DEVELOPING A FRAMEWORK FOR ENGINEERING PRODUCT DEVELOPMENT IN INDIAN CONTEXT

Thesis submitted by

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C E RT I F I C A T E

This is to certify that the thesis entitled, "**Developing a Framework for Engineering Product Development in Indian Context**", submitted by **Ms. SUDESHNA ROY**who got her name registered on 07.05.2013 for the award of Ph. D. (Engineering) degree of Jadavpur University is absolutely based upon her own work under our supervision and that neither her thesis nor any part of the thesis has been submitted for any degree/diploma or any other academic award anywhere before.

(Dr. Nipu Modak)
Signature of the Supervisor
and date with Official Seal

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Ms. Sudeshna Roy, the author of this thesis, was born in the year of 1986 in Kolkata, India. Ms. Roy passed Secondary Examinations from West Bengal Board of Secondary Education and got Merit Certificate (National Scholarship Scheme) for high position secured in the list of meritorious candidates qualifying for awards in 2003. She completed her Higher Secondary Examinations from West Bengal Council of Higher Secondary Education in First Division. Ms. Roy obtained her Bachelor's Degree (B. Tech) in Applied Electronics and Instrumentation Engineering from the Academy of Technology affiliated to West Bengal University of Technology (now known as, Maulana Abul Kamal Azad University of Technology) in the year 2010. She received the award for 'Outstanding Examination Results' from the Academy of Technology in the year 2010. She completed her Master's Degree (M. Tech) in Industrial Engineering and Management from West Bengal University of Technology, Kolkata in the year 2012 and was awarded Gold Medal as First Rank Holder in the said discipline from the University. She is the recipient of INSPIRE Fellowship by Department of Science & Technology (DST), Ministry of Science & Technology, India. She has presented research papers in national and international conferences and has published several research articles in national and international journals, and book chapters out of her doctoral research.

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Place: Kolkata
Date:

Sudeshna Roy

Dedicated
to
My Parents & Uncle

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LIST OF ABBREVIATIONS

AGFI = Average Goodness of Fit	LTV = Long-term Vision
AHP = Analytic Hierarchy Process	M = Management Actions
AVE = Average Variance Extracted	M = Management Actions
CET = Concurrent Engineering Team	MA = Market Analysis
CFA = Confirmatory Factor Analysis	MCDM = Multi-Criteria-Decision-Making
CI = Communication Infrastructure	ML = Maximum-likelihood
CM = Conflict Management	MPD = Modular Product Design
CR = Composite Reliability	NPD = New Product Development
CSF = Critical Success Factor	PCA = Principal Component Analysis
DFM = Design for Manufacturability	PDP = Product Development Process
DFMA = Design for Manufacturability and Assembly	PF = Product Feature
EC = Entrepreneurial Culture	PM = Project Management
EF = Environmental Factors	R&D = Research and Development
EFA = Exploratory Factor Analysis	RMSEA = Root Mean Square of Error Approximation
ERP = Enterprise Resource Planning	RO = Result Orientation
FAHP = Fuzzy Analytic Hierarchy Process	ROI = Return on Investment
FFE = Fuzzy Front End	SEM = Structural Equation Modeling
FL = Factor Loadings	SI = System Integration
GFI = Goodness of fit	SM = Strategic Management
GVA = Gross Value Added	SRW = Standardized Regression Weights
HR = Human Resource	TC = Teamwork Culture
HRM = Human Resource Management	TMS = Top Management Support
IT = information Technology	TQM = Total Quality Management
ITM = Information Technology Management	

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A B S T R A C T

Escalation of the competition in the global market entails manufacturers to improve their product development capabilities for industrial sustainability. Manufacturing is the main contributor of the industry sector conquered by engineering products used for producing other products and components. New product development (NPD) has eventuated as a decisive approach for strengthening the position in the competitive market environment. This work essentially focuses on NPD in the engineering product segment. Despite difficulties and complexities associated with NPD task, it has turned out to be a major determinant of the endurance of the firm. There are various factors – critical for the success of the firm – termed as critical success factors (CSFs); these are influencers in controlling the NPD performance for maintaining the firm's identity and sustainability. Based on their activities, these CSFs are clubbed in five groups, namely, environmental factor, management actions, product development process (PDP), research and development (R&D) activities and teamwork culture. The impact of each group of CSFs is inevitable for NPD success. Similar to the CSFs, the success measures to compute the ultimate performance and the success of the firm are clubbed in five groups namely, economic and financial measures, environment based attributes, NPD team's capability, technological development and quality assurance. This empirical investigation accumulates primary data from 263 experts of Indian manufacturing companies involved in new engineering product development. First, the prioritization of the groups of CSFs has been performed by using fuzzy extent analysis method to rank the groups as per their importance in Indian context. Ranking is followed by the development of a framework considering the five groups of CSFs and the respective group of measures suitable for measuring the NPD success. Validity and reliability of the empirical data is tested by average variance extracted (AVE), composite reliability (CR), and Cronbach's Alpha (α) reliability test using IBM SPSS 21.0. Exploratory factor analysis (EFA) has been performed to extract the manifests having higher contribution on success factors and measures. Depending on the extracted variables, the structural equation modeling (SEM) approach has been applied to develop the framework conveying the impact of CSFs on NPD success by using IBM SPSS AMOS 21.0 software packages. The novelty of this research lies in development of five structural models for the five groups of CSFs relating to their respective groups of success measures. This helps in drawing managerial implications for successful implantation of CSFs for NPD success.

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CHAPTER 1

INTRODUCTION

1.1 Background

The progression of globalization leads to social, cultural and political linkage worldwide, posing a challenge to industrial success and sustainability. Product development is a practice which is particularly a critical point for the transformation of society towards sustainability. Technological innovation upgrades organizational innovativeness through product development (Nikakhtar et al., 2014). This enforces the companies to produce new ideas and strategies for securing their future prospect. Though continuous improvement is a difficult task to be performed (Hailu et al., 2018) but product development is an effective way for revitalizing the success of the firm by providing new products with the features as per the customers' demand (Bhuiyan, 2011).

Globalization bridges the gap among the countries from all corners of the world by making them a part of the globe. This entails the firms to develop new products for sustaining in the worldwide competition. New Product Development (NPD) has become one of the crucial variants for every firm to compete in the universal platform. Successful NPD depends on the performance of newly developed products in global market. On the basis of this scenario NPD has transformed as one of the most critical task by utilizing the advantages of global opportunities for attaining success and survival. It has been observed that the nomenclature, engineering product development or new product development and product development in the engineering manufacturing domain have been used interchangeably and also often deals with the common objectives and methodologies. This work essentially focuses on new product development in the engineering product segment. Here therefore, even though the term NPD has mostly been used, it comes broadly under 'engineering product development' or simply as product development. The engineering product development in the title of the thesis covers new product development in engineering segment.

From NPD strategy to commercialization there are numerous factors influencing the ultimate growth of the firm by performing innovative activities (Chen et al., 2014; de Sousa Mendes and Ganga, 2013). Differences in social, economic and political atmosphere of different countries and varieties of industries create distinguishing factors controlling the NPD performance.

Indian economy is classified in three sectors such as agriculture, industry and service. Among these sectors, industry is the second largest sector with percentage share of 29.02% and Gross Value Added (GVA) of 39.90 lakh crore INR in 2016-17. Manufacturing sector is the main contributor of the industry sector with percentage share 16.57% and GVA of 22.78 lakh crore INR in 2016-2017. The significance of manufacturing sector in Indian economy is unquestionable. Identification of factors critical to success of Indian manufacturing industries is also undoubtedly imperative for economic growth of India (Statisticstimes.com).

1.2 New Engineering Product Development

Engineering product is used for producing other products and components. Components manufactured from such materials are intermediate products such as valves, pumps, compressors, air ventilators and electrical equipments that go into the production of other engineering machinery and systems and such engineering systems themselves. Developing an engineering product basically starts with a concept followed by development of design to shape this concept into reality for developing finished products. It consists of a complex set of activities involving resources of the firm for long period of time. There are several approaches of NPD as mentioned in available literature (Lindemann, 2014; Ulrich and Eppinger, 2012).

NPD is a series of activities a firm involves for developing new products (Bhuiyan, 2011). It consists of developing initial idea that is evaluated, developed, tested and launched as mentioned by Booz et al. (1982). The stages of NPD are represented in Fig. 1.1.

Figure 1.1Stages of New Product Development

As mentioned in Fig.1.1, the first and foremost step of NPD is new product strategy which is the effort of linking the NPD process with the firm's objectives for setting the thrust area for concept development and providing guidelines for screening criteria. According to the new product strategy, the development of innovative ideas for achieving objectives of the firm is performed in idea generation phase. Among the various innovative ideas developed, screening is the process of identification of significant idea and its detailed study as well. Further evaluation of these developed ideas is performed on the basis of the performance of the product like return on investments (ROI), growth rate and profits. The design and development phase evolves into structuring of the developed idea into a product that is producible or manufacturable. After developing the product, testing is performed for early detection of performance of the newly developed product in the market. Finally, introduction of the new product occurs in the market as per suitable time, termed as commercialization.

1.2.1 Success Factors and Measures of NPD

NPD is associated with various factors critical for its success, which are considered as Critical Success Factors (CSFs). These CSFs are identified as key influencers in controlling NPD performance (Ernst, 2002). In previous years, there are a number of studies which have discussed the vitality of CSFs for successful development of new products. Along with the identification of these factors, their beneficial role in NPD and process of utilizing them in practical field is equally necessary. The failure of implementing these factors may lead to failure of NPD, which in turn will lead to organizational failure as well (Daniel, 1961; Rockart, 1979).

Like success factors, success measures are also vital for the firm for measuring their performance on various aspects (Griffin and Lage, 1996; Buiyan, 2011). There are numerous studies identified the dimensions of success measures as per the firm's interest. Success is not elusive; it can be measured through the performance of the firm through various dimensions like customer acceptance, financial performance, technical performance (Huang et al., 2004) as well as quality aspects like meeting the quality guidelines by achieving the design goal and operational aspects (Tishler et al., 1996).

During development process from setting new product strategy to commercialization there are number of CSFs that control the NPD activities. Identification of these factors is essential for

better NPD performance leading towards success of the firm. The success measures are also different in the different product development phases. A brief discussion regarding the identification of the success factors and measures for each phase of NPD is mentioned below.

New product strategy: Identification of the product to be developed, the market and technologies available provides a clear structure of the new product strategy to achieve the success. The main objective of this stage is not only the identification of the strategy but to implement them in practical field. This requires the understanding and coordination among the team members of the various departments to synchronize among their needs, resources and future plans for successful NPD (Cooper, 1999). To, measure the performance of the developed strategy ROI is the most effective measure for comparing the development cost to the profit from the final product. If the expected return from the new product does not meet the development cost the new product strategy need to be modified to meet the firm's objectives (Bhuiyan, 2011).

Idea generation: After recognition of needs and targeted market in new product strategy phase, the idea generation is needed to be occurred to achieve the objective of the firm as set in strategy phase. Structuring of one successful idea requires at least seven ideas (Booz et al., 1982) to be developed as per objectives of the firm. The successful idea requires the optimal usage of available resources within firm (Crawford, 1997) with the help of internal and external sources. Internal sources are managers, employees whereas suppliers, customers and competitors are treated as external sources. The dedicated research and development (R&D) department is also need to be developed for generating innovative ideas in continuous manner with the available resources (Crawford, 1997). As the objective of the firm is the development of the products as per customer demand, the customers involvement in the idea generation phase is one of the essential constituents (Cooper, 1993). The probability of success of the externally generated ideas are greater than the internally generated ones as it involves the suppliers, customers and competitors to broadly consider the overall consequences (Souder, 1987). The success of the idea generation phase can be evaluated by the frequency of the successfully developed ideas. Relating to the CSFs of the idea generation associating the customer involvements recognized as the successful one which necessitates the attention provided to customers for better results (Cooper, 1999).

Screening, evaluation and business analysis: The selection of best idea among the numbers of developed ones is the stage of screening and business analysis. The top managers set the criteria of success, on the basis of which the screening is performed to select the best idea. This selected idea has the potentiality of successful product development (Cooper and de Brentani, 1984). The screening process is succeeded by the business analysis describing the product and its attentiveness to achieve success. The strengths and weaknesses of the ideas are highlighted to measure the probability of success before investing time and fund for development (Cooper, 1980). A thorough market analysis and market research for identifying the customer needs is the main constituent of this phase which is associated with the analysis of technical and operational feasibility. Business analysis strengthens the financial performance of the firm for successful NPD. The financial return such as net present value, internal rate to return, profitability are the success measures of the screening, evaluation and business analysis phase for selecting the best developed idea.

Design and Development: Approval of the best idea from business analysis phase leads towards development stage of the new product. It consists of prototype development to market testing to develop the product within estimated cost and time. The duration of the development phase should be restricted in short span to avoid the changes in customer demand. Introduction of same type of product by competitors during phase also invalids the NPD project of the firm. So reduction of development time has become one of the major factors for becoming the market leader. Customer involvement is another constituent to design the product as per their requirements to avoid future conflicts. As, the customer demand changes according to time, their association in development process, helps in updating the designs as per their needs (Cooper, 1999). The cross-functional team cultures always the faster development activities by synchronizing among various departments in product development process. The main indicator of the success of development phase is the degree of achieving the targeted design expected by the customers. The launch time of the product as per predefined schedule also is treated as another success measure of product development phase.

Testing: Testing is the final validation of the NPD project from strategy formation to development. Design and testing are the simultaneous processes occurring during developing the product. Product functionality is the main factor of the testing as it checks the availability of the

attributes of developed product as per the commitment of the firm. Customer acceptance is the ultimate constituent to measure customers' intent of purchasing the product. Product performance and customer perceived value ensure the success of the NPD through testing of the newly developed products. (Bhuiyan, 2011).

Commercialization: Commercialization means launch of new product as per scheduled time for maximizing profit (Bhuiyan, 2011). It is often hindered by lack of funds, deterioration of market condition and insufficient marketing capabilities to introduce new engineering products in target market as per scheduled time. The cost associated with commercialization is also treated as the vital constituents for this phase. Ultimately, the expected financial returns from perspectives of the commercial strategic objectives of the firm ensure the NPD success (Jung et al., 2015).

The above discussion focuses on the success factors in each phase from strategy development to commercialization. Among these, there are certain common factors involved in more than one phase. The present research work is thus undertaken to study the success factors as well as success measures of NPD irrespective of the phase. Along with the identification of all currently used factors and measures, this investigation is sought to club the factors and measures which roughly perform the similar function. This operation is performed by comparing the factors and measures as mentioned in over 426 published literature on NPD to avoid the repetition among them. The grouping/clubbing of the success factors is also performed as per their operations for NPD. In case of success measures, they are grouped on the basis of the performance attributes they measure.

1.2.2 Identification and Segmentation of Success Factors and Measures

From the available literature the CSFs controlling the NPD success covering all the phases have been identified which are enumerated below in Table 1.1:

Table 1.1 List of CSFs of NPD

• Advertisement & Promotion	• Communication
• Brand	• Concurrent Engineering
• Collaborative Product Design	• Conflict Management

• Cross-functional Team	• Planning
• Customer Focus	• Product Development Process (PDP)
• Design Rules	• Product Launch
• Entrepreneurial Culture	• Product Quality
• Financial Resources	• Product Uniqueness
• Fuzzy Front End (FFE) Activities	• Project Management
• Human Resource (HR) Management	• Research and Development (R&D)
• Impact on Environment	• Result Orientation
• Improvisation	• Sales Force
• Information Technology (IT) Management	• Strategic Management
• Intellectual Capital	• Supplier Involvement
• Learning	• System Integration
• Long-term Vision	• Target Costing
• Market Analysis	• Technology
• Modular Product Design (MPD)	• Time-to-Market
• Organizational Factor	• Top Management Support (TMS)

Similarly, available literature shows that there are number of success measures quantifying the success of the newly developed products from strategy development to commercialization phase. These success measures are also enlisted below in Table 1.2:

Table 1.2 List of Success Measures of NPD

• Achievement of design goal	• Beating competition technologically
• Achieved product performance goal	• Cannibalization effect
• Attain margin goal	• Customer satisfaction
• Attain profitability goal	• Degree of communication
• Attain return on investment (ROI)	• Development cost
• Beating competition to market	• Development time

• Domestic market share	• No of failure
• Expending product family	• Percentage of sales by new product
• Frequency of product launching	• Profitability relative to competitors
• International market share	• Profitability relative to spending
• Meet revenue growth	• Rate of failure
• Meet quality guideline	• Reduction of risks
• Meet unit share goal	• Revenue growth
• Net sales growth	• Technological breakthrough

It has been observed that these thirty eight CSFs dominating the NPD success can be grouped as per their activities and involvement in NPD. These success factors are clubbed in five groups namely, environmental factor, management actions, PDP, R&D and teamwork culture (Table 1.3) for identifying their role in NPD success in manufacturing industries producing engineering products. Similarly, success measures are also grouped as done in the case of CSFs. These success measures are segmented in as groups namely economic and financial attributes, environment based attributes, NPD team's capability, quality assurance and technological development also listed in Table 1.3.

Table 1.3 Segmentation of Success Factors and Measures of NPD

Groups	Success Factors	Success Measures
Environmental Factor	• Environmental Factor	Environment based Attributes: This measure consists the following manifest variables: • Reduced cost • Healthy relationship with investors • Regulatory approvals • Life-cycle analysis • Customer satisfaction
Management Actions	• Conflict Management • Entrepreneurial Culture • HR Management • IT Management • Long Term Vision	Economic and financial attributes: It comprises of the manifest variables as mentioned below: • Attain margin goal • Attain Profitability goal

Groups	Success Factors	Success Measures
	• Organizational Factors • Planning • Project Management • Strategic Management ➢ In this group of factors, TMS controls management actions for achieving NPD success.	• Attain return on investment (ROI) • Domestic market share • Development cost • International market share • Meet revenue growth • Meet unit share goal • Net sales growth • Percentage of sales by NPD • Profit margin • Profitability relative to competitors • Profitability relative to spending • Revenue growth
PDP	• Advertisement & Promotion • Brand • Collaborative Product Design • Customer Focus • Design Rules • Market Analysis • Modular Product Design • Product Launch • PDP • Product Quality • Product Uniqueness • Supplier Involvement • Time-to-Market • Target Costing ➢ Among these success factors, collaborative product design is used as one of the factors of PDP as internal collaboration. ➢ Design rules, product launch, product quality, product uniqueness can be considered as product feature together. ➢ Customer focus, supplier involvement are incorporated together as external collaboration.	Quality Assurance: It comprises of three manifest variables namely: • Achievement of Design goal • Achieved product performance goal • Meet Quality Guideline.

Groups	Success Factors	Success Measures
	➢ Advertisement and promotion, brand, target costing and time-to-market can be incorporated in market analysis. ➢ So, the factors in this group after merging is: • PDP • Product feature • External collaboration • Modular product design • Market Analysis	
R&D Activities	• Financial Resources • FFE Activities • Improvisation • Intellectual Capital • Learning • R&D • Sales Force • Technology ➢ Among these factors, financial resources and sales force can be incorporated in R&D practice as investments and experts within the team.	Technological Development: This group of success measure consists of the following manifests: • Beating competition to market • Beating competition technologically • Cannibalization effect • Expanding product family • Frequency of product launching • Number of failure • Rate of failure • Reduction of risks • Technological breakthrough
Teamwork Culture	• Communication • Concurrent Engineering • Cross-functional Team • Result Orientation • System Integration ➢ Among these factors concurrent engineering and cross-functional team can be considered as concurrent engineering team together.	NPD Team's Capability: The capability of NPD team is quantified by the following measures: • Technological developments • Expansion of product family • Scheduled product launching frequency • Reduction of failure rate • Time associated for development

After grouping the success factors, evaluation (through empirical study) of the combined impact of a particular group of CSFs for measuring the performance of NPD success is the

ultimate objective of this study. Total five frameworks have been developed considering the five groups of CSFs essential for NPD activities.

1.3 Thesis outline

The present thesis is organized as follows:

Chapter 1: Includes introduction of the subject along with a literature review designed to provide the basic understandings already available involving the issue of interest. It presents the research work on NPD, the success factors and measures of NPD identified by the various investigators. The grouping of the identified success factors and measures are also performed in this chapter.

Chapter 2: Provides a description of the methods of the data analysis along with their steps. The design of semi-structure questionnaire for identifying the impact of success factors and measures of NPD is discussed in detail. The content validity of the questionnaire is described as well. The targeted sample for data collection along with their profiles, experiences and organizational type are also mentioned in this chapter.

Chapter 3: Performs ranking of the groups of CSFs by using fuzzy extent analysis method to prioritize them as per the opinion of Indian manufacturing experts developing engineering products.

Chapter 4: Includes the first group of factors considering the R&D activities for technological development considered as the success measures of NPD for firm's success.

Chapter 5: Represents product development process and its related factors as a group for developing the structural model to measure the quality assurance of the newly developed product for NPD success.

Chapter 6: Presents the structural model of the group considering the role of top management support for improving management actions which in turn promotes NPD success of the firm. The economic and financial attributes as performance indicators are identified success measures quantifying the NPD success.

Chapter 7: Includes the fifth group of factors considering the environmental aspects by identifying environmental factor for sustainable NPD considering the environment based attributes as well. A structural model depicting the role of managerial support to motivate entrepreneurial culture for developing environment friendly products is developed.

Chapter 8: Presents the factors of teamwork culture as a group to develop a model in which the NPD teams' capability is used to quantify the NPD success of the firm.

Chapter 9: Provides specific conclusions drawn from the statistical analysis from the primary data collected and suggests ideas and directions for future research.

1.4 Literature Review

The purpose of this literature review is to provide the background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. This treatise embraces the new product development (NPD), various success factors as well as measures of NPD along with the necessity of the grouping of success factors and measures for NPD success. This chapter includes reviews of available research reports:

On new product development (NPD)

On success factors of NPD as per developed groups of CSFs

On success measures of NPD as per developed groups

At the end of this chapter, a summary of the literature survey is presented to summarize the knowledge gap in the earlier investigations. Subsequently, the objective of the present research is also delineated.

1.4.1 New product development (NPD)

There are number of studies identify NPD as essential activity to be performed for ensuring success and survival of the firm in global competition (Cohen et al., 1996; Sun and Wing, 2005). Studies concerning the CSFs are well discussed phenomenon due to its criticality for achieving firm's success. Tough continuous improvement is not an easy task to be performed (Hailu et al.,

2018) but NPD is an effective way of utilizing the available resources as per customers' requirements. In few researches NPD is divided in various phases like idea generation & concept design, definition & specification, prototype and development and commercialization (Sun and Wing, 2005). Bhuiyan (2011) segmented the NPD in seven stages from new product strategy to commercialization. The CSFs associated with the each phases of NPD have also been recognized in these studies. By reviewing the literature from past two decades (Cooper, 1999; Lynn et al., 1999), CSFs of NPD for firm's success have been identified previously in the introduction section. These CSFs are clubbed in five groups as per their commonality in the operation. Similarly, the success measures are clubbed in five groups for measuring the NPD success. These groups of success measures are related with the groups of CSFs as per the performance attributes used by firms obtained from the available literature as well as experts' opinion. Table 1.3 represents the list of groups of CSFs and measures. The literature review based on these groups of CSFs and success measures are discussed in section 1.4.2 and 1.4.3 respectively.

