses environments is crucial for the effective technology management.	Phaal <i>et al.</i> (2004)

Integrative Technology Management Framework	Technology Utilization, Knowledge Management, Technology Acquisition, R&D Management, Technology Integration, Technology Protection, License/Patent Purchasing, Technology Transfer, Technology Planning and Forecasting, Technology Strategy, Technology Assessment, Technology Commercialization and Marketing	(Cetindamar, Can and Pala ,2006)
Technology Management Routines Framework	Producing Scientific and Technological Knowledge, Transforming Knowledge into working Artifacts, matching Artifacts with user Requirements, Providing Organizational Support. This is suitable for large firms only	Levin and Barnard (2008)
Technology Strategy Approach Framework	Emphasizes Technology Strategy Creation and Implementation with the definition of Core and Complementary Technologies, Competencies, Make/Buy Decisions, Environment Analysis, and Planning	Dodgson <i>et al.</i> , (2008)
Technology Management Functions Framework	Technology Strategy, Technology Road Mapping, Technology Development, Information and Knowledge Management, Technology Acquisition and Transfer, Technology Forecasting, Product Development and Life-Cycle Management, and Commercialization.	Kropsu-Vehkaperä <i>et al.</i> (2009)
Dynamic Capability Perspectives Framework	Strategy, Commercial Perspective, Technological Perspective, Push Mechanisms – Capabilities (Knowledge Flows), Pull Mechanisms – Requirements (Knowledge Flows), Innovation, Operations, and Technology Base i.e. Technology Identification, Selection, Acquisition, Exploitation And Protection	Cetindamar, Phaal and Probert,(2009)
Technology Management Process Activities Capability Framework	Identification, Selection, Acquisition, Exploitation, Protection, and Learning; then there are Four Technology Management Supporting Activities : Strategic Management, Knowledge Management, Innovation Management, and Project Management with Control Variables as Firm Size and Industry Characteristics.	Cetindamar <i>et al.</i> (2009a)
Conceptual Framework For Strategic Technology Management in the Context of Automotive	Strategic Business Objective, Government Policy and Regulations, Technology Strategy, In-House Development, Technology Agreement, Joint Venture, Technology Capability, Technology Performance, Business Performance. This Framework provides the Linkages, Hierarchies and Levels of the Identified Factors for Strategic Technology Management and gives very	Sahoo,T, Banwet.D.K, and Momaya.K, (2011)

Industry in India	valuable insights in the Context of Automotive Industry in India	
Artefacts and Processes based Strategic Technology Management Framework	Strategic Technology Management functions are organized in Artefacts, Processes , Tools, Methods and Systems, Organizational Management Functions, Governance , and Collaboration Networks	Sahlman, K. and Haapasalo, H,(2012)
Conceptual Framework for Technology Management in the Context of Automotive Industry in India	Strategic Technology Management is Strategic Management of Technology. It Involves Key activities from Linking Technology Strategy to Business Strategies to Effective Management of Innovation, Technology Transfer, Adoption, Adaptation, Absorption, R&D, Design and Commercialization.	Tapan Sahoo, (2013)
Representative Technology Management Framework	Technology Strategy, Technology Forecasting , Technology Road Mapping, Project Portfolio;, Technology Portfolio , Technology Transfer and Acquisition , Technology Protection	BIS,(2014)
Technology Management Capability Framework	Identification, Selection, Acquisition, Exploitation, Protection, Learning, Strategy Management, Innovation Management, Project Management, Knowledge Management	E, Unsal and Cetindamar.D, (2015)

Based on the suggestion that knowledge-based theory recognizes competencies of human resource as valuable assets of the firm (C. J. Chen, and J. W. Huang, 2009) and other earlier frameworks mentioned, Human Resource Management (HRM) may be one of the important components of technology management, and is a vital force for achieving competitive advantages and superior corporate performance by the firms. Integrated Technology Management Framework in the context of enhancing competitiveness of auto component manufacturing firms in India, encompassing its practices(components) as - Technology Audit, Corporate Technology Strategy, Technology Acquisition, Management of R&D, Creativity and Innovation management, Knowledge Management, Finance for Technology, Protection of Technology, and Human Resource Management (Ram Khilari, 2016).This framework may also fit for other manufacturing sector, provided these practices are relevant in the context of those sectors. Hence, it is almost imperative for firms to seek competencies in these practices for their effective application in all operations of the firms. Next, a brief literature review on each of these identified technology management practices is discussed.