1.4.2 Success Factors of NPD

The global competition leads the firms under the situation where they are bound to develop new products as per customers' requirements for sustaining in the competitive market. Any wrong steps or mistake during development process makes the firm lagging behind by their competitors (Lynn, 1999). The successful development of conventional products are not worthy for sustaining in the global contest. The success of the firm requires the ability in new product development for ensuring the competitive advantages essential for the triumph (Crawford, 1980). There are number of studies concerning the success factors of NPD which help to separate success of the firm over the failures for developing new products (Cooper and Kleinschmidt, 1987; Montoya-Weiss and Calantone, 1994; Ernst 2002). We structure our research on the basis of the literature which empirically analyzed the success factors for measuring NPD success on the basis of the large samples. The considered literature must have the explicit information regarding the statistical significance of the empirical results. The discussions about the researches on the CSFs as per the groups developed are mentioned below.

1.4.2.1 Environmental Factor

Globalization introduces the high-end competition to survive in the market; similarly it brings the threat of global warming as well. As the rate of newly developed products increases, chances of pollution also amplify due to deforestation, species loss and loss of natural resources (Deniz, 2002). Identifying the loss of the society, Government and communities are getting conscious to prevent the pollution and the environmental hazards occurred as the side-effects of the products available for fulfilling the consumers' requirements. This is the high time to focus on developing the products which are sustainable and also hazard-free serving the people as well as the planet. Presently, Government of India has emphasized on 'Swacch Bharat Abhiyan' to make the society as well as industry pollution free for making the world a better place of living. There are various variables of environmental factor for developing sustainable new products in comparison with other alternatives of similar function. These variables covering the environmental aspects are discussed below:

Eco friendliness of the product: The changes in consumer demand create a huge change in NPD. The globalization introduces the world with lots of knowledge and information which makes the consumers aware of their purchase affecting the environment (Isaacs, 2015). Moreover, they are willing to use those products having less adverse effects on environment (Choi, 2012). This indulges the manufacturers to build the eco-friendly products having less carbon foot-print which is less pollutant for the environment. Eco-friendliness of the products mean the product does not harm the environment whether in their production, use or disposal (Isaacs, 2015).

Adverse effect of the product on environment: Reduction of adverse environmental impact of the products makes the products able to make a positive impression on the end-users. This practice associates with the green branding raises the concern of the consumers for the environment (Wong, 2010).

Sustainability of the product: Sustainable product development is concept of developing products with consuming the fewer natural resources for developing less polluted products (Askham, 2011). According to World Commission on Environment and Development, sustainable development is "development that meets the needs of the present without

compromising the ability of future generations to meet their own needs." It preserves the environment as well as ensures the economic growth (Brundtland et al. 1987).

The environmental goal achievement rate of the new green products: Environmental change can be advantageous or unfavourable depending upon its impact on environment. This change may be occurred due to the products, services or various activities of the firm involved for developing new products (Brorson and Larsson 1999). Firms are eager to achieve the environmental goal of developing new green products having minimum negative impact on environment.

Compliance of new green products with the consumers' preference: Environmental improvements are always welcome by taking into account the customer preferences (Bovea and Wang, 2003). Firms are eager to develop new green products with the compliance of new green products as per customers' preferences.

Meeting Government policies for product development: Government introduces policies and regulations for controlling environmental hazards through banning the use of specific toxins and limiting the rate of industry wastes. They simultaneously upgrade the rules and regulations for making it more suitable with the present scenario (Kaval, 2011).

Recycling rate of the new green products: After the useful lifecycle, the product is either disposed or recovered. The product having the high recycling rate with low negative impact on environment are always preferred. This recycling can be done by the firms themselves or by any local firms. The recycling of the products can be done by developing the mandate manufacturer take-back, consumer separation of materials and recycling the products (Bevilacqua et al., 2012).

Hiring responsible employees: Hiring responsible employees and project leaders lead towards successful adoption of activities for reducing the environmental hazards and achieve the goal of sustainable new product development (Kastensson, 2014).

1.4.2.2 Management actions

The management actions consist of the practices involved in NPD influenced by TMS. These practices are considered as the success factors of NPD and recognized as Conflict Management,

Entrepreneurial Culture, HR Management, IT Management, Long Term Vision, Organizational Factors, Planning, Project Management and Strategic Management. The brief overview of each factor is mentioned below:

Conflict Management: Conflict is the differences occur due to incompatible objectives and differences in opinion. These differences in opinion are the resultant of conceptual dissimilarities among the team members (Hellriegel et al., 1986). Conflict management is the process of limiting the negative aspects of conflict occurred in the firm. According to researchers, conflict is two types, such as, relationship conflict and task conflict (Liang et al., 2010). The relationship conflict arises due to the altercation among the team members which may lead towards negative emotions and bitterness hampering the communication among the team members. On the other hand task conflict is the disagreements arise within the firm regarding the issues of how the job has to be performed. This conflict is constructive in nature as it is job-oriented conflict; it increases the communication among the team member to resolve the issues by acquiring more information and find the optimum way to complete the task (Liang et al., 2010). The manifest variables for measuring the conflict management within the firm is identified as application of improved conflict handling process, mutual understanding of company objectives, commitment to collaboration, effectiveness of conflict handling teams, effectiveness of communication management and conflict management culture in the firm (Barki and Hartwick, 2001; Liang et al., 2012). The conflict within the firm needs to be handled properly to avoid the unwanted situations hindering NPD activities. Senior managers perform the conflict management for controlling the dissimilarities arouse for successful completion of the NPD processes (Sommerville and Sawyer, 1997).

Entrepreneurial Culture: Entrepreneurship is an organizational management actions comprising of methods, practices and decision-making of the managers to act entrepreneurially (Lumpkin and Dess, 1996). This practice is expressed in different terms such as entrepreneurship, entrepreneurial management (Stevenson and Jarillo, 1990), entrepreneurial orientation (Lumpkin and Dess, 1996) and entrepreneurial proclivity (Matsuno et al., 2002). The present study collectively terms this constituent as entrepreneurial culture mentioning it as one of the management actions for NPD. Clearly mentioned relative priority of each project target, project target trade-offs between performance and cost, specified project targets trade-offs

between time and cost, specified project targets trade-offs between quality and cost, Risk taking capability for enhancing the probability of success, innovativeness (Barringer and Bluedorn, 1999), emphasis on R&D, technological leadership, and innovations, development of many new lines of products or services (Miller and Friesen, 1978), initiative actions to which competitors then respond, first to introduce new products/services, techniques, technologies, adoption of very competitive, "undo-the-competitors" posture, bold, wide-ranging acts to achieve the firm's objectives and adoption of bold, aggressive posture for exploiting opportunities (Heavey et al., 2009) are the identified manifest variables to measure entrepreneurial culture for NPD success. Top managers' encouragement makes the smooth implementation of entrepreneurial culture for NPD by introducing innovative ideas and risk-taking capability for framing those ideas in practical field (Heavey and Simsek, 2013; Matsuno et al., 2014).

HR Management: HR management is the planned exploitation of human resources and their activities like commitment, flexibility and quality for achieving the organizational goals. HR management considers all the actions related to the management of people in the firm. HR management covers tradition of working as a team, effective use of manufacturing engineering skills, communication and cooperation within NPD team members, communication and cooperation in different NPD teams, exchange of experience of key personnel among various NPD teams, updating NPD work procedures on regular basis, adoption of team-based appraisal system and training in problem-solving skills of NPD personnel (Paauwe 2009). Top managers' support and motivation manages HR of the firm and promotes the HR management for NPD success (Unger et al., 2012; Yang et al., 2015).

IT Management: Construction, harmonization, incorporation of knowledge and information within the firm and its extended value network along with its management is considered as IT management (Conner and Prahalad 1996). It links the each minute information of the firm for the sake of usage to develop new products sustainable in global competition (Criscuolo et al., 2010). This IT management construct is measured by expenditure on IT Management, communication using fiber-optic cables, efficient correction of product problem areas as per customers' views, active use of in house database in development process, usage Groupware, identification of customers' buying pattern using Big-Data Analytics, applications of enterprise solutions, efficient detection of product problem areas as per manufacturers' views, incorporation of pre-

launch for lessons required for full-scale launch, post-launch, chances of technical error compared to competitors, overall products had fewer problems than normal in the industry (Barczak et al., 2007; Barczak et al., 2008; Kawakami et al., 2015). Managerial support to adopt IT skills are needed to exploit these practices to develop IT management within the firm (Kawakami et al., 2015).

Long Term Vision: Vision comprises of set of goals with a clear understanding of these goals as per firm's perspectives, setting the priorities and their trade-offs for success of the firm (Revilla and Rodríguez, 2011). Long-term-vision leads towards NPD effectiveness with the knowledge about the existing resources and skills to develop the new products. Brown and Eisenhardt (1995) describe vision as the accumulation of firm's competence and strategies for concept development as per market demand. Vision requires the clarity of goals, their strategic fitment and trade-offs of goals on priority basis (Revilla and Rodríguez, 2011). Clearly mentioned relative priority of each project target, project target trade-offs between performance & cost, time & cost and quality & cost are the variables measuring the long-term-vision of the firm for successful NPD. Managerial support and motivation provides high degree of strategic fit in turn the long-term-vision for successful NPD (Hong, 2000).

Organizational Factors: Development of organization structure, culture, size and up-to-datedness with due support and coordination among the team members as per the requirements treated as organizational factors for successful development of new products (Sadeghi et al., 2012). This requires the support and motivation of top managers to promote the enriched culture for NPD along with the adoption of new ideas and technologies for better performance. Identification of the measures of organizational factors shows responsiveness to change, in house development of technology related to product, focus on Core competency areas within the organization, availability of production resources (Moorman, 1995), involvement of project leaders in different activities at working level and availability of qualified human resources are used for quantifying the organizational factors for NPD (Hultink and Atuahene-Gima, 2000).

Planning: Planning is the strategic projection of the future activities based on the current situations to develop products as per customers' demand (Franca et al., 2017). As per the requirements of product features and specifications the planning is structured to achieve the

target (Aschehoug and Boks, 2013). Planning of the entire NPD process, organized strategic planning for coordinating NPD and planning to choose space distribution for components and structure are used as the describing the planning of the firm. Efficient managerial participation provides optimal allocation of resources through structuring the future planning for NPD (Yeh et al., 2014).

Project Management: Project is a momentary effort performed to create new product having specific starting and ending time. Project management requires utilization of firm's resources by using knowledge, skills, tools and techniques for fulfilling the customers' requirements (Hyvari, 2006). Effectiveness of project management defines the quality of attaining the objective of the firm as set by the higher authority. An enriched managerial support develops the project-centered culture in the firm for opening the available opportunities for the ease of developing new products (Mir and Pinnington, 2014). Project funding amount, sense of responsibility of project manager, proper monitoring of scheduled projects, efficiency of project manager to deal with design engineers, effort to reduce Cost & Time overrun, standardized skill set of project managers, usage of sophisticated software, stringent/strict management of Project portfolios, executive commitment to project management, corporate understanding of project management, control over line management for both resources and staffs are the key antecedents for measuring the project management activity within the firm (Hyvari, 2006; Muller and Turner, 2007).

Strategic Management: Strategic management means the strategic planning performing the resource allocation to meet the priorities providing the structure and mechanism to motivate the team members of taking the risk with their available knowledge and experience (Arend et al., 2017). The key enabler of strategic management is the managerial support and motivation for encouraging the strategic activities and allows the changes required for product innovation (Cooper and Kleinschmidt, 2007). It requires long term planning, effort to reduce product development cost, correct forecasting of technology trend, emphasis on clearly defined strategic target and effort in behaviour analysis of the competitors to measure the degree of strategic management within the firm for achieving NPD success (Barringer and Bluedorn, 1999; Sadeghi et al., 2012, Tsai, 2012).

Top Management Support (TMS): Top management support refers to degree of senior management support provided for new product development (Evanschitzky et al. 2012). Impact of TMS for developing high quality products within estimated time, achieving financial and technological success are already well-established phenomenon (Swink, 2000). The manifest variables for measuring the TMS are support and motivation from senior management, willingness of management in taking risk on NPD, frequency of annual meeting with participation of all level employees, commitment of Senior Management throughout development process, delegation of top management, leadership by example and support for entrepreneurship culture (Lin, 2007; Unger et al., 2012). TMS promotes the management actions for successful implementation of these practices for NPD. The managerial support and motivation for Conflict Management (Liu et al., 2011), Entrepreneurial Culture (Lee et al., 2000),HR Management (Kianto et al., 2017), IT Management (Wade and Hulland, 2004), Long Term Vision (Crawford and Benedetto, 2000), Organizational Factors (Nellore and Balachandra, 2001), Planning (Yeh et al., 2014), Project Management (Mir and Pinnington, 2014) and Strategic Management (Lau, 2011) is already established in available literature and also be discussed in the Chapter 6 for describing the role of TMS for escalating these management actions for NPD.

1.4.2.3 Product development process

The series of activities starting from new strategy development to commercialization of the new product to the market is defined as product development process (PDP) (Tzokas et al., 2004). The identification of the CSFs on PDP as well as their indicators helps to escalate the NPD activities for success. The interrelationships of these factors are also essential for inferring their combined impact on NPD success. Advertisement & Promotion, Brand, Collaborative Product Design, Customer Focus, Design Rules, Market Analysis, Modular Product Design, Product Launch, Product Development Process (PDP), Product Quality, Product Uniqueness, Supplier Involvement, Time-to-Market and Target Costing, these are the recognized CSFs of the development process and their brief outline is discussed below:

Advertisement & Promotion: Advertisement and promotion is the impersonal communication about the products and services for sharing information for making customers aware of that particular products and services. The communication of information takes place through various

medium (Arens, 2004). Advertisement and promotion comprises of paid form of communication, presence of an identified sponsor, distribution through media, presence of specific audience, lack of personalization of distributed information and aimed action. Expenditure on advertisement, frequency of campaigning activities and active use of Customer Relationship Management (CRM) (Hashemi et al., 2013) helps in quantifying the practice of advertisement and promotion of the firm.

Brand: The brand is a type of product developed by particular company by a particular name which works as an identifier (Styles and Ambler, 1995). The brand promises to provide bundles of attributes to encourage the customers to have that product. These attributes that make up a brand may be real or illusive, rational or emotional, tangible or invisible (Ambler, 1992). The antecedents help in developing the brand considers financial resources spent on branding, company's concern about safety as one of the major brand pillar, importance of security as one of the brand pillar, company's concern about customer satisfaction, concern towards modern and sporty design, treatment towards high performance and intelligent technology as one of the brand pillars.

Collaborative Product Design: Collaborative product design is a method of developing the new products incorporating the close association of suppliers, manufacturers, manufacturing partners and customers by involving them in the design chain (Li et al., 2005). The collaboration mechanism needs a specific design to fulfill the functional as well as performance requirements. Connection & Cooperation with other companies; application of team-collaboration practices to your company's total PD efforts; cross-organizational linkage, which in addition to high levels of integration is characterized by high levels of transparency, mindfulness and synergies in participants' interactions; continued and parallel responsibility of different design disciplines and lifecycle functions for product and process specifications; cooperative relationship between companies aimed at innovation are the practices help in implementing CPD for developing new products (Lu et al., 2000; Morris 2002).

Customer Focus: Customer focus is a part of customer orientation for developing the practice of customer involvement in product development through healthy communication. This practice helps in developing the new products as per customers' expectations (Zhang and Yang, 2018).

Synchronization with market strength; expenditure on market research and intelligence to acquire information and the changing needs of current and potential customers; fulfillment of customer needs as per previous specification; quick responsiveness towards customer requirements; regular meeting and intensive discussions with customers; and customer involvement in design process are the attributes for developing the practice of customer focus for successful NPD (Gassman et al., 2005).

Design Rules: Design rules are specified as 'game rules' denoting the most critical feature of the product and referred when required for introducing new architectures. These design rules are derived from the module levels. The necessary information regarding the critical linkages between the parameters of product and manufacturing domain is also required for establishing the design rules (Lokkegaard et al., 2018). Use of developed design rules, extension of development time for the use of design rules, difficulties faced in understanding the mathematical design rules, difficulties in implementation of design rules, company's interest to understand and apply the mathematical background of the rules, modularization of products based on technical experience and budgeted cost constraints, selective adoption and combination of design rules with modular design are the practices for successful implementation of the practice of design rules for NPD (Bayliss and Clark, 1997; Kubota et al., 2017).

Market Analysis: Market analysis is an approach of gathering the information about the targeted customers' groups, their requirements and consumption pattern for selecting the ideal time for introducing new product to the market (Shinno and Hashizume, 2002). A sound market analysis can be achieved through having a clear idea about turbulent market environment, well-established market plan, market growth, emphasis on customer satisfaction, knowledge about consumption pattern, need for identification of target market, testing of market, investment towards market research for proper market dynamics, advertising and promotional activities, duration of the product total life cycle until definitive replacement and effort in competitor monitoring (Heirati and Aron O'Cass, 2016). This reduces the chance of failure through introducing additional features to the new product.

Modular Product Design: Modular product design (MPD) is the development of the final product by accumulating set of independently designed smaller products functioning together as

a whole (Baldwin and Clark, 2000). These smaller products work as 'a module' refers to a group of functional carriers (such as parts, physical elements in a product). As individually designed, the interdependencies among each module is minimized in case of the assimilated final product (Ulrich and Eppinger, 2012) reducing the complexity as well. MPD increases the probabilities of product varieties through structuring new products with available modules. The MPD practice can be implemented in the firm through adoption of Modular product design practice, increase in product variety, system reliability improvement and product component commonality.

Product Launch: Product launch is the official introduction of the new product to the market (Matikainen et al., 2015). The success of the new product launch completely depends on the customer acceptance along with the achievement of targeted sales, market share and profitability (Montoya-Weiss and Calantone, 1999). The launch effort, campaign activities via Customer Relationship Management (CRM), pre-launch activities and launch timeliness makes the product launch activity successful for NPD (Zhang and Wu, 2016).

Product Development Process: Product development process (PDP) comprises of number of activities from prior stage of ideation to product launch for successful development of new products. Though various researchers segmented the product development in different phases, the concept of development is being same. The researchers like Tzokas et al. (2004) divided the PDP in five stages such as concept testing, prototype testing, pre-test market, test market and launch. Booz et al. (1982) segmented the PDP in seven major phases like new product strategy, idea generation, screening and evaluation, business analysis, design and development, testing and commercialization. Product development performance; investment in NPD; updated technological innovations; training for NPD Management; concurrent workflow; hands-on-working-experience; early involvement of manufacturing; developmental time and cost; testing of products; adoption of TQM; advanced product development methods; frequency of product review; team collaboration and concurrent engineering; and marketing research in PDP are the indicators for measuring the PDP for developing new products (Chaudhuri and Boer, 2016).

Product Quality: Product quality mainly describes the quality standards of products and total quality management system for customer-oriented business environment (Yeh et al., 2014). Setting the product quality helps in achieving the economic success of the manufacturing firms

and enhances the organizational performance as well. Product quality offers flexibility and robustness to the product fulfilling customers' requirements and increasing market share simultaneously (Iamratanakul et al., 2008). Manifest variables of product quality are:

- Product performance of the company
- Technical superiority of products
- Time required to develop high quality product
- Interpretive characteristic of product quality
- Chance to exceed the estimated cost
- Chance of product failure
- Chance of product failure
- Manufacturing guidelines for quality products
- Internal testing of product
- External laboratory test
- Achievement of product specification
- Adoption of Total Quality Management
- Usage of 5S & quality circle in PDP
- Usage of quality function deployment
- Frequency of Product review meeting
- Implementation of Six-Sigma
- Implementation quality standards

Product Uniqueness: Uniqueness of a product is a feature which differentiates that product from others available in the market. Consumers have a tendency to possess the product which is unique and can be easily differentiated from others. They have a self-perception about the uniqueness (Asshidin et al., 2016). The uniqueness of the product significantly motivates the customer's purchase decision (Simonson and Nowlis, 2000). Innovativeness of the product, superiority of the product than its competitors, extrinsic rewards society provides to products of your company as they are somehow different from others and intrinsic satisfaction derived from the perception that they are separable from the crowd, these are the manifest variables used to measure the product uniqueness.

Supplier Involvement: Suppliers' involvement acts as a primary constituent for manufacturing new products through leveraging the resources and skills of the suppliers in the turbulent market environment (Zhang et al., 2017). Supplier collaboration escalates the speed of introduction of new products to the market. Developing novel products with application of new technologies associated by product complexity can be well handled by involvement of suppliers in product development activities (Yan and Dooley, 2013). The firms trend of supplier involvement is measured through collaboration trend with supplier on long term basis, participation of the suppliers in product development team, synchronization time required for supplier involvement

in product development, uncertainty in safety due to exposing the technological information with suppliers, emphasis given on Supplier Relationship Management (SRM), frequency of meetings and discussions with suppliers, expenditure on vendor development and adoption of intelligent systems in monitoring vendor database (Zhang et al., 2017).

Time-to-market: The competition of the firms is highly depended on cycle time of the new product which indicates the introduction of new products rapidly to beat the competitors (Cohen et al., 1996). The time-to-market is specified by the product lifecycle, rapid response and fast information flow (Sorescu and Spanjol, 2008). It enhances the competitiveness of the firm. During the last five years, the design and development time required for new products, comparing with the industry (and particularly with your competitors) the design and development time for new product and the approximate time of design and development of a new product of your company determines the time-to-market of the new product decisive for NPD success. Through these measures tine-to-market can gauge the average organizational rate of developing new products than their competitors (Zhang et al., 2017).

Target Costing: Target costing is described as feed forward technique for managing cost of design and development of new products. Along with the cost, it manages the quality and functionality for fulfilling the customers' requirements. This targeted cost is determined by analyzing the value chain of overall organizational functions with due support from top management. The target costing of the product can be manifested by using of the following formula to compute the desirable production cost of the new product: "maximum allowable cost= potential market price-margin expected for this product", occurrence of changes during the design process of a new product in order to not exceed a predetermined maximum production cost, elimination of attributes during product development which are considered too costly when compared with the value attributed by the clients (e.g. package, warranties, after sales service etc.), negotiation with suppliers and clients about changes on product design and/or its functionalities in order to achieve a predetermined product cost, addition of extra features or functionalities during product development to the product if it is not possible to offer a lower price than competitors, emphasizing on price, functionality and quality during product development to beat competitors designing competitive products and application of target costing techniques in the new product development process comparing with competitors.

1.4.2.4 R&D activities

Research and development (R&D) is a process of developing new ideas for sustaining in the global competition (Jyoti and Deshmukh, 2010). The firms perform R&D activities for developing new products are able to shape their innovative ideas and commercialize them as new product. This accomplishes better market share and provides competitive advantages to the firm for achieving NPD success (Chiesa and Masella, 1996). R&D activities are still inadequate in small and medium enterprises in Indian manufacturing industries due to lack of urge in investing for R&D for avoiding the risk of failure and loss as well (Mitra 2007; Tripathy et al., 2012). The factors related to R&D activities are Financial Resources, Fuzzy Front End Activities, Improvisation, Intellectual Capital, Learning, R&D, Sales Force and Technology. The brief introduction of each factor is stated below:

Financial resources: High-technology industries demands heavier investment in R&D activities for NPD (Covin and Slevin, 1991). Startup of new ventures always needs huge financial resources then the requirements for execution of the project (Chorev and Anderson, 2006). The development of new products are characterized by entrepreneurial culture of the firm which needs high available of funding (Lerner and Avrahami, 2002). Available funds for product development, funds for R&D and funds for marketing are the measures of financial resources required for NPD (Chorev and Anderson, 2006).

Fuzzy Front End (FFE) Activities: Fuzzy front end (FFE) activity is the prior stage ideas generation to check the feasibility of new product from technical and economic perspectives (Mendes and Ganga, 2013). This development of new ideas in the very early stage of innovation, associates high risk factor in investing the financial as well as operational resources which may fail in near future. These barriers can be overcome by interdisciplinary idea generation and screening by historical analogy, interdisciplinary idea selection, idea selection during meeting, intensity of initial planning, level of communication in early phases of product development, effort to reduce market uncertainty and understanding of target market along with the users need (Verworn 2009, Velamuri et al., 2017).

Improvisation: Improvisation is making or creating something innovative in spontaneous manner. It requires well-defined planning of any action for developing new products and the

execution of the developed plan for successful completion of the action (Akgun et al., 2007). It helps to tackle the environmental changes and the turbulent market environment through proper planning and execution (Akgun et al., 2006). Improvisation gathers the knowledge through unlearning which further helps in enriching the resources of the NPD team (Akgun et al., 2007). Figuring out of NPD process as it went along versus following a rigid well-defined plan; improvisation of team in developing this product versus strictly following the plan and improvisation of team in commercializing this product versus strictly following the plan are the variables for measurement of improvisation for NPD (Miner et al., 2001).

Intellectual Capital: Intellectual Capital is the collection of all components of intangible assets including the human intellect and innovation for wealth creation to achieve sustainable competitive advantage (Johnson, 1999). It comprises of three major elements such as human capital, structural capital and relational capital. Human capital defines the human ideas and knowledge having the potential for innovation. The structural ability for creating wealth by utilizing the human knowledge and idea for innovation is considered as structural capital. Relational capital is the relations with customers, suppliers and stakeholders by enhancing the human and structural capital (Johnson, 1999). Enrichment of human capital by employees' and managers' competence, experience, knowledge, skills, attitude and commitment; enhancement of process capital by workflow, operation processes, business development plans, information technology and collaboration; improvement of innovation capital by intellectual properties such as patents, copyrights and trademarks and enhancement relational capital which includes relations with stakeholders, customers, and suppliers are the manifest variables for measuring the intellectual capital of the firm (Edvinsson and Sullivan, 1996).

Learning: Learning is a practice of the firm for integrative capabilities lead to performance benefits. It develops from the collaborative culture of the firm for creating and developing the firm-level capabilities for achieving success (Johnson and Filippini, 2013). The measures of learning is identified as tradition of debriefing of all NPD experiences of NPD team members including maintenance of NPD records of major incidents and decisions; adoption of well-defined process to guide NPD project; adoption of NPD manuals to assist managerial decision-making while managing NPD activities; collective review to assess the progress and performance of NPD projects; trend of attending in-house training; providing on-the-job training to

individuals managing NPD; reporting about progress of NPD projects; maintenance of database containing factual information on each of its NPD projects; maintenance of contact list of potential persons (insiders/outsiders) to assist NPD; development of guidelines to assist managerial decision-making and actions; frequent updating of NPD management guidelines or manuals; managers' participation in committees to expand knowledge; managers' attendance in meetings and seminars to exchange NPD-related information; managers' informal sharing and exchange of NPD-related information; rotation of managers, with substantial prior experience in managing NPD projects; and adoption of managerial incentive schemes; trend of attending externally conducted training programs related to NPD management; managers' accessibility of documented and codified information (Chiang and Shih, 2011; Johnson and Filippini, 2013).

R&D: R&D is a process of ideation of new thoughts and developing them in practice for setting innovative manufacturing strategy (Tripathy et al., 2012). It allows firm's improvement of developing innovative products in continuous manner offering profitability and increase in market share (Lau, 2011). Number of R&D persons; their experience (years); their qualification, investment in R&D infrastructure and methods for sustainable product development; R&D management vision and direction; number of patents; R&D oriented culture; and investment in cleaner technology research are the important attributes for quantifying R&D practices of the firm essential for NPD. Previous studies noticed different aspects of the R&D practices in Brazil, China, Taiwan; but the researches on R&D practices in Indian firms, specially for manufacturing industries are much limited, (Jyoti and Deshmukh, 2010; Tripathy et al., 2012).

Sales Force: Sales force is the salespeople advocate the innovation and promote the new products heading towards market launch. They demonstrate the newly developed products and convince the customers for using these new products as per their specific needs (Webb et al., 2011). The internal knowledge brokering capacity of the sales force helps in acquiring the information about the customers' preferences as well as market dynamics which helps the managers to set the future direction. Sales force is involved in both internal and external (Plouffe and Barclay, 2007) knowledge brokering activities for gathering information about current situation within the various departments as well as from suppliers and customers respectively. Availability of sales force and distribution resource, amount of expenditure and use of market research tools are the manifest variables of sales force for NPD (Berg et al., 2014).

Technology: Technology refers to the technology capability of the firm by identifying various factors from planning to commercialization (Lee and Yoon, 2014). Introduction of new technologies associated with enriched R&D whereas old technologies result in poor unit cost and time-to-market (Tatikonda and Rosenthal, 2000). Investment for upgrading technological infrastructure; technology forecasting to trace the difficulties; usage of CAD/CAM and various state-of-the-art technologies and newly launched technologies; degree of implementation of Cellular manufacturing; adoption of lean manufacturing; presence of Flexible manufacturing, adoption of Design for manufacturability and assembly (DFMA); and use of Enterprise systems (ERP) leads to developing high technology capability within the firm assuring the better R&D activities (Haverila, 2012; Mendes and Ganga, 2013). Technological uncertainty often treated as control variable needs to be taken care of for successful NPD (Chiang and Shih, 2011).

1.4.2.5 Teamwork culture

Teamwork is the coordination among members of the different departments of the firm helps in performing NPD activities successfully by overcoming the cultural barrier (Felekoglu et al., 2013). This teamwork culture develops the platform of sharing knowledge, necessary information to set their priorities for performing the development activities (Beamer and Varner, 2001). Teamwork culture develops the nature of working with dissimilar people having ideologies and tackles the unfamiliar situation with endurance and experience (Felekoglu et al., 2013). As identified from available literature, there a certain constituents helps in developing the teamwork culture within the firm. These are communication, concurrent engineering, cross-functional-team, result orientation and system integration. These factors are described as:

Communication: Communication is a practice of sharing information and idea within the team or the members of different teams helps in decision making in conflicting situations during NPD (Everette et al., 2002). During the development of new products suppliers and buyers are involved with manufacturing teams through intense communication by frequent meetings organized for completion of NPD (Lau, 2014). Communication offers strong internal integration to work with the external members as well (customers, suppliers and vendors) for developing collaborative work culture. Regular meeting for problem-solving, virtual communication, video conference, NPD database system, internet-based telecommunication tools, face-to-face

meetings in between virtual teams are the identified manifest variables for successful adoption of communication infrastructure within the firm (Lau, 2011; Felekoglu et al., 2013).

Concurrent Engineering: Concurrent engineering is an approach of coordination of simultaneous activities among the multidisciplinary teams and manufacturing departments for successful completion of NPD (Romero et al., 2016). It requires the sharing of the information as well as knowledge through a systematic communication on regular basis within teams also with other departments (Mousavi and Darvishi, 2014). Concurrent engineering requires the allocation of resources for continuation of simultaneous interdependent activities of the groups leading reducing the product development time (Chen et al., 2013). Sharing of information among different product development groups, involvement of various disciplines from early stages of NPD, degree of process design is done concurrently with product design, occurrence of manufacturing activities from early stages of product development, designs of product and process development are established concurrently by a group of employees from various disciplines and practice of team culture, these are the attributes for measuring the concurrent engineering culture within the firm (Mousavi and Darvishi, 2014; Romero et al., 2016).

Cross-functional Team: Cross-functional team refers to the teams having greater lateral coordination among them by lowering the communication barriers for successful development of new products (Anthony et al., 2014). The managerial control needs to be effective (Mathieu et al., 2008) for synchronizing among various functional teams for utilization of available resources from different departments (Denison et al., 2008). The manifests of cross-functional team are company culture of working together of new product development project team, marketing, R&D and manufacturing department as a collaborative team; integration of technological knowledge and marketing knowledge for new product development; level of communication of team members for new product development; level of communication among functional groups of development process; sharing of information among different departments; degree of operation in generating new product ideas and sharing information; degree of exchanging complete and accurate information for problem-solving; degree of exchanging opinion for testing or examining the new product; willingness to coordinate to achieve the target of new product development; willingness to coordinate for strategic consideration; willingness to accept

different opinion from the other departments and willingness to solve disagreements among departments (Denison et al., 2008; Mousavi and Darvishi, 2014).

Result Orientation: Result orientation is the strategic orientation defined as principles that direct and influence the activities of a firm and generate the behaviors intended to ensure its viability and performance (Hakala, 2011). Result orientation is also defined by interrelationship of time, costs, quality, people and organization for assuring better NPD performance. This increases the firm's growth rate improves performance of NPD (Deutscher et al., 2016). Interrelationships of time, costs, quality, people and organization; consideration of different times associated; consideration of various cost associated; focus on quality factors; consideration of factors related to people; and accumulation of both financial and non-financial results are the manifest variables for measuring the result orientation of the firm (Berthon et al., 2004; Deutscher et al., 2016).

System Integration: System integration aims to accumulate resources of various functional groups for successful development of new products. There are various kinds of resources required for developing the products and the integration category also changes depending upon the types of resources. This includes the integration of knowledge among the team member within organization. It also covers the accumulation of knowledge from outside the organization that is integration with suppliers and customers (Johnson and Filippini, 2013; Gu et al., 2016). The system integration is manifested by formal department for system integration, experienced engineers for system integration, availability of middle management and presence of a product manager for system integration (Leitman, 2011; Gu, Jiang and Wang, 2016).

1.4.3 Success Measures of NPD

Success is not indefinable, rather it can be multifaceted. The measurement of the success of a firm is quite difficult task to be performed. The success criterion of a product which has to create a completely new market depends on the innovation strategy of the firm. It is different from the performance measurement of the product already exists in the market. Depending upon the scenario the success or failure of the firm can be measured in different perspectives. Montoya-Weiss and Calantone (1994) categorized the product performance in three sections such as financial objectives, market share objectives and technical objectives. Brown and Eisenhardt

(1995) segmented the NPD performance in outcome of product and process performance. Product performance designated as the attractiveness of the product along with its reliability and functionality which make it fit with the market needs. The NPD process performance deals with the schedule and budget adherence along with speed-to-market and productivity. Later customer preferences are also treated as another measure of NPD success (Griffin and Page, 1996). Based on the previous literature the success measures are segmented in seven categories such as cost, customer satisfaction, environmental measures, technological developments, time, quality and additional measures of NPD. These measures are described below:

Economic and financial attributes: A firm has various performance criterion to measure the NPD performance. Financial measure is one of those measures mainly highlights the cost attributes related to NPD. The indicators accumulated as the economic and financial attributes such as attain margin goal, attain profitability goal, attain return on investment (ROI) (Griffin and Page, 1996; Huang et al., 2004), domestic market share (Brown and Eisenhardt, 1995), development cost (Griffin and Page, 1996; Oliver et al., 2004), international market share (Brown and Eisenhardt, 1995), meet revenue goal, meet unit share goal (Griffin and Page, 1996), net sales growth (Brown and Eisenhardt, 1995), percentage of sales by NPD, profit margin, profitability relative to competitors (Montoya-Weiss and Calantone, 1995), profitability relative to spending and revenue growth (Griffin and Page, 1996).

Environment based attributes: NPD success can also be deliberated by environmental measures to portray the better environmental performance of the newly developed products. Reduced cost is one of the environmental measures as firms target to develop products by using minimal renewable resources for better energy efficiency. Firms controlling the environmental risks decrease their weighted average cost of capital. This reduces the development cost as well as the environmental hazards (Deniz, 2002). The healthy relationship with investors also shows the environmental success of the firm as investors are keenly aware of the firms' effort to manage their environmental impacts for better environmental performance. Regulatory approvals are required to launch the newly developed product to the market for commercialization at significant cost. Products with negative impact on environment are unable to achieve regulatory approvals and fail to attain the success (Kaval, 2011). Life-cycle analysis is a method of quantifying the impacts of a product throughout its lifecycle from design to disposal. This can

help to measure the environmental impact of the product for NPD success (Brundage et al., 2018). Lastly, the most vital environmental measure is customer satisfaction. Customers are the ultimate end-user of the product and their satisfaction is another performance attribute of NPD (Griffin and Page, 1996). Present customers are more eager to consume the products which are sustainable and having less hazardous effect on environment. This leads the firms to develop the products with less negative impacts on environment (Kaval, 2011).

NPD team's capability: Teamwork culture among the organization helps to socialize the creativity of the team members for technological innovations. This helps to develop products that are fundamentally different for creating competitive advantage (Hoegl and Parboteeah, 2007). Technological developments (Hart, 1993), expansion of product family, scheduled product launching frequency, reduction of failure rate and time associated for development (Griffin and Page, 1996).

Technological Development: The technological developments provides the competence for beating competition to market, beating competition technologically (Hart, 1993), cannibalization effect, expanding product family, frequency of product launching, number of failure, rate of failure, reduction of risks (Oliver et al., 2004) and technological breakthrough (Hart, 1993).

Quality Assurance: Meeting the quality goal is the most essential criteria a product must have to fulfill the customer requirements. Achievement of design goal (Tishler et al., 1996), achieved product performance goal and meet quality guideline (Griffin and Page, 1996) are the measures to quantify the quality of the newly developed product.

1.5 Motivation/Research Gaps

The literature survey presented above reveals the following knowledge gap in the research reported so far:

NPD and its vital role as a key contributor for continuing business success have been well documented by Booz et al., 1982; Ernst 2002; Ulrich and Eppinger, 2012. It ensures the growth of the company through escalating the profit performance. Though the NPD activities of the firms have been increased drastically in last few decades, but 25%-45% failure rate of new products have been noticed (Crawford, 1987) hindering the introduction of new products in the

market. Montoya-Weiss and Calantone (1994) introduced the empirical study for recognizing the determinants of NPD for better performance. Cooper and Kleinschmidt (1993) studied 12 common denominators of successful NPD and termed those as Critical Success Factors (CSFs) as they are critical to firm's success. There are other literature (Balachandra and Friar, 1997) identified the CSFs of NPD for improving NPD success rates. Lynn (1999) developed a framework of NPD by identifying key success factors for controlling the NPD activities. Like success factors, identification of success measures is essential as performance attributes for quantifying the NPD success of the firm (Tishler et al., 1996; Huang et al., 2004). From these previous attempts this has been clearly observed that identification of the CSFs of a specific sector is critical as well as essential for offering the competitive advantages to sustain in the global competition. Sun and Wing (2005) proposed the CSFs of NPD in Hong Kong manufacturing sector. Huang and Lin (2006) explored the success factors of NPD in high-tech manufacturing industries of Taiwan. Though there are few studies (Roy et al., 2003; Mitra 2007; Tripathy et al., 2012) considering the CSFs of Indian manufacturing industries, but most of them concerned about the R&D practices not the overall approach for identifying the success factors of NPD. From a detailed literature survey few critical research gaps have been identified which must be emphasized for the betterment of NPD performance in Indian context. These gaps are:

- A clear dearth in the empirical study for identifying CSFs of Indian manufacturing sector have been noticed in available literature.
- The importance in implementation perspectives of these CSFs in Indian manufacturing sector is remained unnoticed.
- The grouping of those success factors which are related can also be incorporated and their prioritization as per their importance may also be performed.
- Moreover, the idea of performance measurement is also needed to be improved for sustaining in the global competitive environment. For this, success measures required to be recognized and clubbed in groups similar to CSFs.
- The combined impact of factors on NPD success for each group of CSFs is also essential to be explored for better NPD performance.

1.6 Aim of Research

The knowledge gap in the existing literature summarized above has helped to set the aim of this research work. A comprehensive study of identifying the CSFs and success measures of NPD is needed to be carried out for controlling the performance of Indian manufacturing companies who are developing new engineering products. Grouping of the success factors based on their activities and ranking of these groups may help to enforce the vital factors of NPD for the success of the firm. Similarly, in case of success measures this same group formation is essential as well. Identification of relevant groups of success measures for realizing the combined impact of a group of CSFs for successful NPD is also a vital gap which is to be bridged.

1.7 Objectives of the Research

Based on the aim of the research the objectives are outlined to accomplish the goals as mentioned below:

- Identification of all critical success factors and success measures of NPD along with recognition of their indicators or manifest variables that help in achieving industrial sustainability.
- Grouping of the related CSFs in groups namely, environmental factor, management actions, product development process, R&D activities and teamwork culture.
- Grouping of the success measures in groups namely, economic and financial attributes, environment based attributes, NPD team's capability, technological development and quality assurance.
- Identification of success measures for each group of CSFs to quantify the success of the NPD process.
- Ranking of the group of CSFs based on the data collected from the Indian manufacturing firms involved in new engineering product development.
- Development of a framework comprising of five structural models and realize the impact of each group of CSFs on NPD success along with the validation of the developed models.

Chapter Summary

This chapter has provided:

- An exhaustive review of research works on various success factors and measures of NPD reported by previous investigators
- The knowledge gap in earlier investigations
- The objectives of the present work

The next chapter describes the methods used to rank the groups of CSFs and to develop the structural framework for portraying the combined impact of factors in a group to enhance NPD performance of the firm in turn the firms' success.

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CHAPTER 2

RESEARCH METHODOLOGY

2.1 Preamble

This chapter includes details of research process, design and methodology. The chapter starts by stating the methods used for ranking the groups of CSFs. This is followed by a brief description of factor analysis, exploratory and confirmatory, used for analyzing the manifest variables of constructs. It also incorporates structural equation modeling (SEM) approach helps to develop the framework depicting the combined impact of each group of CSFs for measuring NPD success. The design of questionnaire for SEM is discussed along with its validation. It is followed by sampling and data collection including the list of sectors and number of respondents participating in this empirical study. The content validity for further betterment of the developed questionnaire is described. The detailed data analysis steps are also mentioned for better understanding.

2.2 Analytic Hierarchy Process (AHP)

The identification of the factors (attributes) that help to distinguish the successful NPD from unsuccessful one is essential for prioritizing those using multi-criteria decision making (MCDM) techniques. MCDM is a decision-making tool compromising of both qualitative and quantitative factors for selecting optimal possible options (Mardani et al., 2015). It is grown as a part of operations research for evaluating the prioritization of the criteria on the basis of experts' opinion (Zavadskas et al., 2014). Analytic Hierarchy Process (AHP) is one of those MCDM techniques used to rank the factors as per their importance and priority. It is first introduced by Thomas Saaty in 1980 dealing with the complex decision making on the basis of the decision makers' priorities through developing pair wise comparison matrix (Saaty, 1980). In the practical scenario, conventional AHP is unable to express the précised data as the human thoughts. Introduction of fuzzy logic helps to define the ambiguous data like human thinking which are difficult by conventional AHP.

2.3 Fuzzy Analytic Hierarchy Process (FAHP)

The fuzzy analytic hierarchy process (FAHP) approach allows more precise portrayal of the decision making process taking into consideration the uncertainty in human preference (Kwong and Bai, 2002). Van Laarhoven and Pedrycz (1983) explained FAHP to compare fuzzy ratios described by triangular fuzzy membership functions. Buckley (1985) derived the fuzzy priorities of comparison by using trapezoidal membership function. Later, Boender et al., (1989) modified the method stated by Laarhoven and Pedrycz (1983) to a more robust approach of normalization of local priorities. Da-Yong Chang (1992) introduces extent analysis on FAHP on the basis of degree of possibilities of each criterion. The pair-wise comparison matrix has been constructed by placing the triangular fuzzy values for the linguistic variables by using the responses from the industrial experts (Aggarwal and Singh, 2013). A questionnaire for determining the importance level of each factor has been developed to priorities the factors using extent analysis on FAHP. The present research aims to prioritize the groups of CSFs as described in Chapter 1.

2.4 Factor Analysis (FA)

The most famous statistical procedure for investigating relations among the set of observed and latent variables is factor analysis. The co-variation among these set of observed variables helps in acquiring the information among the latent constructs. There are two types of factor analyses: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

EFA is method to determine to which extent the observed variables are related to their underlying latent constructs. It handles the scenario when the relation between the observed variables and latent constructs are completely uncertain. In FEA, the relations among the observed or manifest variables are represented by the factor loadings. On the basis of these loading values, the contribution of each observed variable to their respective latent construct can be recognized. This EFA helps in identifying the observed variables with higher loading values which can be further considered for structural model development (Gorsuch, 1983; Byrne, 2016). But EFA alone is not adequate to evaluate all essential measurement properties of the constructs, so CFA has been done.

CFA is a method of data analysis applied when the researchers have a detailed idea about the latent variable structure. The knowledge about the connection among the latent and manifest variables are already been gathered from the available literature or from the experts opinion. In case of CFA, the indicators of the respective latent constructs are set free to load on that factor and restricted to have zero loadings on the remaining factors. In this research two measurement models are evaluated by using CFA, one is measurement model for input constructs and another one is for output constructs. After CFA, the full model is developed using SEM followed by the goodness-of-fit tests to investigate the fitness of the model to the sample data.

2.5 Structural Equation Modeling (SEM)

2.5.1 Overview

Structural Equation Modeling (SEM) a multivariate data analysis technique. It is a methodology for representing, estimating, and testing relationships between latent constructs and measured variables, which are used to describe those latent constructs (Rigdon, 1998). SEM is a statistical approach for analyzing the hypotheses about relations among the latent constructs, which have been developed from previous literatures and collected data from company experts. Simultaneous statistical analysis can be performed to test the hypothesized model to verify the extent to which it is consistent with the data. The model developed by SEM comprises of both a measurement model and a structural model. The measurement model portrays the connection between the latent constructs and their respective manifest variables which means the CFA model. There are two measurement models, one is input measurement model incorporating the input constructs and another one is output measurement model describing the output constructs. The structural model depicts the links among the latent constructs. The measurement model and structural model together constitute the complete model which is evaluated by SEM (Joreskog, 1973) using IBM SPSS AMOS 21.0.

2.5.2 Steps of SEM

SEM comprises of five steps for development of complete model relating the latent constructs as well as their manifest variables. The steps are (Hair et al., 1995):

- Model Specification: Specification is formulating a hypothesis involved in the interrelationships of the variables in a proposed model.
- Identification of the model: Identification involves the study of conditions to obtain a single, unique solution for each and every free parameter specified in the model from the observed data.
- Estimation of free parameters: Parameter estimation is done by comparing the actual covariance matrices representing the relationships between variables and the estimated covariance matrices of the best fitting model.
- Assessment of model and model fit test: The basic task of SEM modeling is to examine "fit" of an estimated model to determine how well it models the data for accepting or rejecting models.
- Model Modification: The model may need to be modified in order to improve the fit, thereby estimating the most likely relationships between variables.

2.6 Design of Questionnaire and Validation

This study incorporates development of two questionnaires. One is for prioritizing the groups of CSFs and another is for framework development.

The questionnaire for extent analysis method on FAHP gathers the information regarding the pair-wise comparison among the groups of CSFs. There are five group of CSFs required to be prioritized namely, product development process (PDP), teamwork culture, management actions, environmental factor and R&D activities. First, the priority of PDP on other remaining groups such as teamwork culture, management actions, environmental factor and R&D activities are needed to be responded. Similarly, the priority of each group of CSFs respective to other remaining groups is captured as per the experts' opinion from Indian manufacturing industries involved in new engineering product development. The survey instrument used for this purpose is Saaty's 9 point scale where '1' stands for equally important, '3' for weakly important, '5' for fairly important, '7' for strongly important and ' 9' for absolutely important. The other values like 2,4,6,8 represent the intermediate values of this scale. The developed questionnaire is enlisted as Appendix A mentioned at the end of the thesis. The consistency ratio of each response is tested. If the value of consistency ratio is less than or equals to 0.10 (Saaty, 1980),

the response is converted into fuzzy triangular numbers for further analysis. Fuzzy extent analysis method is applied to prioritize the groups of CSFs to rank them by calculating their weights as per experts' opinion.