3.1 Corporate Technology Strategy

Technology strategy is one of the key elements in strategic technology management, as to which technologies, competencies and capabilities are needed for achieving competitive advantage, which technologies are to be used, what should be the investment level on technology development, what is the make or buy strategy for technology, how to introduce technology to the market as embedded in products, and how to organize technology development and technology management (Burgelman et al.,2001). Technology strategy should be an integral part of the corporate strategy of the firm, and needs to be connected with the firm's business strategy, strategy on products, services and processes throughout its value chain activities (Burgelman *et al.*,2001; Schilling, 2008; Dodgson et al.,2008). The determinants of technology strategy as suggested by them are technology push, strategic action, technology evolution, internal force, external force, organizational context, industry context, and marketing pull. Technology strategy comprises of the definition, development and use of those technological competencies that constitute the company's competitive advantage (Dodgson et al.,2008). Earlier research also proposes a model for formulating technology strategy for manufacturing company, where managers have the competency in (i) market situation knowledge (ii) identification of key success factors in the market(KSF) (iii) identification of internal success factors (ISF) (iv) identification of technological needs(ITN), (v) identification of key technologies (vi) attractiveness assessment, and(vii) capability auditing (Ahmad Jafar Nezhad, et al., 2013).

3.2 Technology Acquisition and Transfer

The primary purpose of technology transfer is to reduce R&D costs, speed up product development and make it more effective to complement a company's own competence and resources so as to access to new technology from partners. Appropriate technology transfer has 40 percent positive effect on firm's productivity and 29 percent effect on its innovation capacity (Nguyen Thi Duc Ngguyen and Atsushi Aoyama, 2014). Therefore, technology transfer should become an integral part of organizational culture for progressive firms and the purpose of technology acquisition should be to reduce the total time required to convert an idea into a commercial success, but decision to acquire technology may be taken by the management at the right time for exploiting gains of the technology to be acquired. Innovation comes from technology transfer and is very crucial for a firm to remain competitive. Keeping in view competitiveness as one of the objectives of technology acquisition, the managers while going for technology transfer, should concentrate on: show- how, know-how, know – why and know-everything about the technology which progresses through Incubation, Anticipation, Confrontation, Implementation, and Follow-up (Daniel, 2003). The process of technology transfer has a number of aspects such as, the quality of technology, stage of technology in the technology life cycle, standing of technology supplier, price of technology, payment

terms, intellectual property rights issues and many others. All these factors have a bearing on the performance of an organization. An organization must critically evaluate whether to buy, develop, subcontract or jointly develop technology (Vinay Kumar, 2014). Vinay Kumar (2014) suggests a technology acquisition process framework comprising complex issues and activities such as: need for technology, identify mode and source of technology(through data banks, international bodies, and trade fares), evaluate technology supplier(market share, financial health, patents held, reputation), evaluate technology(input-output norms, utility usages, pollution, safety, environment norms), negotiate, agreement, acquisition, and implementation, which are to be followed by a firm while going for technology acquisition