An extensive semi-structure questionnaire covering the input (success factors) and output constructs (NPD success quantified by various success measures) including their manifests is developed. This questionnaire is mainly divided into three sections: The first part is designed to acquire the personal information and organization profile of the respondent. The second and third part captures the responses on input and output manifest variables respectively. Present work uses 7 point Likert scale (1= strongly disagree; 2= disagree; 3= slightly disagree; 4= neutral; 5= agree somewhat; 6= agree; 7= strongly agree) to get the responses for each item on the perception about the importance in implementation of a manifest variable involved in NPD. There is also an open-end section for respondents to insert additional measures for each constructs as per their suggestions which is not mentioned in the questionnaire. This structure of the questionnaire is itself a novel approach capturing the detailed information and experts' opinion. The underlying theoretical background for elaboration of this questionnaire takes the theoretical and metric principles of reliability and validity maximizing the inferences from its use. A pilot study considering fifty respondents (n=50) from Eastern India (mainly from Kolkata and Howrah) is performed for validating the developed questionnaire and its further improvement.

2.7 Sampling and Data Collection

This empirical research is targeted to realize the importance in implementation of NPD practice in Indian engineering manufacturing sector. The list of manufacturing companies is obtained from Capitaline Plus which is one of the most current databases of India. Few small scale companies are also identified through snowball sampling methods which were not listed in the aforementioned database. The population of interest is the all industries developing engineering products with manufacturing facilities in India. The industries like power sector, agriculture, construction sector and services are excluded from the list. Initially, data has been collected from 380 experts from different organization type of Indian manufacturing companies by visiting and direct interviewing and few over telephonic interviews and e-mail sharing. Mostly, the Directors, Vice-Presidents and executives in the managerial level of design and

development departments who are directly involved in the manufacturing process having adequate years of experience are considered as right persons to be questioned as their knowledge and experience are dependable for future analysis. The 78.16% of total sample delivers response to the request among those 69.21% is reliable and usable. Finally, 263 responses among the total data have been considered reliable for final analysis. At the same time the observation to variable ratio is more than 5 which is quite acceptable for SEM analysis (Fabrigar et al., 2010). Profiles of the reliable respondents utilizable for this study have been mentioned in Table 2.1.

Table 2.1 Sectors and number of respondents participating in the empirical study

Sample Characteristic	Classifications	Total	Percentage
Geographical Location	Indian Manufacturing Companies	263	100
Organization Type	Fabricated components	46	17.49
	Electrical equipment	33	12.55
	Industrial valves	32	12.17
	Textile Machineries	27	10.27
	Firefighting equipment	26	9.89
	Hydraulics & pneumatic	25	9.50
	Burners and heaters	22	8.37
	Material handling equipment	21	7.98
	Cell and battery	14	5.32
	R&D sectors	9	3.42
	Air ventilators	8	3.04
Respondent's Profile	Executive	69	26.23
	Manager	83	31.56
	Senior Manager	48	18.25
	Vice President	36	13.69
	President	27	10.27
Respondent's experience	0-5 years	87	33.08
	6-10 years	65	24.71
	>10 years	111	42.21

2.8 Content Validity

Content validity of a questionnaire is the way to measure the degree to which the survey instrument can measure the constructs (Sangoseni et al., 2013). This validation is established by a panel of experts from Indian engineering industries, through a pilot study which has been performed in Eastern part of India for checking the content validity. The experts having clear idea about the constructs of interest analyze the developed instrument for establishing a content valid questionnaire. They review the questionnaire thoroughly for checking the readability, clarity and comprehensiveness to suggest the essential modifications which are incorporated in the final questionnaire.

2.9 Data Analysis

After the primary data collection from the industry experts, the average variance extracted (AVE), composite reliability (CR) and Cronbach's Alpha tests have been performed for validity and reliability testing of the obtained data set using IBM SPSS 21.0. The values of CR greater than 0.5 are considered as highly reliable and the values in between 0.3 to 0.5 are considered as moderate. For convergent validity, the value of AVE should be greater than 0.5 indicate reliable factors (Holmes and Smith, 2001). Again α values should be either greater or equals to 0.8 is considered as reliable and the data set can be used for analyzing the developed framework (Nunnally, 1978; Ong et al., 2004). After the validity and reliability testing of the survey data the EFA is performed using IBM SPSS 21.0 for assessing the essential measurement properties of the constructs. It identifies loading of each individual manifest variable to measure the latent constructs and the indicators having higher ($\geq$0.60) loadings (Hair et al., 2010) are extracted for further SEM model development. By using the manifest variables extracted from EFA, the SEM is performed. For the analysis, SEM develops both measurement model and structural model. There are two measurement models – input measurement model and output measurement model. These measurement models are evaluated by CFA. Principal component analysis (PCA) based CFA is employed for recognizing the standardized regression weights (SRWs) of the manifests for measuring the contribution of the indicators for the respective constructs (Hair et al., 1995). Finally the complete structural model is developed by SEM with data from Indian manufacturing

industries, to identify the impact of the input latent constructs on the output latent constructs by estimating the path values among them.

Chapter Summary

This chapter has provided:

- The method used for prioritizing the groups of CSFs as per experts' opinion.
- The description of SEM approach for establishing the framework for NPD success.
- The details of questionnaire developed for this empirical research along with the sampling and data collection from Indian manufacturing industries.

The next chapter presents the ranking method including the analysis for prioritizing the groups of CSFs using fuzzy extent analysis.

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CHAPTER 3

GROUP RANKING OF CRITICAL SUCCESS FACTORS

3.1 Preamble

This chapter deals with the prioritization of the groups of CSFs by using fuzzy analytic hierarchy process (FAHP) based extent analysis method to rank these groups as per their importance on the basis of the experts' opinion. A questionnaire for collecting the responses from Indian manufacturing experts is developed. On the basis of the primary data collected the fuzzy extent analysis is performed to rank the groups of CSFs essential for NPD.

3.2 Extent Analysis Method

The fuzzy extension of Saaty's priority theory is one of the very popular areas of research. Da-Yong Chang (1992) introduced a new approach of handling FAHP named as extent analysis method where the pair-wise comparison of triangular fuzzy numbers is performed. This method calculates the synthetic extent value for pair-wise comparison. The steps of extent analysis method performed for prioritizing the groups are represented as follows (Chang, 1996):

Step 1: Defining the problem and objective

The objective of this study is the prioritization of groups of CSFs of NPD mentioned as product development process (PDP), teamwork culture (TC), management actions (M), environmental factors (EF) and R&D activities (R&D) for successful implementation of NPD activities in Indian engineering manufacturing firms. A questionnaire has been developed to accumulate the responses from the industry experts as represented at the end of this thesis as Appendix A.

Step 2: Pair-wise Matrix Formation

Firstly, the pair-wise comparison matrix of responses of the manufacturing experts has been developed. The experts have to select the linguistic variables in the questionnaire to priorities the factors which are then be converted into fuzzy triangular numbers. Let as assume:

$M \epsilon F(R)$ is called the fuzzy number if:

1) exists $x_0 \epsilon R$ such that $\mu_M(x_0) = 1$.

2) For any $\alpha \epsilon [0,1]$,

$A\alpha = [x, \mu_{A\alpha}(x) \geq \alpha]$, is a closed interval where F(R) is all fuzzy sets and R is the set of real numbers.

The Saaty's triangular scale for fuzzification of the linguistic variables has been shown in Table 3.1. This table provides the generalized form of triangular fuzzy numbers by converting the linguistic variables.

Table 3.1 Saaty's scale for both linguistic and triangular numbers

Linguistic Values	Triangular Fuzzy Numbers
1	(1,1,2)
x	(x-1, x, x+1) where x = 2,3,4,5,6,7,8
9	(8,9,9)
1/x	(1/(x+1), 1/x, 1/(x-1))

After checking the consistency ratio, the consistent responses are converted into fuzzy numbers for applying the extent analysis method using the values of Table 3.1. As, the responses have been collected from 263 experts of various Indian manufacturing companies developing engineering products, the geometric mean of those responses have been calculated which helps to obtain the pair-wise comparison of criteria which are the groups of success factors in this study such as product development process (PDP), teamwork culture (TC), management actions (M), environmental factor (EF) and R&D activities (R&D). The geometric mean of 263 experts

of those responses have been calculated which helps to obtain the pair-wise comparison of criteria which are the groups of CSFs in this study have been enlisted in Table 3.2.

Table 3.2 Pair-wise comparison matrix of the groups of CSFs based on the responses of industry experts

	PDP	TC	M	EF	R&D
PDP	(1,1,2)	(1.81,2.85,3.86)	(1, 1.87, 2.88)	(1.15,2.17, 3.18)	(0.67,0.93,1.64)
TC	(0.26,0.35,0.55)	(1,1,2)	(0.25,0.34,0.53)	(0.37,0.49,0.87)	(0.20,0.26,0.35)
M	(0.37,0.54,1.07)	(1.89,2.93,3.95)	(1,1,2)	(1.15,1.76,2.81)	(0.26,0.36,0.57)
EF	(0.32,0.48,0.93)	(1.32,2.05,3.10)	(0.44,0.57,1.07)	(1,1,2)	(0.21,0.27,0.38)
R&D	(0.75,1.07,1.83)	(2.86,3.90,4.92)	(1.74,2.77,3.78)	(2.64,3.72,4.76)	(1,1,2)

Step 3: Calculating fuzzy synthetic extent value (S_i) with respect to i^{th} criterion

Let us assume G= g {g_1, g_2, g_3,……..g_m} be a goal set. The extent analysis for each object of each goal has been performed. The m extent analysis values for each object has been obtained, such as

$$M_{gi}^{1}, M_{gi}^{2}, M_{gi}^{3}, \ldots\ldots\ldots\ldots\ldots, M_{gi}^{m}, \quad (1)$$

where all M_{gi}^{j}, (j = 1, 2, 3, ……m) are triangular fuzzy numbers and i = 1, 2, 3, ……, n.

Now, if the values of extent analysis of i^{th} object for m goals are $M_{gi}^{1}, M_{gi}^{2}, M_{gi}^{3}, \ldots\ldots, M_{gi}^{m}$, then the values of fuzzy synthetic extent with respect to the i^{th} object can be defined as (Chang, 1992)

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \Theta \left(\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right)^{-1} \quad (2)$$

Now, from Equation (2), we get

$$S_1 = (5.63, 8.82, 13.56) \Theta \left(\frac{1}{53.05}, \frac{1}{34.66}, \frac{1}{24.67}\right)$$

$$= (0.1062, 0.2543, 0.5497),$$

$$S_2 = (2.09, 2.44, 4.30)\odot\left(\frac{1}{53.05}, \frac{1}{34.66}, \frac{1}{24.67}\right)$$

$$=(0.0393, 0.0703, 0.1743),$$

$$S_3 = (4.67, 6.59, 10.41)\odot\left(\frac{1}{53.05}, \frac{1}{34.66}, \frac{1}{24.67}\right)$$

$$= (0.0881, 0.1901, 0.4218),$$

$$S_4 = (3.29, 4.36, 7.49)\odot\left(\frac{1}{53.05}, \frac{1}{34.66}, \frac{1}{24.67}\right)$$

$$= (0.0620, 0.1259, 0.3035),$$

$$S_5 = (8.99, 12.46, 17.29)\odot\left(\frac{1}{53.05}, \frac{1}{34.66}, \frac{1}{24.67}\right)$$

$$= (0.1695, 0.3593, 0.7007),$$

Step 4: Calculation of priority vectors of fuzzy AHP

To calculate the estimates of the vectors of weights under each criterion, a principle of comparison of fuzzy numbers must be followed. The membership function for calculating priority vectors is shown in Fig.3.1. The degree of possibility for x ϵ R fuzzily restricted to belong to M, to be greater than y ϵ R fuzzily restricted to belong to M. So, it can be stated as degree of possibility (V) of $M_1 \geq M_2$ is defined as

$$V(M_1 \geq M_2) = sup_{x \geq y}\ [\min(\mu_{M1}(x), \mu_{M2}(y))] \quad (3)$$

When a pair (x, y) exists such that x ≥ y and $\mu_{M1}(x) = \mu_{M2}(y) = 1$, then we have

$$V(M_1 \geq M_2) = 1 \quad (4)$$

Since, $M_1$and M_2 are convex fuzzy numbers. So we have

$V(M_1 \geq M_2) = 1$, if $m_1 \geq m_2$,

$$V(M_1 \geq M_2) = \text{hgt}(M_1 \cap M_2) = \mu_{M1}(d), \quad (5)$$

Here, d = ordinate of highest intersection point D between μ_{M1} and μ_{M2} as shown in Fig. 3.1.

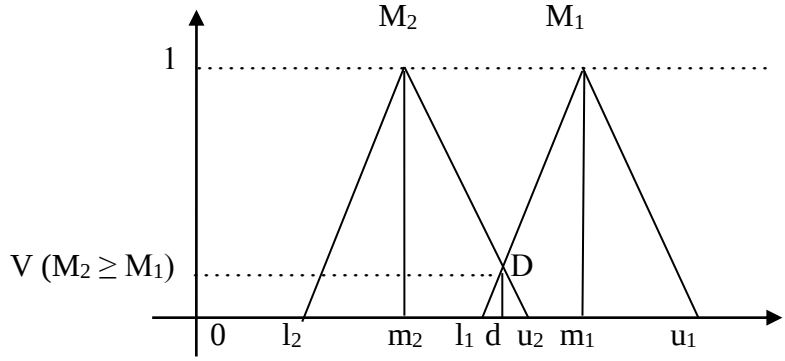

Figure 3.1 Membership functions for calculating priority vectors of FAHP

When $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, the ordinate D is given by Equation (6)

$V (M_2 \geq M_1) = hgt(M_1 \cap M_2)$

$$D = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \tag{6}$$

To compare M_1 and M_2, both values of $V (M_1 \geq M_2)$ and $V (M_2 \geq M_1)$ are required.

Now, from Equation (5) and (6), we calculate

$V(S_1 \geq S_2) = 1,$

$V(S_1 \geq S_3) = 1,$

$V(S_1 \geq S_4) = 1,$

$$V(S_1 \geq S_5) = \left(\frac{0.1695 - 0.5497}{(0.2543 - 0.5497) - (0.3593 - 0.1695)}\right) = 0.78$$

Similarly,

$V(S_2 \geq S_1) = 0.27,$

$V(S_2 \geq S_3) = 0.42,$

$V(S_2 \geq S_4) = 0.67,$

$V(S_2 \geq S_5) = 0.02,$

The other estimated degree of possibilities (V) for S_3, $S_4$and $S_5$are also calculated in the similar ways and their values are enlisted in Table 3.3.

Table 3.3 Estimated values of vectors of weights for each factor

For S_1	For S_2	For S_3	For S_4	For S_5
$V\ (S_1 \geq S_2) = 1$	$V\ (S_2 \geq S_1) = 0.27$	$V\ (S_3 \geq S_1) = 0.83$	$V\ (S_4 \geq S_1) = 0.61$	$V\ (S_4 \geq S_1) = 1$
$V\ (S_1 \geq S_3) = 1$	$V\ (S_2 \geq S_3) = 0.42$	$V\ (S_3 \geq S_2) = 1$	$V\ (S_4 \geq S_2) = 1$	$V\ (S_4 \geq S_2) = 1$
$V\ (S_1 \geq S_4) = 1$	$V\ (S_2 \geq S_4) = 0.67$	$V\ (S_3 \geq S_4) = 1$	$V\ (S_4 \geq S_4) = 0.77$	$V\ (S_4 \geq S_4) = 1$
$V\ (S_1 \geq S_5) = 0.78$	$V\ (S_2 \geq S_5) = 0.02$	$V\ (S_3 \geq S_5) = 0.60$	$V\ (S_4 \geq S_5) = 0.36$	$V\ (S_4 \geq S_5) = 1$

Step 5: Calculation of $d'(A_i)$

The weight vectors with respect to each element can be represented by $d'(A_i)$.

Let us assume $d'(A_i)$= $\min V\ (S_i \geq S_k)$, for k = 1, 2, 3, …….n; k ≠ i (7)

Now calculate $d'(A_i)$ for i values.

From Equation (6), it is obtained

$d'(A_1)$= $\min V\ (S_1 \geq S_2, S_3, S_4, S_5)$

= $\min(1, 1, 1, 0.78) = 0.78,$

$d'(A_2)$= $\min V\ (S_2 \geq S_1, S_3, S_4, S_5)$

= $\min(0.27, 0.42, 0.67, 0.02) = 0.02,$

$d'(A_3)$= $minV\ (S_3 \geq S_1, S_2, S_4, S_5)$

= $\min(0.83, 1, 1, 0.60) = 0.60,$

$d'(A_4)$= $minV\ (S_4 \geq S_1, S_2, S_3, S_5)$

= $\min(0.61, 1, 0.77, 0.36) = 0.36,$

$d'(A_5)$= $minV\ (S_5 \geq S_1, S_2, S_3, S_4)$

= $\min(1, 1, 1, 1) = 1,$

Step 6: Calculation of weight vector

Now, calculate the weight vector which is given by

$$W' = (d'(A_1), d'(A_2), d'(A_3), \dots \dots . d'(A_n))^T, \quad (8)$$

where, $A_i (i = 1, 2, 3, \dots \dots \dots n)$ are n elements.

Now we have to calculateW'. From equation (8) we get,

$W' = (0.78, 0.02, 0.60, 0.36, 1)^T$

Step 7: Calculation of normalized weight vector

Finally, via normalization, we get the normalized weight vectors

$$W = (d'(A_1), d'(A_2), d'(A_3), \dots \dots \dots \dots, d'(A_n))^T \quad (9)$$

where, W is a non-fuzzy number.

Now, via normalization using Equation (9) we obtain the weight vectors for all the factors which are groups of CSFs of NPD namely, product development process (PDP), teamwork culture (TC), management actions (M), environmental factor (EF) and R&D activities (R&D):

$W = (0.28, 0.01, 0.22, 0.13, 0.36)$

The results of the fuzzy AHP framework by using Chang's extent analysis method suggest the weights of the groups of CSFs and thus rank those factors as listed in Table 3.4 based on the degree of importance provided by the experts of Indian engineering manufacturing companies.

Table 3.4 Estimated values of vectors of weights for each group of CSFs

Sl. No.	Groups of CSFs	Weights	Ranking
1.	Product Development Process	0.28	2
2.	Teamwork Culture	0.01	5
3.	Management Actions	0.22	3
4.	Environmental Impacts	0.13	4
5.	R&D Activities	0.36	1

The perception and ideas of human being vary from person to person. So, according to that the linguistic values of the human decisions change simultaneously. The fuzzification of the linguistic values ensures a less volatile decision. In this study, FAHP framework using Chang's extent analysis have used to priorities groups of success factors critical for NPD success for ensuring better firm's performance.

The weights of the factors as shown in Table 3.4 depict the priorities of the respective groups. This study identifies the group of R&D activities consisting of R&D and its associated factors as the vital most for NPD succeeded by PDP, management actions, environmental impacts and finally the teamwork culture as per the responses from the experts. The subsequent chapters are arranged as per the priorities of by the respective groups.

Chapter Summary

This chapter has provided:

- The detailed method of prioritizing the groups of CSFs step by step.
- It provides the mathematical calculations along with the steps of ranking by using synthetic extent analysis method.
- It is observed that R&D activities has considered as the most vital group which is succeeded by PDP, management actions, environmental factor and teamwork culture.

The next chapter presents the structural framework considering the R&D activities and its directly and indirectly related factors for NPD success measured by technological development.

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CHAPTER 4

RESEARCH AND DEVELOPMENT IN NEW PRODUCT DEVELOPMENT

4.1 Preamble

This chapter presents a framework for scrutinizing the interrelationship and impact of constituents or factors of Research & Development (R&D) on NPD success, besides identifying those. Such cited factors, deemed to be critical, are R&D practices, technology, learning, intellectual capital as well as the fuzzy front end (FFE) activities followed by improvisation for innovation. NPD has grown into a compelling strategy of manufacturing industries for confronting volatility and rapid changes of market due to globalization. The aforementioned practices lead to the technological developments of the firm resulting in NPD success. An interrelationship framework considering factors of R&D practices and technological improvement is developed, in this work, using Structural Equation Modeling (SEM) approach. This empirical study is based on the responses of 263 domain experts across Indian manufacturing industries. The magnitude of the interrelationship, investigated utilizing the above modeling, indicates that technology, learning and intellectual capital directly influence R&D practice, comprised of R&D infrastructure and investment, which in turn escalates NPD success. There are also two other constituents, namely FFE activities and improvisation for innovation, forming part of development process, promotes NPD success as well.

4.2 Background

Research and development (R&D) is an imperative for a firm and it should engage for continuous improvement and updating its technologies and resources for innovative product development. The surge of modification of products or NPD is impacted by escalated R&D practices (Kawazoe and Abetti, 2014; Nicholas et al., 2015). Enhancement of profitability and market share has resulted through invention by dint of continuous research and implementation (Lau, 2011), where Indian firms were neglectful in the investment in R&D.

Technology resources embolden R&D implementation for improved NPD; it provides technical capabilities and opportunities (Mendes and Ganga, 2013). R&D practices, enwrapped on a continual basis, promise technological advancement in developing high-tech products and these ensure customer satisfaction as well (Coskun Samli and Weber, 2000). Technology resource is a driver of an R&D unit, liable for successful development of innovative products (Wang et al., 2014), influencing purchasing decisions of customers and providing competitive advantages (Hsieh et al., 2008). Another constituent, 'Learning', indulges R&D practices for achieving PI success (de Medeiros et al., 2014) through overcoming the cultural barriers and knowledge sharing (Roy and The´rin, 2008). This spurs the collaborative nature of the firm for better NPD performance (Brown and Eisenhardt, 1995) and promotes interactive learning through integration among its different units while actualizing superior NPD performance by proper understanding of firm's capabilities (Johnson and Filippini, 2013). It also helps in organizing R&D activities as a collaborative process. According to Zhou and Fink (2003) a popular intangible asset for developing competitive advantage is the intellectual capital, which is considered to be a constituent of R&D practices and is a combination of human capital, structural capital and relational capital contributing to successful development of innovative products (Hsu and Fang, 2009). The structural capital, amongst the aforementioned three types, chiefly influences the R&D practices of the firm that is presented in terms of investments and number of employees in R&D department for innovative development. Intellectual capital, in turn, is enriched by organizational learning for better firm's economy (Lynn, 1999).

Technology, Learning and Intellectual Capital, the three constituents directly influence R&D practice, however, two other factors, namely fuzzy front end (FFE) activities and improvisation for innovation also act as other constituents of the development process. R&D begins with FFE activities, which is the pre planning phase of development, comprising of ideation and conceptualization in product and process innovation; followed by NPD process and commercialization (Awag, 2005). FFE activities are the ideation phase along with the accumulation of technical and marketing knowledge for NPD success (Mendes and Ganga, 2013). The FFE activities followed by the improvisation is the planning through continuous research and execution of findings concurrently for developing an attitude in team to change its thinking and project routines for firm's betterment (Akgun et al., 2007).

The above identifies the constituents or factors, directly and indirectly related to the R&D practices for development of new products and hence there is a need to understand their effects and influences comprehensively, considering both types of factors. A model that comprehensively establishes the outcome accommodating the directly and indirectly influencing factors is practically unavailable in the existing literature. This work addresses the need and presents a model considering both types of constituents, stated in details as above. Further, it studies the impact of those factors on technological developments, which remained unexplored. There is a need to understand the interactions and influences of both types of constituents or factors that directly and indirectly influences the R&D practices and technological developments simultaneously and comprehensively. A model that can comprehensively present the nature of the influences or relationship is scantily available in the existing literature. Therefore, the objective of this work has been to develop a model that accommodates the above referred types of constituents comprising of factors namely, technology, learning, intellectual capital, FFE and improvisation for innovation. To study the impact of a factor on the other a structural equation based model is developed where the findings present a precise degree of these interrelationships. Through this, managers will be able to gain a purposeful insight about the interrelationship and take necessary actions thereof.

4.3 Objective

The objective of this study is the achievement of successful NPD of the Indian manufacturing firms by encouraging R&D activities and culture. Identification of the constructs directly and indirectly related to R&D practices and also their manifests which are used to quantify the factors are been carried out to measure the success of the firm which is manifested by technological improvements. A questionnaire accumulate the responses for degree of importance in implementation for each item according to experts' opinion in Indian manufacturing companies is been edged.

4.4 Conceptual Framework for Hypotheses Development

Implementation of R&D is growing rapidly as it offers enormous success (Hume 2000). There are limited numbers of researches on the factors influencing R&D practices in Indian manufacturing firms (Tripathy et al., 2012). Concerning this gap, this research recognizes the

direct and indirect constructs of R&D practices for firm's success in global scenario. A valid theoretical background develops hypotheses interpreting the relationships of these constituents for achieving NPD success.

4.4.1 Effect of R&D on NPD Success

Investments in R&D helps in developing own design capabilities and additional features which provide uniqueness to the product which cannot be easily substituted by competitors (Sun and Wing, 2005). Though R&D practices are highly risky and requires long gestation period, it is necessary for being competitive (Yang et al., 2014). R&D practices are particularly specified as investments in infrastructure, hiring skilled human resources, sustainable product development (Haverila, 2012; de Medeiros et al., 2014). This helps to improve manufacturability of the firm for successful development of new products (Kim and Kim, 2009). As per Chorev and Anderson (2006), quality of the newly developed products critically depends on R&D team quality, similarly necessity of skilled human resources and their practical experiences helps in developing successful R&D practices for efficient development of new products (Chang and Chen, 2004). Based on the above discussions and researches, the statement can be drawn that:

H1: R&D activities positively influence the NPD success of the firm.

4.4.2 Effect of Technology on NPD success and R&D

Technology advancement leads to innovation to attain firm's success providing competitive advantages through developing new products (Kobeda et al., 2016). R&D is closely associated with technology which enhances the R&D quality by supporting through technological enrichments (Haverila, 2012; Mendes and Ganga, 2013). According to Tsai (2012) recognition of resources of technology development is essential for successful NPD. Technological uncertainty often treated as a control variable of NPD which signifies that the advanced technological support increases the probability of firm's success by effective NPD (Chiang and Shih, 2011). From this discussion the hypotheses can be set that:

H2a: Technology enhances NPD success of the firm.

H2b: A higher emphasis on technology improves the R&D activity which is important for NPD success.

4.4.3 Effect of Learning on NPD success, R&D and Intellectual Capital

Learning depicts the interaction of customers with the developed products as a result of strong collaborative culture. Interactive learning practice helps to develop an overall knowledge about the customer requirements confirming firm's success (Johnson and Filippini, 2013). Investments in R&D practices lead to overcome the cultural barrier to encourage the learning of new ideas for innovation (de Medeiros et al., 2014). The positive impact of learning practice on intellectual capital motivates the NPD of the firm (Hsu and Fang, 2009). The organizational learning is treated as one of the assets for enriching intellectual capital in turn the success in developing new products. These implications draw a relationship of learning with NPD performance and R&D practices. According to researchers these interactions can be interpreted as:

H3a: Learning practice has an affirmative impact on NPD success.

H3b: Learning also encourages R&D practices of the firm.

H3c: A higher level of learning enriches firm's intellectual capital.

4.4.4 Effect of Intellectual Capital on NPD success and R&D

Intellectual capital of the firm defines all the intangible assets of the company as total abilities, knowledge, learning, strategies and other activities which directly or indirectly added competitive advantages for fulfilling final objectives (Hsu and Fang, 2009). Amongst the three types of intellectual capital, relational capital is treated as the most effective one succeeded by human capital and structural capital. The structural capital is segmented in various constituents among them investments in R&D and numbers of R&D experts are the relevant factors essential for enriching the intellectual capital of the firm for innovative product development. From these the interferences can be retrieved as:

H4a: Enriched quality of intellectual capital helps in attaining NPD success.

H4b: Intellectual capital positively influences R&D practices of the firm.

4.4.5 Effect of Improvisation on NPD success

Improvisation is the instantaneous planning and executing of any actions for development of new products. Team unlearning leads to improvisation and finally innovation motivates the improvisation culture on NPD (Akgun, 2007). Team improvisation positively influences the new product success by implementing knowledge acquired by unlearning. This improvisation culture develops the ambience for generating new concepts and approaches for satisfying customer requirements. Improvisation motivates the members to think differently from their conventional way and experimenting new ideas, plans, problem solving approaches to search the better alternatives for future betterment (Miner et al., 2001). From these detailed discussions captured from the implications of the previous literatures the assumption can be drawn:

H5: Improvisation leads the firm towards NPD success with positive influence.

4.4.6 Effect of Fuzzy Front End (FFE) Activities on NPD success

FFE is the very much preliminary step of idea generation from technical and marketing studies to new product feasibility test from both technical and economic perspectives. This primary pillar of NPD activities brings success to innovative product development (Mendes and Ganga, 2013). The direct and indirect impact of FFE for influencing the next stage of NPD is performed by identifying the components relative to FFE. This includes generating and selecting interdisciplinary idea, reduction of technical uncertainty as well as market uncertainty and intensity of initial planning (Verworn 2009). This concept motivates the NPD by developing high quality product in reduced cost and low development time (Awag, 2005). For this concern, FFE is properly conceptualized for chasing success. From these evidences it can be stated that:

H6: Effort in FFE positively influences the NPD success of the firm.

This theoretical background helps in framing the comprehensive research model exploring the developed hypotheses that examine the impact of R&D activities and its associated variables on NPD success. A path model of constructs directly and indirectly motivating the R&D practices for attaining NPD success is developed as shown in Fig.4.1.

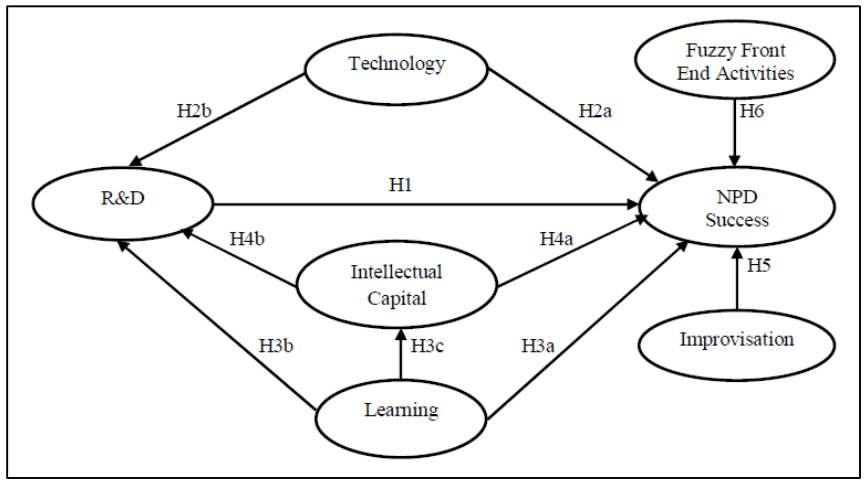

Figure 4.1Path model of constructs depicting the directly and indirectly related factors of R&D for NPD success

4.5 Results & Discussions

The hypotheses testing to develop the framework considering the success factors as constructs and their indicators as manifest variables are performed by using Structural Equation Modeling (SEM) approach. Maximum likelihood (ML) method is used for hypotheses testing to develop a relationship among the R&D related constructs with the NPD success of the firm as well as their indicators. After the estimation of the hypotheses set, the adequate fitness tests are performed for feasible explanation of assumptions about the interactions among latent constructs. After the estimation of the hypotheses set, the adequate fitness tests are performed for feasible explanation of assumptions about the interactions among latent constructs. The proposed model is scrutinized and elucidated successively by assessment of the reliability and validity of structural model. For factors extraction which is again important to discover the innovative patterns among the constructs related to R&D activities (Tripathy et al., 2012). In this study among 54 numbers of manifests 35 are selected having the loading values greater than or equals to 0.60 as per the conventional practice (Hair et al., 2009). The data analysis incorporates a detailed data survey from manufacturing experts of Indian engineering firms and a semi-structure questionnaire is developed for accumulating the opinion and suggestions of experts for realizing the framework depicting the interplays of the constructs for NPD success. The 7 point Likert scale is employed as a survey instrument for quantifying the degree of importance in implementing the factors for achieving NPD success. The scope of sharing the own ideas of experts regarding the indicators of the constructs have also been provided for value addition. Interview protocol with description

of latent variables related to R&D activities and their effect on technological developments of newly developed engineering products are listed in Appendix B as mentioned in the end of the thesis. On the basis of the developed questionnaire, a pilot study has been performed in Eastern part of India for checking the content validity. After that, the data survey is done and reliability of the collected data has been tested by composite reliability (CR), average variance extracted (AVE) and Cronbach's Alpha reliability tests. Finally, 263 responses are found as the reliable and useful for framework development. At the same time the observation to variable ratio is more than 5 which is quite acceptable for SEM analysis (Fabrigaret al., 2010; Gorsuch, 1983). On the basis of that, the further analysis is performed for structural model formation portraying the interactions of associate factors of R&D activities and their impact on NPD success measured by technological development.

4.5.1 Analysis of Measurement Validity

EFA has been used for dimension reduction which selects 35 manifest variables among 54 by selecting the factors having loading values greater than 0.60 as per the conventional practice. In Table 4.1, the list of constructs along with the factor loadings of their indicators is précised by each principal component. The average variance extracted (AVE), composite reliability (CR) and Cronbach's Alpha tests have been performed for validity and reliability testing of the obtained data set using IBM SPSS 21.0. The values of CR greater than 0.5 considered as highly reliable and the values in between 0.3 to 0.5 are considered as moderate. For convergent validity, the value of AVE should be greater than 0.5 indicate reliable factors (Holmes and Smith, 2001). Again α values should be either greater or equals to 0.8 is considered as reliable and the data set can be used for analyzing the developed framework (Nunnally, 1978; Ong et al., 2004). The framework structuring the interrelationships of R&D practices and their impacts on NPD success is analyzed by SEM approach using IBM SPSS AMOS 21.0 software packages.

4.5.2 Measurement Model Results

For testing uni-dimensionality of the scale and estimating model fit, confirmatory factor analysis has been performed. The model has a good model-data fit (χ^2 = 518.082, degrees of freedom = 237, χ^2 /degrees of freedom = 2.186, RMSEA = 0.053, GFI = 0.857, AGFI = 0.811) (Hair et al., 1995). The selected factor loadings (FL) by using EFA of the resulting model ranged

from 0.694 to 0.934 and standardized regression weights (SRW) of the selected manifests ranged from 0.52 to 0.96 as listed in Table 4.1. Values of reliability indices such as CR, AVE and α are also enlisted in Table 4.1. CR values range from 0.77 to 0.93 indicating sufficient level of reliability and AVE values from 0.49 to 0.67 showing the sufficient convergent validity of the data. The α values are also ranges from 0.765 to 0.928, mostly greater than or equals to 0.8, also satisfactory for using the data for model development purpose.

Table 4.1 Latent constructs and indicators of R&D activities including factor loadings, standardized regression weights, validity and reliability indices

Latent Constructs and their Indicators	Factor Loadings	SRWs	t Values
Research & Development (R&D) Practice: [CR=0.92; AVE= 0.63; α=0.917]	-	-	-
1. Number of R&D persons (m1)	**.858**	0.82	_a
2. Experience (years) of the R&D team members (m2)	**.842**	0.61	9.913
3. Qualification of the R&D team members (m3)	**.821**	0.74	10.234
4. Investment in R&D infrastructure and methods for sustainable product development (m4)	**.802**	0.95	9.807
5. R&D management vision and direction (m5)	**.797**	0.50	9.989
6. Number of patents	.443		
7. R&D oriented culture	.412		
8. Investment in cleaner technology research	.409		
Technology (T): [CR=0.77; AVE= 0.49; α=0.765]	-	-	-
1. Investment for upgrading technological infrastructure (m6)	**.925**	0.45	_a
2. Technology forecasting to trace the difficulties (m7)	**.884**	0.67	10.845
3. Usage of CAD/CAM and various state-of-the-art technologies and newly launched technologies (m8)	**.870**	0.89	10.652
4. Degree of implementation of Cellular manufacturing (m9)	**.842**	0.97	9.754
5. Adoption of lean manufacturing (m10)	**.811**	0.62	9.429
6. Presence of Flexible manufacturing (m11)	**.726**	0.79	8.997
7. Adoption of Design for manufacturability and assembly (DFMA)	.428		
8. Use of Enterprise systems (ERP)	.419		

Latent Constructs and their Indicators	Factor Loadings	SRWs	t Values
Learning (L): [CR=0.78; AVE= 0.49; α=0.792]	-	-	-
1. Tradition of debriefing of all NPD experiences of NPD team members including maintenance of NPD records of major incidents, decisions (m12)	**.916**	0.74	_a
2. Adoption of well-defined process to guide NPD project (m13)	**.902**	0.55	10.863
3. Adoption of NPD manuals to assist managerial decision-making while managing NPD activities (m14)	**.897**	0.79	9.378
4. Collective review to assess the progress and performance of NPD projects (m15)	**.835**	0.68	9.506
5. Trend of attending in-house training (m16)	**.822**	0.83	9.485
6. Providing on-the-job training to individuals for NPD (m17)	**.804**	0.53	8.891
7. Reporting about progress of NPD projects	.395		
8. Maintenance of database containing factual information on each of its NPD projects	.346		
9. Maintenance of contact list of potential persons (insiders/outsiders) to assist NPD	.330		
10. Development of guidelines to assist managerial decision-making and actions	.309		
11. Frequent updating of NPD management guidelines or manuals	.293		
12. Managers' participation in committees to expand knowledge	.272		
13. Managers' attendance in meetings and seminars to exchange NPD-related information	.224		
14. Managers' informal sharing and exchange of NPD-related information	.219		
15. Rotation of managers, with substantial prior experience in managing NPD projects	.205		
16. Adoption of managerial incentive schemes	.198		
17. Trend of attending externally conducted training programs related to NPD management	.195		
18. Managers' accessibility of documented and codified information	.140		

Latent Constructs and their Indicators	Factor Loadings	SRWs	t Values
Intellectual Capital (IC): [CR=0.82; AVE= 0.53; α=0.823]	-	-	-
1.Enrichment of human capital by employees' and managers' competence, experience, knowledge, skills, attitude and commitment (m18)	**.831**	0.57	_a
2. Enhancement of process capital by workflow, operation processes, business development plans, information technology and collaboration (m19)	**.804**	0.54	8.971
3. Improvement of innovation capital by intellectual properties such as patents, copyrights and trademarks (m20)	**.779**	0.87	8.356
4. Relational capital which includes relations with stakeholders, customers, and supplier (m21)	**.706**	0.91	9.108
Improvisation (I): [CR=0.93; AVE= 0.67; α=0.928]	**-**	**-**	-
1.Figuring out of NPD process as it went along versus following a rigid well-defined plan (m22)	**.783**	0.58	_a
2. Improvisation of team in developing product versus strictly following plan (m23)	**.746**	0.74	10.542
3. Improvisation of team in commercializing this product versus strictly following the plan (m24)	**.694**	0.79	8.953
Fuzzy Front End (FFE) Activities: [CR=0.88; AVE= 0.59; α=0.875]	-	-	-
1. Interdisciplinary idea generation and screening by historical analogy (m25)	**.907**	0.93	_a
2. Interdisciplinary idea selection (m26)	**.884**	0.74	9.959
3. Idea selection during meeting (m27)	**.801**	0.68	10.308
4. Intensity of initial planning (m28)	**.739**	0.52	10.514
5. Level of communication in early phases of product development (m29)	**.704**	0.37	8.363
6. Effort to reduce market uncertainty	.388		
7. Understand target market and users need	.373		

Latent Constructs and their Indicators	Factor Loadings	SRWs	t Values
NPD Success: [CR=0.79; AVE= 0.48; α=0.816]	-	-	-
1. Technological breakthrough (m30)	**.934**	0.81	_a
2. Beating competition technologically (m31)	**.886**	0.99	10.112
3. Expanding product family (m32)	**.880**	0.92	9.739
4. Rate of failure (m33)	**.803**	0.71	9.226
5. Frequency of product launching (m34)	**.789**	0.85	8.752
6. Reduction of risks (m35)	**.752**	0.74	10.967
7. Beating competition to market	.419		
8. Cannibalization effect	.406		

Notes:

- ✓ [EFA was performed for factor extraction based on loading values.
- ✓ CFA are performed to calculate the individual regression weights of extracted manifests.
- ✓ Maximum-likelihood methods are applied for measurement model estimation.
- ✓ _a indicates an initial parameter of t-values set at 1.0
- ✓ All t-values are significant to $p < 0.01$
- ✓ Model fit indices: $\chi^2 = 518.082$, degrees of freedom = 237, χ^2 /degrees of freedom = 2.186, RMSEA = 0.041, GFI = 0.904, AGFI = 0.889]

In measurement model analysis, the principal component based exploratory factor analysis is conducted on both input and output manifests to identify the measures with high loadings comparing others for data reduction purpose. The measures, with loading values greater than 0.60, are considered for further analysis. IBM SPSS 21.0 is used for performing the EFA. In case of R&D practice construct, number of R&D persons (m1), year of experience of R&D team members (m2), qualification of the R&D team members (m3), investment in R&D infrastructure and methods for sustainable product development (m4), R&D management vision and direction (m5) are the extracted variables as their loadings are >0.60. The other indicators like number of patents, R&D oriented culture and investment in cleaner technology research are not considered for further model development as their loadings are <0.60. In case of technology, investment for upgrading technological infrastructure (m6), technology forecasting (m7), usage of CAD/CAM and various state-of-the-art technologies and newly launched technologies (m8), degree of

implementation of cellular manufacturing (m9), adoption of lean manufacturing (m10) and presence of flexible manufacturing (m11) treated as extracted factors, whereas adoption of design for manufacturability and assembly (DFMA) and use of Enterprise systems (ERP) are not been counted due to their lower factor loading values. The same process is repeated for learning. Tradition of debriefing of all NPD experiences of NPD team members including maintenance of NPD records of major incidents and decisions (m12), adoption of well-defined process to guide NPD project (m13), adoption of NPD manuals to assist managerial decision-making while managing NPD activities (m14), collective review to assess the progress and performance of NPD projects (m15), trend of attending in-house training (m16) and providing on-the-job training to individuals managing NPD (m17) are the variables with higher loading values. The other measures like reporting about progress of NPD projects, maintenance of database containing factual information on each of its NPD projects, maintenance of contact list of potential persons (insiders/outsiders) to assist NPD, development of guidelines to assist managerial decision-making and actions, frequent updating of NPD management guidelines or manuals, managers' participation in committees to expand knowledge, managers' attendance in meetings and seminars to exchange NPD-related information, managers' informal sharing and exchange of NPD-related information, rotation of managers, with substantial prior experience in managing NPD projects, adoption of managerial incentive schemes, trend of attending externally conducted training programs related to NPD management and managers' accessibility of documented and codified information are remained unconsidered due to lower factor loadings. In case of intellectual capital all the identified indicators having the loading values >0.60, so enrichment of human capital by employees' and managers' competence, experience, knowledge, skills, attitude and commitment (m18), enhancement of process capital by workflow, operation processes, business development plans, information technology and collaboration (m19), improvement of innovation capital by intellectual properties such as patents, copyrights and trademarks (m20) and relational capital which includes relations with stakeholders, customers, and supplier (m21) all are considered for model development purpose. Similarly for improvisation, all the identified manifests such as figuring out of NPD process as it went along versus following a rigid well-defined plan (m22), improvisation of team in developing this product versus strictly following the plan (m23), improvisation of team in commercializing this product versus strictly following the plan (m24) and relational capital which includes relations

with stakeholders, customers, and supplier (m21) are utilized. For FFE, interdisciplinary idea generation and screening by historical analogy (m25), interdisciplinary idea selection (m26), idea selection during meeting (m27), intensity of initial planning (m28), and level of communication in early phases of product development (m29) having the loading values >0.60 so these are used for future analysis. But the remaining indicators like effort to reduce market uncertainty and understanding of target market and users need are not considered. In this way the dimension reduction of the indicators of input constructs are performed to make the analysis more concise. Similarly the indicators of output constructs such as technological breakthrough (m30), beating competition technologically (m31), expanding product family (m32), rate of failure (m33), frequency of product launching (m34) and reduction of risks (m35) are extracted for model formation. The other identified indicators like beating competition to market and cannibalization effect are remained unused due to their low factor loading values. After dimension reduction, the regression weights of recognized manifests are calculated. The positive values of regression coefficients depict the positive linkage of indicators with their respective latent constructs. The t values of the identified manifest are also estimated to find out their significance.

4.5.3 Structural Model Results

Analysis of measurement model is followed by the structural model examination. The results suggests the appropriate model-to-data fit in case of structural model as well (χ^2 = 566.109, degrees of freedom = 261, χ^2 /degrees of freedom = 2.169, RMSEA = 0.049, GFI = 0.883, AGFI = 0.856) (Hair et al., 1995). The structural model representing the hypothesized relationships between constructs and indicators developed by using IBM SPSS AMOS 21.0 software is shown in Figure 4.2. Path estimates between the constructs ranges from 0.47 to 0.94 depicting that proposed hypotheses are supported and the values are listed in Table 4.2.

Table 4.2 Statistics of path estimates for factors of R&D activities

Path Descriptions	Hypotheses	Standardized Estimates	t-Values
R&D ⟶ NPD Success	H1	0.94 (***)	7.335
T ⟶ NPD Success	H2a	0.79 (***)	6.058
T ⟶ R&D	H2b	0.55 (***)	4.759

Path Descriptions	Hypotheses	Standardized Estimates	t-Values
L ⟶ NPD Success	H3a	0.60 (***)	4.998
L ⟶ R&D	H3b	0.49 (***)	3.890
L ⟶ IC	H3c	0.89 (***)	6.842
IC ⟶ NPD Success	H4a	0.72 (***)	5.396
IC ⟶ R&D	H4b	0.62 (***)	5.102
I ⟶ NPD Success	H5	0.47 (***)	3.789
FFEA ⟶ NPD Success	H6	0.52 (***)	4.432

Notes:

- ✓ [*** indicate the significance at p value <0.01
- ✓ Model fit indices: χ^2 = 566.109, degrees of freedom = 261, χ^2 /degrees of freedom = 2.169, RMSEA = 0.039, GFI = 0.908, AGFI = 0.896]

The structural model as shown in Fig. 4.2 represents the interrelationship among the constructs to analyze the developed hypotheses based on theoretical background. Before assessing the path estimates the fitness of the developed structural model is performed as discussed earlier. According to the estimated path values represented in Table 4.2, it has been observed that all the latent constructs such as R&D practice, technology, learning, intellectual capital, improvisation and FFE are positively correlated with NPD success as their values are all positive. Moreover, the positive impact of technology, learning and intellectual capital on R&D is observed from the obtained values. Learning is also connected positively with intellectual capital as per the Table 4.2. The t values for all the paths are calculated for identifying the significance which shows that these estimated paths are significant for p<0.01.