3.3 Creativity and Innovation Management

Creativity is defined as generation of ideas requiring divergent thinking process, whereas innovation is putting these ideas with convergent thinking into actions by refinement and implementation (Gurteen, 1998). Innovations can arise at many different points in the development process including conception, R&D, transfer (the shift of the technology to the production organization), production and deployment or market place usage and links it with competitiveness and/or productivity. Innovation includes discovery, experimentation, and development of new technologies in production process with the purpose of creating more effective products (C. López and Á. L. Merono, 2011). Brainstorming, virtual prototyping, product life cycle management, idea management, project management, and project line planning and portfolio management are some common tools for innovation management. The goal of innovation management within a company is to cultivate a suitable environment to encourage innovation (Rickne, et al, 2012). Senior management's support is very crucial for successful innovation. Their clear direction and endorsement are essential to innovation pursuits (Wong,2012). To manage innovation, measurement and assessment of the outcome of the processes on the dimensions of inputs to the innovation process, output from the innovation process, impact of the innovation output, measures to assess the activities in an innovation process, and availability of factors that facilitate such a process, is essential. Kataria.S (2013) suggests that managers need to concentrate heavily on the innovation network which requires deep understanding of the issue. Now the concept of inclusive innovation i.e. giving rights, voice, capabilities and incentives for the excluded groups of the people of the company to become active participants, is very important in the process of development and innovation (A. Mehta, 2012; Foster and Heeks, 2013b)..This can be achieved if the companies develop strong innovation management capabilities and apply them.

3.4 Knowledge Management (KM)

The competitive advantage of the firms lies with its knowledge assets. The knowledge growth cycle of new products or technologies also follows growth in S- curve with stages of knowledge search, idea creation, knowledge generation, knowledge internalization, knowledge externalization, knowledge growth, knowledge decay, and knowledge renewal. To survive and meet changing customer requirements, minimizing competitive threats and developing future technology trajectory, the firms should, therefore, formulate

technology strategy by aligning knowledge evolution, knowledge search, knowledge creation and knowledge envisioning (Bowonder & Miyake, 2000). Knowledge management focuses on organizational objectives of improved performance, competitive advantage, innovation, the sharing of lessons learned, integration and continuous improvement of the organization (Gupta et al, 2004). Core components of KM include people, processes, culture, structure and technology depending on the specific perspective (Spender & Scherer, 2007). Knowledge sharing remains a challenge for knowledge management, as there is no clear agreement on these aspects, and as such, barriers may include time issues for knowledge works, the level of trust, lack of effective support, technologies and culture (Jennex, 2008). Technological information and knowledge require codification and systematic management for accessing, storing, sharing and deploying it for business benefits and productivity

Human Resource is one of the important constituent of Knowledge Management. Tacit knowledge represents internalized knowledge that an individual may not be consciously aware of, such as how he or she accomplishes particular tasks (Spender & Scherer, 2007 ; Addicot, et al, 2006). At the same time, explicit knowledge represents knowledge that the individual holds consciously in mental focus, in a form that can easily be communicated to others (Bray David, 2013). A successful KM effort needs to convert internalized tacit knowledge into explicit knowledge to share it, and the same effort must permit individuals to internalize and make meaningful any codified knowledge retrieved from the Knowledge Management effort (Rhetorical Structure Theory, 2013).

3.5 Research and Development (R&D) Management

The concern of R&D management is to reduce lead times, improve just-in-time deliveries of new products, minimize the number of unsuccessful R&D projects, improve efficiency, and cut research cost (Niosi, 1999). Decision makers need to give due emphasis on selection of suitable projects, structured methods for their implementation, measures for effective monitoring of their progress, systems for financing the projects and other related aspects. The perspective on managing R&D processes has changed over the years, moving from a technology centred model to a market driven high interaction focused view. Due to profound progress in manufacturing technology, rapid changing business environment, and continuously shortening product life cycle, hi-tech industries must put more efforts in their R&D for developing technologies to meet customer demands and achieve new product development performance. This can be achieved when R&D management ability is stronger, R&D tendency is higher, and technology status is superior (Pang and Chih, 2007). Holt and Jayawama,(2009) have highlighted concerns like, what was done and how, instead of how many, how much and the frequency. Literature also emphasizes that development of networks or alliances among firms and public institutions or universities (Busom, et .al., 2008). In new R&D concepts emphasis has to be on cross-functional communication, collaboration, greater inclusion of community experts and stakeholders, such as, suppliers, customers, Government and partners in R&D in the full life cycle of R&D process(Sofo, 2008). To cope with fast changing business environments, firms are

increasingly opening up their organizational boundaries to tap into external source of knowledge. By restructuring their R&D system, firms face the challenge of balancing internal and external R&D activities to gain profit from external knowledge. The firms that increasingly rely on external R&D activities have a better innovative performance (Berchicci, L, 2013). Under the sixth generation R&D model, organizations will develop methods to share intellectual property as well as forms of collaborations that are new to previous R&D management practices (Alex K. Kensen, Jhc Pretorius Leon Pretorius, 2014). Therefore, understanding R&D mission and industry life cycle is very important issue in the management of R&D which is indicative of having in place relevant competencies in this sub-domain.

3.6 Protection of Technology

The aspects of intellectual property protection and their impact on innovation and technology diffusion is very important to safeguard the interests of innovators, developers of technology, product and processes. The firms' valuable technologies need to be protected in term of copyright, trademarks, patents, and others in order to assure the technologies will be benefiting only the firm (Phaal, Farrukh, and Probert, 2004). Protection is also needed to the firms' knowledge and intellectual properties including the staff (Cetindamar, Phaal, and Probert, 2009). The company should develop strong IPR strategies and policies to protect technology, process and product designs to avoid their copying by the competitors.. The firms should balance their patent portfolio by holding a share of patents, which are essential for standards, and by holding a share of patents on technologies that are not standardized. It is necessary to identify and assess the financial impact of patents essential to standards. The companies, therefore, should pursue a common strategy for developing competency in patenting and standardization to exploit patented inventions in technology fields where standards matter (Tim, Peter, and Knut, 2015)

3.7 Technology Audit

The industrializing countries need to adopt technological catch up strategy in building their innovation capabilities and developing infrastructure (Varblane et al, 2007). In this context, it becomes very necessary that technological performance may be evaluated at the firm level which can be achieved with a performance measurement model called Technology Audit or Technology Assessment. The purpose of technology audit is to improve opportunities and future plans for technology development and its diffusion. It is an important component to formulate technology strategy, and is a systematic approach to assess the technological strengths and weaknesses of the company against the most relevant competitor. Its focus is on accessing core competencies of a technological unit. In the days ahead, each entity would have to depend on the strength of its technology base as the knowledge resident in the technology base is ultimately going to be responsible for retaining existing core competencies and for development of new competencies(Kumar and Bhat, 2000).

Earlier research proposes systematic comprehensive technology audit for firms to evaluate the opportunities and threats for attaining competitiveness (Janes and Dolinsek,

2007). It is an innovation oriented activity to recognize potentials and benefits of new technology at early stages of its development and to explore strategies for future technology development (Fleischer and Grunald, 2007). Technology audit is not only an analysis performed to identify strength and weaknesses of technological aspects of an organization, but also to evaluate the opportunities as well as threats from which potential for international competitiveness arises (Ayse Gonsel and Dilek Cetndamar, 2010). From the literature review it is observed that there are several technology audit models, but their applicability differs from case to case and industry to industry with different perspectives, such as, technology environment, technology categorization, markets and competitors, innovation process, value addition, and acquisition and exploitation of technology. The technologies, skills, R&D equipment, R&D out puts, and infrastructure need to be assessed as forces for evaluating long term competitiveness of the firms. (Mohammad et al, 2010) have identified six indicators which are (i) human resources (ii) equipment (iii)knowledge management (iv) communication management(v) marketing and sales, and (vi) achievement. For assessing technological capabilities of R&D organizations, they suggested each indicator needs to be evaluated separately.