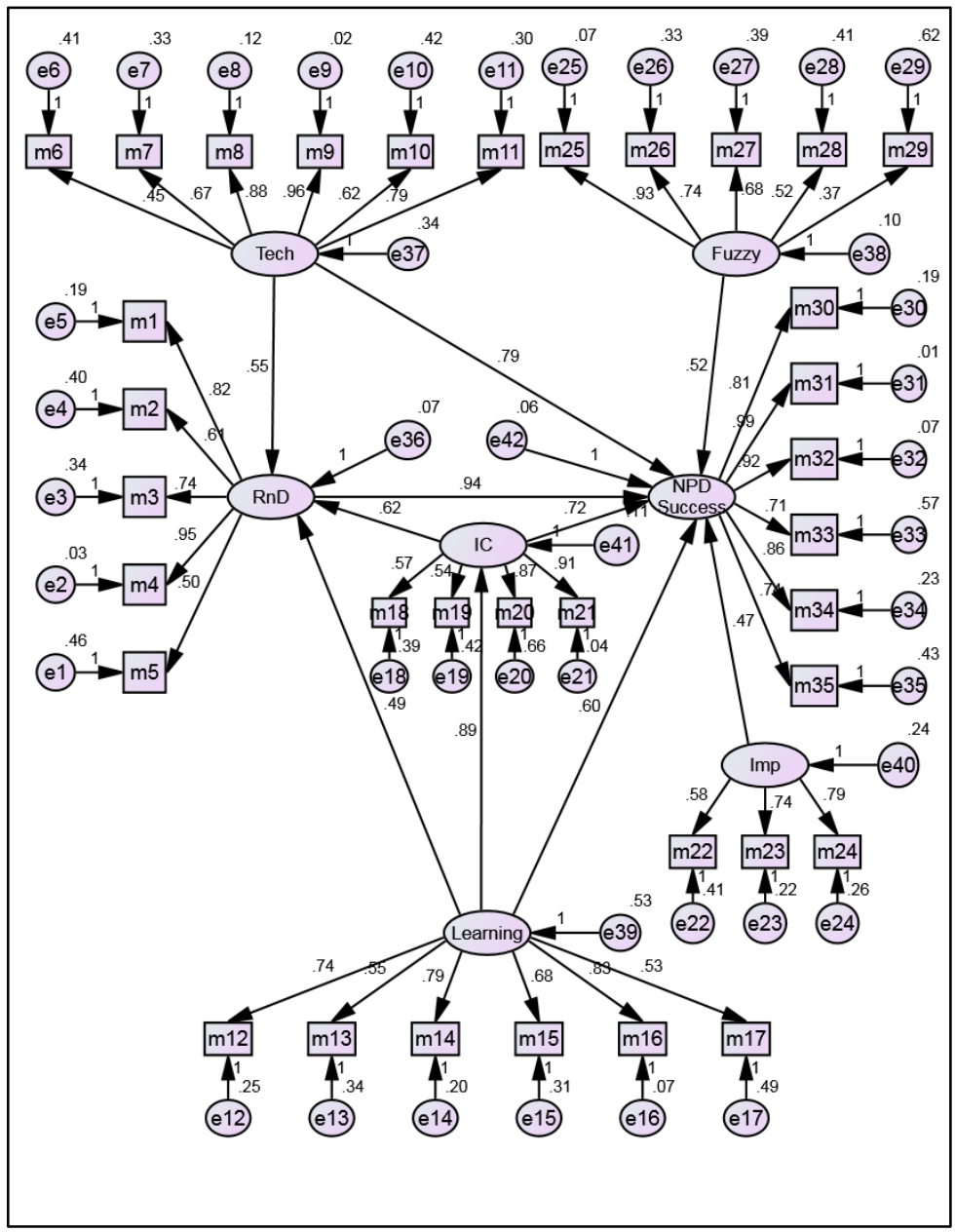

Figure 4.2 SEM model of R&D activities after execution depicting the interrelationships of latent constructs and their manifests including path estimates

Figure 4.2 symbolizes the detailed framework of the interrelationship model containing all the latent constructs along with their indicators. This model clearly represents the regression weights of indicators for measuring their respective latent constructs as listed in Table 4.1. Similarly it shows the path estimate between the latent construct for interrelating them as listed in Table 4.2. In this model there are standardized errors associated with all the latent constructs

and their indicators as well. These standardized errors represent the difference between the actual and estimated path values for individual path coefficients. In this model, the arrows are also containing high relevance as it depicts that which construct has the impact on another construct. The complete model itself states the interrelationship of all the constructs along with their indicators to enhance the technological improvements for NPD success.

As observed in the existing literature, the requirement of R&D practice within the firm is necessary for competitive advantages for beating the competitors (Yang et al., 2014). The effort of R&D experts' to develop the products with unique features prevents the competitors to replicate the product which escalates the NPD success of the firm as well (Chang and Chen, 2004). The present study develops the model representing the positive impact of R&D on NPD success (H1) since the R&D is found to be positively related to NPD success (path estimate=0.94, $p<0.01$). This helps to draw interpretation that R&D influences the NPD success of the firm.

The requirement of technology advancement is essential for adoption of R&D within the firm. Technology supports the R&D practice through offering modern technologies for implementing innovative ideas generated as a result of continuous research practice (Mendes and Ganga, 2011; Kobeda et al., 2016). It emphasizes the NPD success of the firm by implementing the modern technologies (Chiang and Shih, 2011). This empirical research portrays that technology enhances the NPD success (H2a) as the technology is positively related with NPD success having the path estimate as 0.79 ($p<0.01$). Similarly, technology encourages the R&D practice of the firm (H2b) as the path estimate between these two constructs is 0.55 ($p<0.01$). This discussion infers that technology influences R&D practice of the firm as well as NPD success.

Learning gathers the knowledge and information from several functional teams of the firm to accumulate the customers' requirements for NPD success. It escalates the R&D practice by overcoming the cultural barrier and also enriches the intellectual capital assuring NPD success (Hsu and Fang, 2009; de Medeiros et al., 2014). This study depicts the positive influence of learning on NPD success of the firm (H3a) as it comprises of positive path value between learning and NPD success (path estimate=0.60, $p<0.01$). Similarly, learning also influences R&D practice of the firm (H3b) and the intellectual capital also (H3c) having the positive path estimate

as 0.49 ($p<0.01$) and 0.89 ($p<0.01$) respectively. According to this discussion, it can be stated that learning practice of the firm motivates NPD success as well as R&D and intellectual capital as well.

Intellectual capital treated as one of the intangible assets of the firm for escalating the NPD success by fulfilling the final objectives (Hsu and Fang, 2009). It motivates to invest for R&D practice and adopt R&D experts for developing innovative products ensuring the NPD success. The present study highlights the positive effect of intellectual capital to enhance the NPD success (H4a) as well as the R&D practice (H4b) as the path value between these factors are 0.72 ($p<0.01$) and 0.62 ($p<0.01$) respectively. This shows that intellectual capital of the firm motivates the NPD success of the firm and also enriches the R&D practice.

Improvisation for innovation is one of the factors which are not directly related to R&D practice but essential for R&D activities of the firm. It positively influences NPD success through acquiring the knowledge by unlearning. This practice helps to adopt new concepts for satisfying the customers' demand (Miner et al., 2001). As per this empirical study, the positive impact of improvisation for innovation on NPD success (H5) is represented by the path value between improvisation and NPD success (path estimate=0.47, $p<0.01$). This interprets that improvisation for innovation is essential for NPD success though does not have direct positive impact of R&D practice.

Like improvisation, FFE is another constituent which does not directly connected to R&D practice but is the very prior stage of NPD influencing R&D activities indirectly. FFE develops and selects interdisciplinary ideas at the very prior stage of NPD (Verworn, 2009) helps in developing high quality products for NPD success (Awag, 2005). The present empirical study infers the positive impact of FFE on NPD success (H6) as the path estimate between FFE and NPD success is obtained as 0.52 ($p<0.01$). So, it can be stated that the FFE escalates the NPD success of the firm.

4.6 Conclusion

4.6.1 Theoretical Contribution

This empirical research has made important contributions to the theory on the constituents directly and indirectly related to the R&D of the firm for developing technically sound new

products. R&D practices, technology, learning and intellectual capital these are the factors directly linked with R&D activities of the firm, whereas improvisation for innovation and FFE activities are recognized as the factors having indirect impact on NPD success. The interrelationship among these factors are also portrayed for realizing the necessity to implement R&D for technologically improved NPD in Indian manufacturing industries for firm's success and survival.

4.6.2 Managerial Implications

The interpretations of this empirical study provide the essentiality of NPD success for industrial sustainability through the realization of R&D activities in practical field. These results contribute significant managerial implications.

First, this study identifies the R&D practices, technology, learning and intellectual capital as the directly related factors influencing NPD performance. R&D practices of the firms depend upon the availability of R&D experts within the team, their experience and qualification. For successful adoption of R&D practices, the investments to build the R&D infrastructure and adopt the new methods are one of the essential phenomena to be taken care of. Progression of this practice in continuous manner helps to achieve sustainable NPD. Similarly, the investment for upgrading technological infrastructure, technology forecasting to trace the difficulties, usage of CAD/CAM and various state-of-the-art technologies and newly launched technologies, implementation of cellular manufacturing, lean manufacturing and flexible manufacturing upgrade the technology available in the firm for NPD activities. The learning practice of the firm accumulates the tradition of debriefing of all NPD experiences of NPD team members including maintenance of NPD records of major incidents, decisions. This helps in developing a well-defined process for providing the guidance to NPD projects. The managerial decision-making is influenced by adoption of NPD manuals, collective review to assess the progress. Accordingly, in-house training programs and on-the-job training to individuals managing NPD activities helps in developing a rich learning practice within the firm. Enhancement of firm's intellectual capital is an essential criterion for better R&D activities. The enrichment of human capital is achieved by employees' and managers' competence, experience, knowledge, skills, attitude and commitment. Similarly, workflow, operation processes, business development plans, information technology and collaboration enhance the process capital of the firm. Intellectual properties such

as patents, copyrights and trademarks escalate the innovation capital. Moreover, healthy relationship with stakeholders, customers, and supplier improve relational capital of the firm. Accumulation of these four types of capital improves intellectual capital for NPD success.

Second, improvisation for innovation and FFE activities are recognized as the factors indirectly related to the R&D practice, boost up the NPD success. In case of improvisation for innovation the manifests for quantifying the constructs are identified as figuring out of NPD process as it went along versus following a rigid well-defined plan, improvisation of team in developing this product versus strictly following the plan and improvisation of team in commercializing this product versus strictly following the plan mentioned as per their contribution in measuring the construct. For FFE activities, the contribution of the measured variables are recognized as interdisciplinary ideas generation and screening by historical analogy followed by selection of interdisciplinary ideas, selection of idea during meeting, intensity of initial planning and level of communication in early phases of product development.

Finally, this study also recognizes the linkages among the associated factors of R&D activities impacted on NPD success. The findings depict that R&D practice has a major contribution for controlling NPD success of the firm which is followed by intellectual capital, technology, FFE activities, learning and improvisation for innovation. The NPD success of the firm is measured by technological improvements leading to the successful development of new products. The technological improvements of the firm are manifested by technological breakthrough, beating competition technologically, expanding product family, rate of failure, frequency of product launching and reduction of risks.

Chapter Summary

This chapter has provided:

- A structural framework comprising of directly and indirectly related success factors of R&D activities to portray their interplay and their combined impact on NPD success measured by technological developments.

- The quantification and prioritization of factors as well as their indicators have also been performed.
- Managerial implications have been drawn to aid in enhancement of NPD success by realizing the importance of the factors associated with R&D activities to set the future actions for goal achievement.

Thesis work reported in this chapter has been published (Journal / Book Chapter) in the following reference:

Roy, S., Dan, P. K., & Modak, N. (2019). Leveraging New Product Innovation through R&D Practices in Engineering Manufacturing Sector: A Study in Indian Context. *International Journal of Innovation and Sustainable Development*, Inderscience, **ESCI** (Article in Press).

Roy, S., Dan, P. K., & Modak, N. (2019). Role of R&D Practices for Effective Product Development Process in NPD. In *Optimizing Current Strategies and Applications in Industrial Engineering* (pp. 140-159). IGI Global. DOI: 10.4018/978-1-5225-8223-6.ch006.

Roy, S., Modak, N., & Dan, P. K. (2016). Effects of technological improvements on new product development success in Indian manufacturing industries: Structural Equation Modeling Approach. In R. K. Jain & S. P. VK (Eds.), Decision Sciences for Business Excellence: A Cross-functional Perspective. New Delhi: Excel India Publishers. ISBN: 978-93-86256-21-8.

The next chapter presents the structural framework considering the PDP and its associated factors for developing high quality new products.

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CHAPTER 5

PRODUCT DEVELOPMENT PROCESS FOR NPD

5.1 Preamble

This chapter realizes essentiality of product development process (PDP) and associated factors for improving quality of new products intended for achieving success in Indian manufacturing enterprises. The interrelationships of PDP with these allied factors are explored by using Structural equation modeling (SEM) approach. Analysis of this study uses primary data collected from 263 experts of Indian manufacturing companies. The designed semi-structured questionnaire incorporating real life experiences of the experts for manifesting the PDP and allied constructs ensuring the model to be more concrete and practical for implementation. The findings suggest that PDP along with its allied factors such as product feature, external collaboration, modular product design and market analysis are positively influence quality of newly developed products in turn escalating NPD success. The study illustrates that PDP is enhanced by external collaboration with suppliers and customers and detailed market analysis. Again market analysis inflates the product feature which is also influenced by modular product design. This interrelationship model introduces a novel approach to express the effect of PDP and the associated factors for improving quality of the newly developed products and prioritized them to assure the NPD success which bridges the gap in empirical studies about the practical importance of PDP in Indian manufacturing enterprises.

5.2 Background

The structured use of methods for NPD process is very much effective for NPD and it also been the matter of concern to the researchers in recent times (Graner 2016). The continuous improvement of PDP is needed due to the development of innovative products as customers

always looking for the newly launched products than the existing ones. Not only is the innovativeness, the performance of the developed product similarly crucial for customer acceptance. A keen study on product features (PF) states the performance rating of the product in comparison with the similar kind of products as well as the uniqueness. Along with the method of PDP and PF, there are certain perspectives associated with the development procedure which cannot be ignored. Besides, there are certain practices like collaborative competence which all the firms should adopt for achieving NPD success as per requirements and priorities of the customers. However, the impact of collaborative culture, both internal and external are ambiguous on NPD success (Johnson and Filippini, 2013), but the study about the role of antecedents to collaborative competence is still inadequate. Previous study explores the external collaborative competence for enriching the quality of new products developed as per customers' requirements (Chaudhuri and Boer, 2016). Similarly, modular product design (MPD) is another effort of increasing the range and the number of innovations in the firm without much sacrificing the development time and cost (Garud et al., 2009; Lau, 2011). Creating varieties of products is one of the major aims of MPD in achieving success (Robertson and Ulrich, 1998). Modularisation is an approach of organizing complex products in simpler forms (Bayliss and Clark, 1997).These simple modules can be assimilated in various combinations to develop new products with quality assurance. The strategic direction of all these practices (PDP, PF, external collaboration, MPD) are deeply dependent on the market analysis (MA) which is an effort of accumulating the customer needs. This practice is commonly carried out by structured observation of customers through personal interviews, both face-to-face and telephonic. Product design test and product price test are also the process of MA for testing the probable changes required for achieving success. MA leads towards the accurate knowledge about the marketplace for becoming quick responsive to the customer needs which is to develop quality products (Acur et al., 2012). Though the importance of the discussed factors is available in previous articles but a comprehensive framework considering PDP and its associated variables in a single model is practically unavailable. The interrelationships of these constructs including their antecedents and their effects on quality of the new products are remained unaddressed previously. This drought in the study evinces the essentiality of empirical researches to bridge the gaps by responding the aroused questions, such as: (1) what are the associated variable of PDP and how critical they are in NPD activities?, (2) what are the antecedents of PDP and its associated variables and how they

impacted to quantify the constructs?, (3) what are the key performance outcomes to measure the success of NPD?. Responses of the set questions help to draw appropriate inferences essential for setting future activities of NPD. Practical implementation of the managerial implications can be possible through development of the effective support system and conductive environment in the organization for developing high quality new products as per customers' requirements.

The aim of this research is to point out the vitality of PDP in association with the other factors like features of the developed product, collaboration with customers and suppliers, modularity and also market analysis for developing high-quality new products as per customers' need. The interrelationship among these variables presents a novel comprehensive model depicting the role of these associated factors in NPD success in terms of quality measures.

5.3 Objective

Realizing the significance of NPD for industrial sustainability, this research identifies the impact of PDP and its associated variables on NPD success. Recognition of constructs and their antecedents, their importance rate and their interplay for developing new products with better quality as per customer demand has been realized by collecting primary data from Indian manufacturing experts.

5.4 Conceptual Framework for Hypotheses Development

Product development process (PDP) is the series of activities from generation of new and creative ideas to actual launch of new product in the marketplace (Tzokas et al., 2004). Though the PDP is well established fact essential for NPD perspective, the identification of all associated variables, their antecedents, interrelationships and combined impact on NPD success in terms of quality measures of the newly developed products are being unexplored. This study assembles these associated variables of newly developed products such as PDP, product features (PF), external collaboration (EC), modular product design (MPD), market analysis (MA) for developing quality products as per customer requirements (Roy et al., 2017). The role of development process of new products is undoubtedly crucial for NPD success and has previously been discussed in available literatures. The discussed theoretical background

help to develop the hypotheses useful for framing structural model depicting the interrelationship of PDP along with the associated factors with NPD success.

5.4.1 Effect of PDP on NPD Success

The significance of PDP for NPD success is a well-established phenomenon (Ernst, 2002). Segmentation of PDP into several stages and formalization of PDP enhances the methods of NPD (Graner 2016). Development process of new products has been identified as a critical success factor for NPD (March-Chorda et al., 2002). A clear idea about the PDP helps the firm in utilizing the resources optimally for developing the products as per increasing demand. PDP comprises of five major stages including concept testing, prototype testing, pre-test market, test market and launch of the product (Tzokas et al., 2004). It concerning all aspects, both positive and negative, provides better product performance through several development phases. Sufficient investment in NPD makes the firm technologically updated. Besides, the training culture for skill development, concurrent workflow practice, hands-on-working experience reduces the development time and cost. Moreover, adoption of newly developed techniques like total quality management (TQM) and other advanced development methods enriches the performance of the firm. Collaborative culture and concurrent engineering practice within the organization build the healthy working environment which involves the market research, testing of products and frequent product review for NPD success. As per the above discussions the statement can be drawn:

H1: Effective PDP positively influences the NPD success of the firm.

5.4.2 Effect of Product Feature (PF) on NPD Success

The degree of innovativeness is a well-discussed factor escalating the success of newly developed products (Song and Montoya-Weiss, 1998). Though the innovative product is more attractive and satisfactory to the customers than the existing ones, but there is a risk associated with the pioneer products to become too innovative and ahead of their time (Graner, 2016).

In this era, markets are no longer restricted within Nation divisions. Globalization brings the opportunity to consumer to enjoy multinational products as per their requirement and purchasing ability from any corner of the world. Consumers are always eager to buy quality products in low

cost. As each individual is unique, their needs are also different from others which make the uniqueness as the universal consumer characteristic (Tian et al., 2001). So, the requirement of innovativeness is unavoidable and companies should have the culture to explore creative ideas for innovation to achieve sustainability by enriching the product feature. From this discussion the statement can be developed as:

H2: Product features with high degree of innovativeness ensure the NPD success by providing quality products as per customer needs.

5.4.3 Effect of External Collaboration (EC) on NPD Success and PDP

External collaboration (EC) among the NPD team, suppliers and customers is another key factor for NPD. The close and committed coordination with suppliers and customers leads towards effective use of knowledge and information for strategic activities for successful NPD (Chaudhuri and Boer, 2016). Though, there are risks associated with the development process due to involvement of suppliers and customers, but it fastens the development process and also offers varieties of products (Ryall, 2013). Moreover external collaboration proposes the high degree of innovativeness which makes the EC as an antecedent of NPD success for producing quality products (Kortmann et al., 2014).

Supplier integration enhances the quality of the newly developed products which provides better product development performance (Johnsen, 2009) by identifying and solving the potential problems up front. Similarly, the customer integration introduces the joint approach of decision-making of NPD teams and the potential customers for improving the innovation capabilities (Lin et al., 2010). EC involves the customers' involvement in PDP which make the NPD team updated with the information of customer requirements, their taste and their taste and their latest interest which help the design team to develop products as per their demand to avoid uncertainty in NPD (Koufteros and Marcoulides, 2006).

Supplier and customer integration in PDP controls the internal design process as per the changing requirements of customers along with time which produces new products with desired quality (Droge et al., 2004). In summary, the effect of external collaboration on NPD success is mixed. But literatures and opinion from manufacturing experts state the positive effect of EC on

NPD success measured by quality of the developed products. From this the statement can be drawn:

H3a: EC during product development has a positive impact on NPD success.

H3b: EC positively influences the PDP.

5.4.4 Effect of Modular Product Design (MPD) on NPD success and PF

Modular product design (MPD) is a design approach in which the final product is an assimilation of set of independently designed smaller products functioning together as a whole (Baldwin and Clark, 2000). The interdependency of each individual component of the modular product is minimized. A clear definition of interfaces and functions of each individual model reduces the interdependency of each component of the modular product (Ulrich and Eppinger, 2012). Designing small complex modules rather than developing a complete new complex product is much effective in terms of flexibility and innovativeness (Baldwin and Clark, 2000). Combination of individual modules offers varieties of newly developed products as per customer demand.

MPD is a key facilitator of NPD success. It adds the competitive capability to the market in terms of product quality, cost, customer satisfaction and delivery on time. The impact of MPD on delivery time, cost of the product, flexibility and customer service is been explored in previous studies (Antonio et al., 2006). Available researches identify that, though the reduction of development time is a main contributor of MPD (Partanen and Haapasalo, 2004), the associated flexibility offers high-end customization which brings customer satisfaction. This summarizes the competitive capabilities for NPD success (Gershenson et al., 2003; Baldwin and Clark, 2000). This empirical study searches the effect of MPD on quality of the new products to ensure the NPD success. The quality aspects is treated as a competitive capability of new products enriched by modular product design as a high quality modules can be reused for NPD by avoiding the faulty modules for better NPD performance.

Modularization of product structures is capable to produce varieties of products with unique characteristics and features as per customer desire with predictable product quality for NPD

success (Meyer and Lehnerd, 1997). This offers high degree of innovativeness by providing additional features to the new products. These observations help to draw the statements as:

H4a: MPD practice influence the NPD success of the firm through assuring high quality product.

H4b: MPD enriches the product feature by adding uniqueness to the new products.

5.4.5 Effect of Market Analysis (MA) on NPD success, PDP and PF

The successful development of innovative products not only depends on the process of product development, but also on the detailed idea of the target market. It is associated with the consumption pattern, customer satisfaction and selection of ideal and effective time for launching new products in the market helps in NPD success and PDP as well. This involves the generation of market plan with strategic market research and market testing to gauge the viability of the product in target market prior to wide scale roll-out. Market analysis gathers the first-hand information about the required characteristic of newly developed products which ensures the modification of product features for customer satisfaction (Heirati and Aron O'Cass, 2016). Market research leads towards better understanding of customer needs and similarly the area of application as per the requirement of the end users. This results the development of products with additional unique features as per the customer demand to achieve NPD success (Graner, 2016). Inadequacy in market analysis leads to product failure due to lack of information for setting PDP for successful development of new products (Cooper, 1983). It also involves the systematic estimation of technical similarities and dissimilarities between the newly developed product of their company and similar kind of available products of the competitors. This comparative approach adds the additional features to the new product to be developed which reduces the chance of failure. This can be interpreted as:

H5a: The high degree of market analysis leads to NPD success.