3.8 Finance Technology Development

Presently financing technology , technology management and commercialization are being debated at large. Developments in one field lead to further developments in the others, and new technology based firms often face difficulties in financing their business projects, R&D investments, and commercialization of new technologies (Jarunee Wonglimpiyarat , 2014). Worldwide, there are a number of funding mechanisms available for technology development, innovation and R&D. Mostly these are provided by the national and international financial institutions. National Governments, as a policy measure for technology and industrial development as well as to foster R&D and innovation and for development of a particular cluster/ sector of industry, provide support. FDI flows, Venture Capital/ Equity Capital (VC/EC), Technology Business Incubation programmes funds for these activities, are also available. Despite all these available funding mechanisms, managing finances for technology development, R&D projects and innovation is a very important management function and need to be managed carefully, as with large investments, any failure involves high risk. Therefore, the investment need to be decided on three major considerations, in order of priority these are: (i) production related investment, market related investment, and R&D related investment (ii) setting specific R&D limits, and (iii) setting goals for strengthening existing business for new development in relation to core technology development and generic technology development (IGNOU, 1999).

It may be concluded that for proper utilization of finances, reduction in failure, minimization of risks and maximizing profitability, it may be necessary for the top management, and managers of R&D , technology, and finance of firms to collectively choose the technology development, R&D and innovation projects after their careful review and scrutiny with respect to the company's technology strategy, future business plans and market dynamics.

3.9 Human Resource Management (HRM)

Due to globalization, company consolidations, technological advances, and further research, Human Resource (HR) functions after the first decade of 21st century are mainly focusing on strategic initiatives like acquisitions, talent, succession planning, industrial and labour relations, and diversity. Human resource management (HRM, or simply HR) is a function in organizations designed to maximize employee performance from the view point of employer's strategic objectives(Johnason. P, 2009). HR is primarily concerned with the management of people within organizations, focusing on its policies and systems (Collings and Wood, 2009). Firms with a poorly defined corporate strategy that does not explicitly incorporate human resources, are likely to lose ground to their competitors (G. W. Bohlander, and S. A. Snell, 2003).) Increasing core competencies of the firms, particularly in HR, is key to success of firms and the enhanced involvement of humans resource in the development and implementation of business strategy will lead to increased effectiveness of firms and the industry as a whole. To access knowledge and expertise of the employees, company may require good capacities to human knowledge management so as to exploit and ensure effective utilization of human resource in achieving organizational goals (S. Sudin , 2011). No organization can perform at peak levels unless each employee is committed to the company goals and works as an effective team member. Strategic human resource practices are primary means by which firms can shape the skills, attitudes, and behaviour of individuals to align with the business strategic objectives Technical HRM is more important in explaining perceived organizational performance, whereas, strategic HRM is better at predicting human capital accumulation, and firms should , therefore, acquire competencies in formulating their HR policies accordingly(Chien,and Carol, 2014). Therefore, HR competencies which can recognize relevant talent for technology management, help groom and retain that talent would be key to support all other sub-domains and successful technology management function.

Conclusion

The content analysis of the literature review on the concepts, definition, models / frameworks indicates that researchers have identified several components and routines of technology management to be practiced by the managers. These frameworks are firm centred, some are general in nature, some are specific to large firms, some are specifically developed keeping in view the firm size and industry characteristics, and some researchers have discussed technology management frameworks particularly in the context of automotive and component industry. All these frameworks and their elements at firm level are multidimensional and complex in nature. The framework developed by Ram Khilari,2016, encompassing its practices as Technology Audit, Corporate Technology Strategy, Technology Acquisition, Management of R&D, Creativity and Innovation management, Knowledge Management, Finance for Technology, Protection of Technology, and Human Resource Management, though developed in the context of auto component manufacturing in india, is a 'Representative Integrated Broad Technology Management Framework' and may be useful to other manufacturing firms also . The top management should pay more attention for developing competencies of managers in each component of this framework so as to effectively apply these practices

in all operations of firms for achieving overall improved performance and thereby enhancing competitiveness. For this they should organize short, medium and long term training and MDPs for managers.

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