H5b: Market analysis escalates the PDP for providing uniqueness as per customer requirements.

H5c: Market analysis enriches the product feature by enriching the degree of innovativeness and reducing the chances of product failure.

There is insufficiency of the empirical researches in previous literatures to recognize and develop a comprehensive framework considering the PDP along with its associated variables in Indian scenario by accumulating the valuable responses from engineers of manufacturing industries of various parts on India. Moreover, the implementation of high-end PDP and its associated factors in small and medium enterprises in India is inadequate due to the socio economic structure. This scenario leads towards a gradual decay in future growth in long-term basis which is accompanied by incompetence resulting overall failure in global market.

This research is an attempt to identify associated variables of PDP as well as their manifests from available literatures and experts opinion to develop a comprehensive framework depicting the combined effect of these constructs on quality of the new products in turn the successful completion of NPD. The above theoretical background helps in framing a comprehensive path model illustrated in Fig.5.1, exploring the developed hypotheses to relate PDP and its associated factors for developing quality products.

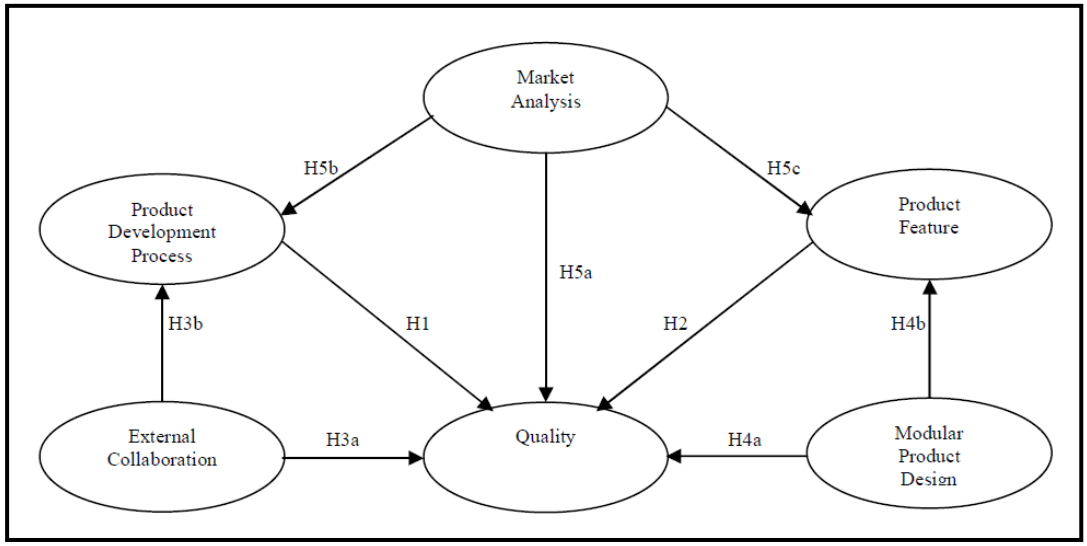

Figure 5.1 Path model of interrelationships of constructs portraying the combined effect of PDP and its associated variables on quality of the new products for NPD success

5.5 Results & Discussions

Structural Equation Modeling (SEM) a multivariate data analysis technique has been used for testing the hypotheses about the means, variances and co-variances of observed data used to develop a structural model depicting the interrelationship of constructs. The structural equation model generally comprises of two parts, one is structural model and another one is measurement model. The structural part represents the interrelationships of latent constructs, whereas the measurement model is the connection of latent constructs to their measured variables by confirmatory model (Joreskog, 1973; Hair et al., 2010). This study uses maximum-likelihood (ML) estimation method for hypotheses testing for constructing the relationship model using PDP and its associated variables as success factors for analyzing their effects on NPD success of the firm as well as their indicators by utilizing the theoretical background from the previous literatures as well as the practical data collected from the engineering experts of the firm. Adequate number of fitness tests has been carried out for viability testing of the assumptions made about the interrelationships of the latent constructs.

The data analysis incorporates the collection of practical responses from Indian manufacturing experts developing the engineering products. This needs to develop a detailed questionnaire for survey purpose. A semi-structure questionnaire comprising of queries regarding the degree of importance in implementing the indicators of the constructs has been formed. The questionnaire also incorporates an open-end section for accumulating the additional manifest variables as suggested by experts used to measure the mentioned constructs. The interview protocol with the description of the latent variables is enlisted in Appendix C at the end of this thesis. Validity and reliability of the survey data is tested by using average variance extracted (AVE), composite reliability (CR) and Cronbach's Alpha reliability testing. These reliability tests eliminate the erroneous data and identifies the reliable responses suited for the data analysis which help to draw the future implications. This study uses the responses of 263 experts mainly NPD personnel, design & development experts and managers for data analysis. For factors extraction which is again important to discover the innovative patterns among the associated factors of PDP, EFA has been performed by using IBM SPSS 21.0 (Tripathy et al., 2012). In this case, all the indicators

identified have the loading values greater than or equal to 0.6. So, all the identified indicators have been used for structural model development. The formation of interrelationship model portraying the interplays among the PDP and its associated constructs as well as their combined impact on development of high quality new products have been accomplished by IBM SPSS AMOS 21.0 software package.

5.5.1 Analysis of Measurement Validity

In this research the two-step approach (Anderson and Gerbing, 1988) has been used to test the developed hypotheses among the constructs. In the first step the validity and reliability of the scales using average variance extracted (AVE), Cronbach's alpha, and composite reliability (CR) have been tested listed in Table 5.1 using IBM SPSS 21.0. The reliability indices portrays reliability as well as internal consistency of the of the collected data sample. As per Table 5.1 values of reliability indices are fair enough as the values of α greater is ≥ 0.8 (Nunnally, 1978; Ong et al., 2004). The composite reliabilities range from 0.626 to 0.808 depicting the variance captured is greater than the variance indicated by the error components. The convergent validity is adequate as because values of the average variance extracted (AVE) of all variables ranging from 0.501 to 0.631 also treated as trustworthy as values ≥ 0.5 (Holmes and Smith, 2001). Second, for factors extraction to identify the manifest variables having higher contribution to measure the constructs related to PDP, EFA is performed. The loading values greater than or equals to 0.6 are extracted for measurement model formation (Hair et al., 2010). In this study, all the 36 measures have the loading values greater than 0.6. So, all the identified manifest variables are used for model formation. Third, confirmatory factor analysis (CFA) is performed using IBM SPSS 21.0 with covariance matrix as input for testing the uni-dimensionality of the six latent constructs consisting PDP and its associated variables along with the NPD success in terms of quality of the new product. The values of the standardized regression weights (SRWs) of the manifests of respective constructs are enlisted in Table 5.1.

As this section describes the validity test of the constructs, the next section incorporates the results of CFA as measurement model results along with the structural model results for developing set of relationships among constructs.

5.5.2 Measurement Model Results

SEM approach for confirmatory factor analysis (CFA) has been conducted on the manifest variables of the six latent constructs including the output latent construct which is NPD success. SEM performs the estimation of path values by assessing several model fitness parameters like chi-square including degree of freedom (Hu and Bentler, 1998), goodness-of-fit (GFI), adjusted-goodness-of-fit (AGFI) and root mean square of error approximation (RMSEA) (Chen, 2016). The results are χ^2 = 478.69, degrees of freedom = 252, χ^2 /degrees of freedom = 1.899, RMSEA = 0.047, GFI = 0.891, AGFI = 0.875 (Hair et al., 2010). The values of standardized regression weights (SRWs) range from 0.43 to 0.98 as listed in Table 5.1. The SEM approach was conducted on the manifest variables of the six latent constructs and the absolute value of factor loadings is greater than 0.5 for most of the cases (Fathian et al., 2008). There are certain values which is nearly 0.5 which are also considerable.

Table 5.1 List of manifest variables of PDP and its associated constructs including path estimates and reliability indices

Latent constructs and their Indicators	Factor Loadings	SRWs	t values
Product Development Process (PDP)	-	-	-
[CR=0.686; AVE=0.501; α=0.871]			
m1: Product development performance	.917	0.43	_a
m2: Investment in NPD	.892	0.76	9.224
m3: Updated technological innovations	.887	0.89	9.067
m4: Training for NPD Management	.852	0.81	10.448
m5: Concurrent workflow	.829	0.91	10.209
m6: Hands-on-working-experience	.808	0.74	10.017
m7: Early involvement of manufacturing	.784	0.88	9.289
m8: Developmental time and cost	.763	0.79	8.976
m9: Testing of products	.751	0.79	9.115
m10: Adoption of TQM	.730	0.87	9.576
m11: Advanced product development methods	.712	0.96	9.283

Latent constructs and their Indicators	Factor Loadings	SRWs	t values
Product Development Process (PDP)	-	-	-
m12: Frequency of Product review	.698	0.63	10.036
m13: Team collaboration and concurrent engineering	.683	0.74	9.465
m14: Marketing research in PDP	.672	0.59	8.712
Product Feature (PF) [CR=0.808; AVE=0.631; α=0.980]	-	-	-
m15: Product performance rating	.832	0.48	_a
m16: Technical comparative of products	.807	0.87	8.635
m17: Product failure chance	.792	0.73	9.844
m18: Product Uniqueness	.752	0.93	10.406
External Collaboration (EC)	-	-	-
[CR=0.791; AVE=0.612; α=0.936]			
m19: Involvement of customers in NPD	.859	0.95	_a
m20: Involvement of suppliers in NPD	.821	0.98	10.003
m21: Collaboration for knowhow	.782	0.84	9.959
Modular Product Design (MPD)	-	-	-
[CR=0.773; AVE=0.588; α=0.924]			
m22: Adoption of Modular product design	.944	0.64	_a
m23: Increase in product variety	.897	0.51	8.079
m24: System reliability improvement	.863	0.42	8.413
m25: Product component commonality	.842	0.39	8.941
Market Analysis (MA)	-	-	-
[CR=0.626; AVE=0.507; α=0.829]			
m26: Market plan generation	.895	0.72	_a
m27: Customer satisfaction	.872	0.74	9.224
m28: Requirement and consumption pattern	.833	0.65	9.405
m29:Target market and growth pattern	.809	0.65	9.007
m30: Market testing	.793	0.93	8.729
m31: Market research	.755	0.95	10.787
m32: Advertisement and promotion	.729	0.81	10.852
m33: Competitor monitoring	.690	0.66	7.235

Latent constructs and their Indicators	Factor Loadings	SRWs	t values
Quality assurance (Q) [CR=0.736; AVE=0.529; α=0.887]	-	-	-
m34: Meeting quality guidelines	.856	0.55	_a
m35: Achieved product performance goal	.811	0.89	8.360
m36: Achievement of design goal	.736	0.66	10.965

Notes:

- ✓ [CFA are performed to calculate the individual regression weights of extracted manifests.
- ✓ Maximum-likelihood methods are applied for measurement model estimation.
- ✓ _a indicates an initial parameter of t-values set at 1.0
- ✓ All t-values are significant to $p < 0.000$
- ✓ Model fit indices: $\chi^2 = 478.69$, degrees of freedom = 252, χ^2 /degrees of freedom = 1.899, RMSEA = 0.047, GFI = 0.891, AGFI = 0.875]

In case of measurement model the factor analysis has been performed for validating the occurrence of the manifest variables for quantifying their respective latent constructs. The responses from the industry experts have shared their opinion to recognize the role of the manifests for successful implementation of the constructs through developing the practices as described through manifests. In case of PDP, product development performance (m1) is a vital measure to express the PDP which also identifies the consistency rate of the company. Besides, investment for completion of NPD (m2), updated technological innovations (m3), arrangement of systematic training programs on regular basis (m4), concurrent workflow of product development activities (m5), real life experiences (m6), involvement of manufacturing department from the initial stage of idea generation for sharing opinion about feasibility of the innovative ideas (m7), time for product development and the cost for development (m8), internal and external testing of products for quality assurance and control (m9), adoption of TQM process for long-term success (m10), adoption of advanced product development methods like failure-mode-effect-analysis (FMEA), design for manufacturability (DFM), lean manufacturing, Just-in-Time (JIT) culture (m11), frequent product review (m12), implementation of team collaboration and concurrent engineering practices (m13), performing market research to acquire information about customers' requirements (m14), these are the quantifying indicators used to measure the

PDP. Similarly, in case of product features, the product performance rating (m15) i.e. analysis of competitiveness of the developed product on the basis of consumers report, technical superiority of the products (m16), chance of product failure in meeting the customer demand (m17) and innovativeness of the product (m18) help in measuring product features. In case of external collaboration, customer participation during the development process to achieve the desired product which have been predefined in previous meetings (m19), involvement of suppliers which means the collaboration trend of suppliers with product development team (m20) and collaboration with experts from other companies to acquire practical knowledge quantify the external collaboration culture in the company for successful completion of PDP. Modular product design is another construct associated with PDP is measured through adoption of modular product development practice which is development of a product through assimilating a set of small products designed independently but functioning together as a whole (m22), increase the product variety by assembling the individual modular parts (m23), improvement of system's reliability (m24) and reusing the common components (m25). Among these constructs associated with PDP for developing new products market analysis is one of the vital most deliberate by well-established market plan generation for achieving the objectives within scheduled time (m26), customer satisfaction (m27), identification of required product and its consumption rate (m28), target market and the growth pattern as well (m29), market testing before commercializing the new products (m30), market research (m31), advertisement and promotion (m32) and keen monitoring on competitors' activities (m33). Like success factors, success measures i.e. outcome performance of the NPD is expressed by the quality of the newly developed products which is again quantified by meeting quality guidelines (m34), attaining the product specification to achieve the product performance goal (m35) and achieving design goal (m36). After identifying the indicators of success factors and measures, SEM approach has been conducted on the identified manifest variables to calculate the standardized regression weights (SRWs) for finding the linkage values of the predictor variables of the PDP and its associated constituents along with the performance outcome i.e. product quality assurance. The regression weights having positive values are considerable for further analysis. In this case, indicators of the latent constructs, both for success factors and measures, having positive values ranges from 0.42 to 0.98 are used for structural model development. Table III enlists the constructs along with their indicators including their SRWs as obtained from the analysis.

5.5.3 Structural Model Results

Analysis of measurement model is followed by the formation of structural model. In case of structural model, SEM offers modeling of a set of relationships among constructs along with the estimation of all hypothesized paths to test the direct effect of one construct on another one. In this study, maximum-likelihood estimation has used for path value estimation. The fitness tests depicts the overall acceptable fit of the developed model with the values asχ^2 = 506.69, degrees of freedom = 264, χ^2 /degrees of freedom = 1.917, RMSEA = 0.041, GFI = 0.921, AGFI = 0.906 (Hair et al., 2010). Similarly, the structural model results show that all paths are significant at the level of 0.05. The structural model including the standardized regression weights (SRWs) developed by AMOS 21.0 is shown in Fig.5.2. Most of the path estimates between constructs range from 0.35 to 0.91 portraying the proposed hypotheses are supported. The values of path estimates are enlisted in Table 5.2.

Table 5.2 Statistics of path estimates showing the path values of defined hypotheses among the PDP and its associated variables along with the quality of the new products

Path Description	Hypothesis	Standardized Estimate	t values
PDP ⟶ Q	H1	0.82	6.081 (***)
PF ⟶ Q	H2	0.70	5.937 (***)
EC ⟶ Q	H3a	0.56	5.576 (***)
EC ⟶ PDP	H3b	0.35	3.139 (***)
MPD ⟶ Q	H4a	0.46	4.881 (***)
MPD ⟶ PF	H4b	0.53	5.442 (***)
MA ⟶ Q	H5a	0.41	4.689 (***)
MA ⟶ PDP	H5b	0.91	7.316 (***)

Notes:

- ✓ [*** indicate the significance at p value <0.001
- ✓ Model fit indices: χ^2 = 506.09, degrees of freedom = 264, χ^2 /degrees of freedom = 1.917, RMSEA = 0.041, GFI = 0.921, AGFI = 0.906]

The interrelationships among the latent constructs are represented by the structural model for analyzing the specified hypotheses among them developed from available literatures and experts' opinion. The path estimates in between the latent constructs are calculated by multiple regression analysis using SEM approach. The structural model results are enlisted in Table III which shows the path estimates between two constructs to depict the effect of one on another. Likewise, the values of path estimates, the direction of the arrows also show that which factor has the impact on which factor to describe the set hypotheses. According to the structural model results as mentioned in Table 5.2, the relationships among the constructs can clearly be explained. It portrays that improved PDP positively influences quality of the newly developed product as the path estimates among them is positive and having a high value as 0.82. PDP is again escalated by external collaboration and market analysis with path values mentioned as 0.35 and 0.91 respectively. Again product features and external collaboration accelerate new product quality as their path values are 0.70 and 0.56 respectively. Product feature is motivated by modular product design consisting of high path value as 0.53. Market analysis also improves the product quality as the path value between these factors is 0.41 as shown in the Table 5.2. The development of high quality product ensures the NPD success of the firm for achieving competitive advantages.

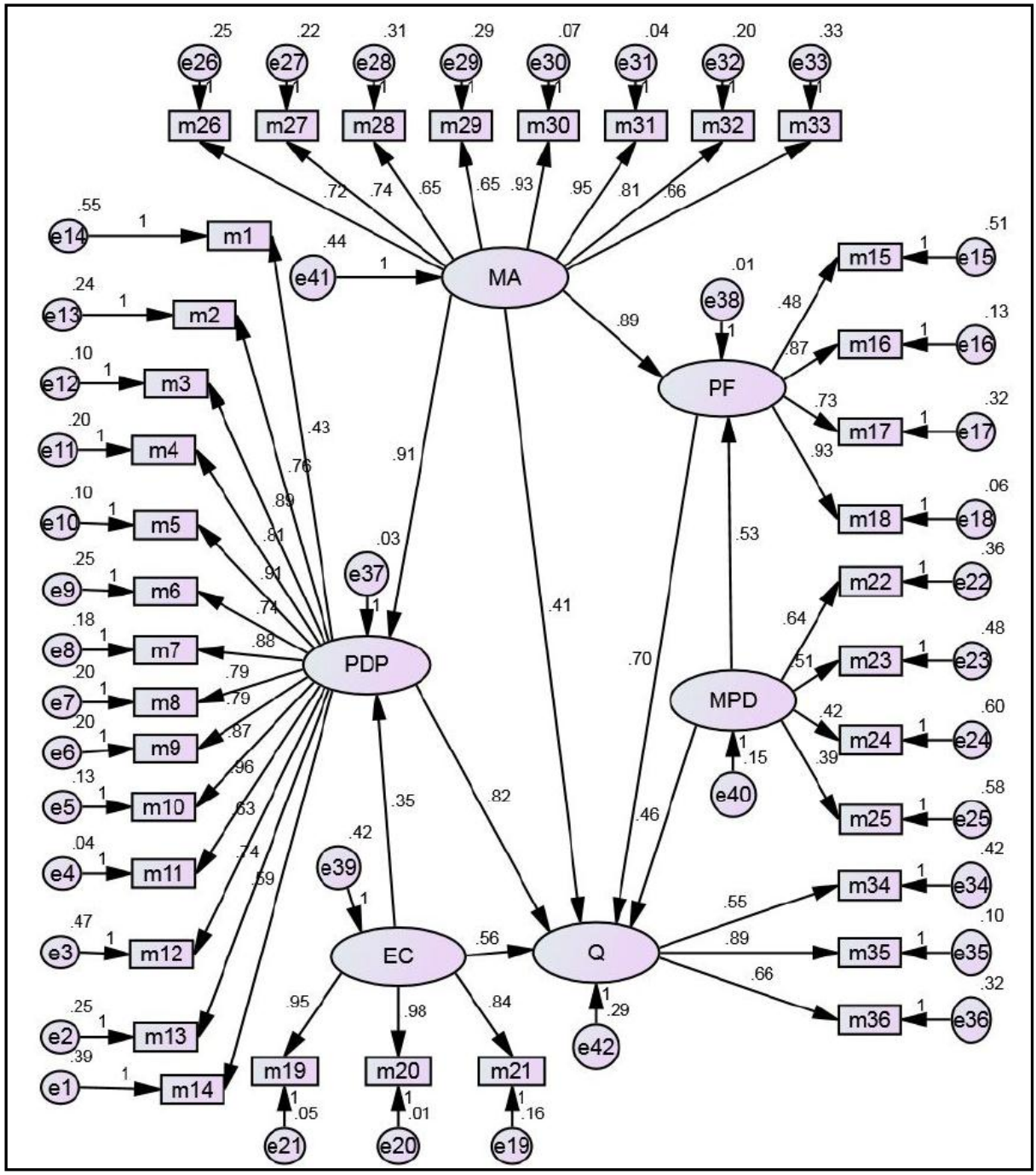

Figure 5.2 SEM model after execution portraying the combined impact of PDP and its associated variables on quality of the new products

This analysis provides a path model shown in Fig.5.2 and the values of path estimates as listed in Table 5.2 inferring the feasibility of the developed hypotheses about the relationships of the PDP and its associated variables and their effects on quality of the new

products. The path estimates show the positive impact of PDP along with its associated variables such as product feature, external collaboration, modular product design and market analysis on quality of developed product which in turn escalates the NPD success of the firm. Moreover, the study also depicts that external collaboration in the firm escalates the development process which is again improving the quality of the new products. Similarly, modular product design introduces addition innovative features to the new products which are also responsible for better quality of the developed products. Besides, product feature is also be enriched by detailed market analysis. The strategic investment in market analysis accelerates the PDP as well for ensuring the successful completion of development process assuring the high quality products for NPD success. The standardized errors associated with each manifest variable are represented by the error terms as e1 to e36 along with the errors for individual path co-efficient for each construct as e37 to e42. After developing the interrelationship among the success factors and their success measures, prioritization of the constructs is carried out using FAHP and the calculations are discussed in the next section.

As per the existing literature, importance of PDP for NPD success is undoubtedly established fact (Ernst, 2002). From ideation to product launch, PDP escalates the NPD success through adopting several practices like sufficient investment for technological upgradation, training, concurrent workflow which help to develop the higher quality new products (Tzokas et al., 2004). According to this present study, PDP has positive impact on NPD success quantified by the product quality which is represented by the path value liking the PDP and quality (path estimate=0.82, $p<0.01$). This discussion states that by improving PDP of the firm the high quality new products can be developed which further helps in NPD success.

Uniqueness of the newly developed products steals the customers' attraction than the existing products (Graner, 2016). The degree of innovativeness in the specifications adds the innovative feature to the newly developed products motivating NPD success (Song and Montoya-Weiss, 1998). But there are associated risks for developing the unique products first to market. In this study, product feature is assumed as the positive motivator of NPD success (H2). As per the analysis it is observed that the path estimate between product

feature and NPD success is 0.70 ($p<0.01$). This interprets that the innovativeness in product feature of newly developed products encourages NPD success of the firm.

External collaboration with suppliers and customers develops the practice of sharing the information as well as knowledge for developing new products as per requirements (Chaudhuri, & Boer, 2016). It enriches the innovativeness of the product for high quality NPD (Kortmann et al., 2014). Involvement of supplier and customers for PDP and also their valuable decisions for NPD helps in improving the innovation capabilities also escalating the NPD success (Lin et al., 2010). As per the discussions, it can be stated that the external collaboration positively influence the NPD success (H3a) and it also improves the PDP (H3b) as well. The path estimates in between external collaboration and NPD success is 0.56 ($p<0.01$) and in between external collaboration and PDP is 0.35 ($p<0.01$). This infers that external collaboration improves the NPD success of the firm and it also escalates the PDP for developing high quality new products.

MPD motivates NPD success by reducing the development time of the product providing flexibility and introducing high-end customization for customer satisfaction. It also offers varieties of products with additional features fulfilling customer desires by improving product features essential for NPD success (Meyer, & Lehnerd, 1997). The present study develops a framework representing the influential role of MPD for NPD success (H4a) and for improving product feature (H4b) since MPD is found to be positively related to quality (path estimate=0.46, $p<0.01$) and product feature (path estimate=0.53, $p<0.01$). From this discussion, it can be interpreted that MPD positively influences PDP and quality of the developed product successful NPD.

Market analysis provides a clear idea about the target market for developing the new products by realizing the consumption pattern, customer requirement for NPD and identifying ideal time for launching the new products. Market analysis gathers the required information for PDP and escalates the PDP by testing the viability of the product as per customers' view (Heirati, & Aron O'Cass, 2016). Identification of customer requirements through market analysis helps to incorporate the additional product features as per customer demand (Graner, 2016). In conjunction with the view of previous researches, this study supports the hypotheses (H5a, H5b

and H5c) showing the positive impact of market analysis on quality (path estimate=0.41, $p<0.01$), PDP (path estimate=0.91, $p<0.01$) and product feature (path estimate=0.89, $p<0.01$). This explains that a detailed market analysis can accumulate the information helps in developing the quality products as well improving PDP and product feature for NPD success.

The crucial and novel contribution of this study is that it highlights the integrative perspective of PDP and its associate factors (namely, PDP, product feature, external collaboration, MPD and market analysis) for developing the high quality new products. The interplay of these factors along with the quantification of their manifest variables have been performed for identifying their combined impact on product quality for achieving firm's success.

5.6 Conclusion

5.6.1 Theoretical Contribution

This study has made important contributions by realizing the impact of PDP and its associated variables for high-quality NPD for attaining NPD success in Indian manufacturing sector developing engineering products. The quantification of the indicators of the factors is performed for identifying the contribution of the variables to measure their respective constructs. Moreover, the framework portraying the interrelationship among these factors is developed to realize their combined impact on the quality of the newly developed products.

5.6.2 Managerial Implications

This empirical study interprets the necessity of NPD success for achieving industrial sustainability by realizing the comprehensive impact of PDP and its associated variables in practical field. The results obtained from the developed framework contribute significant managerial implications for NPD success.

First, this study identifies the PDP and its associated factors such as product feature, external collaboration, MPD and market analysis related to PDP escalating quality of the new products. A framework incorporating these factors is developed from which the managerial implications can be drawn as the PDP and its associated variables have the

positive impact on developing high quality products. It also interprets the combined effect of external collaboration and market analysis on PDP to escalate the quality of the new product to be developed. Similarly, product feature is positively motivated by the joint impact of modular product design and market analysis. PDP along with its associated variables control the quality of the new product which is measured by meeting quality guidelines, achieved performance goal and achievement of design goal. Finally, the quality of the new product results in the NPD success with assuring competitive advantages in the global perspective.

Along with findings, this study accumulates the valuable suggestions from experts for successful development of high-quality innovative products provides competitive advantage to the companies for ensuring sustainability in long run. As per their suggestions, developing the products as per customers' requirements to achieve the product delivery target is one of the key to maintain the company reputation of the company. Similarly, in case of enriched external collaboration, involvement of development persons till the end of the product development bridges the gaps occurred among the manufacturers, suppliers and customers. Market analysis always utilized to identify the type of product needed by the customers which are essential for their daily use. At the same time, importance of the proposed product in their daily life which is to be developed is also being recognized. This helps in developing the products with minute specifications essential for customer satisfaction. Adoption of these valuable insights will help to structure a practical framework succeeding towards NPD success in future aspects.

Chapter Summary

This chapter has provided:

- A structural framework depicting the impact of PDP and its associated factors for factors for improving quality of new products intended for achieving success in Indian manufacturing enterprises.

- The interplays of PDP with these allied factors are explored by using Structural equation modeling (SEM) approach.
- The quantification of factors as well as their indicators has also been performed for realizing their impacts on NPD success.
- Managerial implications have been drawn to aid in enhancement of NPD success and to implement these factors for goal achievement.

Thesis work reported in this chapter has been published (Journal / Book Chapter) in the following references:

Roy, S., Modak, N., & Dan, P. K. (2017). Product Quality as Factors and Measures for New Product Development Success in Indian Manufacturing Industries. *Materials Today: Proceedings*, *4*(2), 1385-1393, **Scopus**.

Roy, S., Modak, N. and Dan, P. K. (2017). Identification of Success Factors of Products and Services for Industrial Sustainability: A Structural Equation Modeling Approach. *Advances in Economics and Business Management*, *4*(3), 173-177.

The next chapter draws the framework realizing the cascading effect of top management support to implement management actions for successful NPD by developing cost effective new products.

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CHAPTER 6

MANAGEMENT ACTIONS FOR NPD

6.1 Preamble

The purpose of this chapter is to study the cascading effect of management actions on new product development (NPD) for achieving success in Indian manufacturing industries. The critical linkage of managerial support for establishing management actions has been explored to realize the NPD success in terms of financial and economic measures. The structural equation modeling approach is used to investigate the relationship depicting the managerial control on management practices for NPD success. Primary data from263 experts of Indian manufacturing industries have been collected for the purpose of this analysis. Senior management motivation, risk-taking attitude, problem-solving capacity, awareness in novel development cascade the management actions such as information technology management, conflict management, project management, human resource management, strategic management, organizational factors, planning, long-term vision, and entrepreneurial culture to escalate the NPD success, which in turn be articulated by financial and economic terms. The findings suggest that managerial support influences the adoption of management actions leading toward NPD success. The developed framework realizes the necessity of implementation of these management actions cascaded from the top management support (TMS) for influencing the financial and economic measures of NPD success. The cascaded framework depicting the TMS for implementing management actions for NPD success in Indian manufacturing sectors adds novelty to the available literature. Moreover, this study uses a semi-structured questionnaire which incorporates the practical experiences of the experts for quantifying the constructs in a more detailed manner than available in the previous literature. Besides, the realization of comprehensive management

actions along with the support from senior management escalates the implementation of the developed framework for NPD success in near future.

6.2 Background

Escalation of the competition in the global market entails manufacturers to improve their product development capabilities for industrial sustainability. New product development (NPD) activities have eventuated as a decisive approach for strengthening the position in the competitive market environment. According to the perspective provided by Buyukozkan and Arsenyan (2012), NPD performance has become a decisive characteristic of a firm's success and survival. Despite difficulties and complexities associated with the NPD task, it has turned out to be a major determinant of the endurance of the firm (Sarja, 2015).There are numerous factors related to the technology, market, and research and development (Ernst, 2002; Bhuiyan, 2011), which are critical for the success of the firm, termed as critical success factors (CSFs), influencers in controlling the NPD performance, for maintaining a firm's identity and sustainability. The interplay of CSFs is inevitable and has been discussed by several researchers. Sadeghi et al. (2012), Akgün et al. (2007), and Sun and Wing (2005) have highlighted several common success factors of NPD.

The availability of resources and their optimized utilization clinch success in NPD, lending competitive advantages. This utilization, as mentioned here, can best be attained with the support of and motivation from the top management teams for the smooth operation of NPD activities. Approaches of top managers and their interactions with subordinates follow a trickle-down pattern, for cascading effects down the hierarchy, augmenting organizational capabilities with a knowledge-enriched workforce, essential for NPD success (Lin, 2007, Roy et al., 2016). Though the technical aspects of the TMS are widely emphasized, the social aspects remain unfocused. Top managers identify the utility of various management actions and realize their impact on the overall NPD success. These practices demand continuous modification due to the dynamic changes in the market environment. Management practices deal with several constituents such as information technology management (ITM), conflict management (CM), project management (PM), human resource management (HRM), strategic management (SM), organizational factors,

planning, long-term vision (LTV), and entrepreneurial culture (EC) for the strategic execution of NPD activities through astute managerial control. An extensive literature review identifies certain gaps in the respective areas which can be worked upon, based on the research findings, as done here, to enhance NPD success. The focus of the previous literature was on studying the effect of TMS on management practices like PM (Unger et al., 2012), CM through knowledge sharing culture (Lin, 2007), corporate entrepreneurship (Heavey and Simsek, 2013), in isolation, addressing and investigating the partial effect. A comprehensive framework considering all management practices together in a single model, however, is practically unavailable. The context (i.e. antecedents and drivers) and the extent (i.e. outcome effects) with respect to management practices, in particular for NPD success, have also rarely been addressed. Furthermore, there is a glaring dearth of a higher order model comprising TMS and management actions together in a comprehensive approach. This evinces that managerial support for NPD success, through improving the management actions, is largely unexplored. In the view of these critical research gaps, this study raises few questions which need to be responded to. These specific research questions are the following:

RQ1. What are the management actions and their components and how critical are they in case of NPD activities?

RQ2. What are the components of TMS and how they enhance the management actions which in turn improve the success of the NPD efforts?

RQ3. What are the key performance outcomes that measure the success of NPD?

These questions need to be responded to draw appropriate inferences. The organization needs to build the support system and create a conducive environment for implementing management practices, mentioned hereinafter, efficiently, for achieving the desired economic and financial performance.

The objective of this research has been to develop a comprehensive higher order model for realizing the coordinating relationship in the critical linkages of management actions on NPD and decipher the cascading effects of TMS to the lower functional levels. The contribution of this research, at first, is concerning the examination of a comprehensive set of management actions. This includes identification of management constructs as well as their antecedents, collated from the available literature resource as well as from the primary

source in the form of opinion and views provided by experts. Analysis of the utilization of TMS and its resources for achieving NPD success through the implementation of management actions as linkage mechanism is the other or the second contribution. The third contribution of this work is in associating the application of financial and economic improvements for quantifying NPD success and thereby delineating the importance of the referred cascading interaction mechanism. Finally, this study draws responses from Indian manufacturing industries developing engineering products for analyzing the linkage model, an area largely unexplored, and underpins another feature of novelty in this research.

6.3 Objective

Providing the significance of NPD in any firm, this empirical study identifies the effect of TMS on NPD success in Indian manufacturing industries. Management actions are used here as a linking factor to control the impact of TMS on NPD success. This study focuses on importance in implementing the TMS and management actions to achieve success which in turn is manifested by economic and financial measures. A thorough questionnaire survey has been conducted for collecting data from Indian manufacturing companies.

6.4 Theoretical Formulation

Advancement in manufacturing and providing world class system is a major challenge in attaining success (Eid, 2009). This advancement is not limited to the modification of the existing products but also emphasize on NPD activities. Integrative approach for analyzing the comprehensive manufacturing systems in a firm needs to be developed for recognizing the capabilities of overall manufacturing systems through a single model (Singh and Agrawal, 2008). Identification as well as the importance in implementation of success factors should also be a matter of concern for obtaining productive results. A valid theoretical background develops hypotheses interpreting the relationships of success factors for achieving betterment of innovation performance. Implementation of more than one management actions together increases the probability of developing new products (Haneda and Ito, 2018). Information technology (IT) is one of these management actions termed as information systems and technology (IS/IT) (Relich and Pawlewski, 2018; Caldeira and Ward, 2002), information flow (Criscuolo et al., 2010) by various researchers which has

been named as ITM in the present study. Similarly, another management action conflict handling is described as CM, which has been previously named as interpersonal conflict (Yang et al., 2015; Liu et al., 2011) and conflict harmonization (Ayers et al., 1997).PM is a factor as termed in various literature (Mir and Pinnington, 2014) is mentioned as the same in this study also. Another management action, HRM (Haneda and Ito, 2018) or human resource (HR) development (Sun, 2001) is named as HRM for developing the integrative framework. SM is stated as strategic flexibility (Dai et al., 2018) and NPD strategy (Tsai, 2012) which together is clubbed as SM in this current study. Another management action termed as organizational factors in the present study is actually described as organizational practices (Haneda and Ito, 2018) and as organizational enablers in the available literature. Planning and control (Yeh et al., 2014), product planning (Lau, 2011), and planning (Akgun et al., 2007) are all similar describing the management action which is planning of systematic steps for product development are termed as planning in this research. Organizational vision describes the vision clarity for achieving NPD success (Lynn and Akgun, 2001) and is described as LTV in the present study for setting future activities as per the objective treated as one of the management actions for NPD success. Entrepreneurial orientation (Dayan et al., 2016) and corporate entrepreneurship (Heavey and Simsek, 2013) is the cascading effects of management actions widely used management action introduced as an EC in this present study. This discussion figures out the identified management actions along with their various labels as mentioned by previous researchers. The role of managerial support to implement these aforementioned management actions are well discussed in the literature (Globocnik and Salomo, 2015).There are a number of papers considering the success factors of NPD, but not all such studies provide a comprehensive list of all management actions for successful NPD. This exhaustive study combines all relevant management actions together (nine constructs) in a single framework without replication endeavouring to bridge the gap and provide an exhaustive list of the identified management practices cascaded from TMP for the NPD success measured in terms of financial and economic improvements, which may be useful for academicians and practitioners for effectively executing the NPD process.

6.4.1 Hypotheses Development

This study aims to assimilate management actions, holistically, in a single model for expounding the integrative effects on NPD success. From idea generation of commercialization, TMS is an inseparable part of different phases of NPD (Sun and Wing, 2005). Control of TMS over integrative managerial actions for enhancing NPD success is discussed in this section along with hypotheses development for interpreting their standalone relationship for NPD success.

6.4.1.1 Effect of TMS on ITM and NPD Success

High innovation capability of multinational firms is attributed to their operation at the global scale and expansion. This is due to linking minute information throughout the organization in globally expanded firms with appropriate ITM (Criscuolo et al., 2010).A high-end ITM is described as "creation, coordination, integration and management of knowledge and information within a firm and its extended value network" (Conner and Prahalad 1996). Significant productivity improvements in the manufacturing sector has been observed due to adoption of ITM through bridging the gaps among the team members for synchronizing their knowledge and decisions (Bardhan et al.,2013) by developing information systems and technology competencies built with effective managerial support (Caldeira and Ward, 2002). Application of IT management in NPD process and its positive impact on NPD success is inevitable. The use of IT tools and replacement frequency encourages NPD task proficiency which also ensures NPD success of the firm. Impetus from higher administration improves IT usage and performance by articulating vision for IT and its tools including their replacement as per requirements (Kawakami et al., 2015). The senior management that supports IT functions is crucial for performance (Wade and Hulland, 2004). Lack of TMS can hinder the firm from recognizing the value of ITM essential for NPD success (Kawakamiet al., 2011). A successful NPD requires application of IT tools for implementing collaboration among the NPD teams as well as by IT adoption and using their decisions. Therefore, it can be stated that:

H1a. Effective TMS enhances ITM practice of the firm.

H1b. As ITM practice increases, NPD success of the firm is enhanced.

6.4.1.2 Effect of TMS on CM and NPD Success

Deficiency of understanding among team members or between teams in an organization leads to interpersonal conflict, which hampers the project progress and affects NPD success (Yang et al., 2015). Volatility in user requirements also creates interpersonal conflicts affecting project performance, negatively (Liu et al., 2011). Conflict results in jealousy, poor communication along with frustration, and low morale (Barki and Hartwick, 2001) reducing the team decision-making efficiency. Conflict management is the process of restraining the negative aspects of conflict arises within the firm while trying to amplify its positive aspects. Managerial control is exercised to overcome the internal and external conflicts caused due to value diversity in achieving organizational success (Liang et al., 2012). Conflict may be beneficial or detrimental depending on its type and nature and collective efforts often help to convert those with positivity for NPD success. The effective top managers need to be capable to minimize the interpersonal conflicts through harmonizing among the team members, which in turn positively impacts the NPD of the firm (Liu et al., 2011). Managerial control is the phenomenon used to handle internal and external conflicts in the firm (Barki and Hartwick, 2001). Control over the conflict occurs due to value diversity (Liang et al., 2012) and TMS helps to achieve organizational success overcoming these conflicts are often been scrutinized. Therefore:

H2a. Effective TMS provides better conflict handling in the firm which ensures enhanced CM.

H2b. As CM increases, NPD success of the firm is enhanced.

6.4.1.3 Effect of TMS on PM and NPD Success

Project management (PM) has developed as one of the management functions (Kenny, 2003), which increase the firm's productivity. Systematic PM is necessary for improving the NPD performance of a firm and has led project manager. Organizational structuring, technical ability, leadership proficiency, and the characteristics of an effective project manager can be drawn to fashion PM practices for better NPD performance and thereby

ensuring completion of the project within the time and budget. The modeling effort in previous literature has affirmed the linkage of PM to project success (Brown and Adams, 2000). It helps prioritizing the project goals and achieving them through project team practices that in turn secures organizational success (Munns and Bjeirmi, 1995). The success based on the performance always varies across industries. The strong managerial support for PM develops a project-centered culture to widen new avenues for NPD (Mir and Pinnington, 2014). Top managers' insight for project reviews within NPD teams for project management helps to use the tacit knowledge more efficiently (Koners and Goffin, 2007). Essentiality of synchronization of project manager's guidance style with the nature of the project is vital task to be achieved (Muller and Turner, 2007).Therefore, the inference can be drawn that:

H3a. Effective TMS enhances PM culture in the firm.

H3b. As PM practice increases, NPD success of the firm is enhanced.

6.4.1.4 Effect of TMS on HRM and NPD Success

Human resource management (HRM) is one of the vital management practices of controlling human issues which develop and implement creative ideas for innovation (Kianto et al., 2017). Commensurate HRs with knowledge sharing practice and adequate financial support pave the way to better NPD performance (Huang et al., 2010). HRM practice explores the formation of global NPD teams for achieving success in a competitive global market through the active role of top management for leadership, commitment, and coordination (March-Chorda et al., 2002). This practice confirms project success and organizational benefits in NPD activities (Yang et al., 2015), learning and knowledge sharing (Chiang and Shih, 2011), and inter-organizational collaboration for better communication as a relational competency for NPD performance (Paulraj et al., 2008). Senior management adheres to sufficient HRs available for progress of the firm (Unger et al., 2012) by maximizing the utilization of available HRs (Heavey and Simsek, 2013). Managerial effort of customizing traditional HRM practices is required for the advancement of knowledge sharing and creation in the firm through investing in people as their knowledge is critical for organizational knowledge creation and hence innovation (Kianto et

al., 2017). Top managers handle the people that are HRs in the firm to utilize their knowledge for NPD success of the firm. Therefore:

H4a. Effective TMS offers a competent HRM practice in the firm.

H4b. As HRM practice increases, NPD success of the firm is enhanced.

6.4.1.5 Effect of TMS on SM and NPD Success

Strategic planning, as efficiency enabler, asserts proper allocation of resources and investigation in the appropriate field to meet priorities based on profitability. Though strategic sourcing lifts organizational performance (Kotula et al., 2015) and strategic planning increases a firm's profitability, innovation-related activities often gets hampered due to lack of risk-taking capability and attitude. Identification of proper strategy is one of the primary managerial implications which are to be drawn for firm's success. Breaking of the conventional strategic idea leads towards firm's performance improvement (Arend et al., 2017). Without the capacity of higher authority to encourage change in SM, it is impossible to embolden product innovation (Cooper and Kleinschmidt, 2007; March-Chorda et al., 2002). Breaking away from the conventional strategic idea leads to a firm's performance improvement while trading-off between the profitability and innovative performance (Song et al., 2015). Strategic flexibility exclusively depends on managerial cognition and capabilities for innovation. Top managers poise between newly developed products and modification of the existing products to optimize the investment (Lau, 2011).Therefore, it can be stated that:

H5a. Effective TMS proposes enhanced SM to the firm.

H5b. Adoption of sound SM process and practices in work ethos enhances the NPD success rate of the firm.

6.4.1.6 Effect of TMS on Organizational Factors and NPD Success

Organizational factors such as organizational structure, organizational culture, firm lifecycle, size of the organization, and up-to-datedness influence NPD performance (Sadeghi et al., 2012). Rapid organizational changes necessitate adoption of innovation-oriented strategies for NPD success (Haneda and Ito, 2018). Improvement of organizational

factors depends on the managerial inferences and views and the awareness of managers leading to enriched organizational culture offering better operational performance. Managerial propositions and support for developing organizational vision, embodied with mission, strategy and culture (Nellore and Balachandra, 2001), organizational factors and grafting (Globocnik and Salomo, 2015), organizational learning and technological competitiveness (Martin-Rojas et al., 2011), knowledge sharing culture (Lin, 2007) influence exploration for innovative ideas and innovation capability of the firm. Identification of variables of organizational factor and, conversions of service capabilities into organizational capabilities are critical for NPD success. The inference, from the above, can be drawn as follows:

H6a. Effective TMS offers efficient control over organizational factors of the firm.

H6b. As implementation of organizational factors increases, NPD success of the firm is enhanced.

6.4.1.7 Effect of TMS on Planning and NPD Success

Planning is the first and foremost step of the NPD among a series of activities to be carried out. Product development planning has not always been considered by the entrepreneurs to be a significant contributor, but researches indicate that good planning leads to the firm's success (March-Chorda et al., 2002). It offers projection of the future based on the current situations that helps to fix problems as anticipated from the trends (Franca et al., 2017). Excellent planning and control was considered as a one of the factors of NPD which is critical to achieve ultimate firm success (Yeh et al., 2014). Establishing product requirements and their specification (Aschehoug and Boks, 2013) is involved at this stage. Strong managerial control spurs NPD activities for planning of competitive strategies for resource allocation (Yeh et al., 2014). Therefore:

H7a. Effective TMS enhances planning for NPD success of the firm.

H7b. As implementation of planning increases, NPD success of the firm is enhanced.

6.4.1.8 Effect of TMS on LTV and NPD Success

Vision is the clear thought of objectives, priorities, and future activities of a firm for achieving sustainable success and survival. Vision comprises various aspects such as the core purpose, values, and the overall long-term objectives of the firm (Franca et al., 2017). It is the probable and desirable state of the firm which the top management observes as the cause for the firm's existence (Fritzroy and Hulbert, 2005). Statement of vision is forward looking for identifying the firm's aspiration on a long-term basis. The capability to develop long-term vision is a quality of management, on which the future of the firm depends. Team vision, transparency of vision, vision support, and steadiness of vision is also crucial (Lynn and Akgun, 2001). Senior management concern for goal, objectives, and activities of the project team for NPD is critical in decision making (Crawford and Di Benedetto, 2000). Managerial control develops trust and learning practice in the organization, which promotes LTV within the team, favoring NPD performance (Yam and Chan, 2015). Therefore, the following statements can be drawn:

H8a. Effective TMS enriches LTV of the firm.

H8b. As LTV increases, NPD success of the firm is enhanced.

6.4.1.9 Effect of TMS on EC and NPD Success

EC of a firm is the propensity to welcome innovative and novel ideas to develop new products. It comprises innovativeness, proactiveness, and risk-taking attitude of a firm's top-level managers for ensuring a firm's growth and profitability (Rauch et al., 2009).Direct effect of entrepreneurial orientation in a firm's growth rate through risk-taking capability helps to accept the unidentified substances with proper strategy and tact (Miller and Friesen, 1978). Motivation from the top management influences the risk-taking behavior of the firm in developing new products, needed for growth and survival. TMS as well as project manager's skill, ability to motivate and authority delegation by top management, such as the organizational characteristics, are important for EC development as well as for NPD success, irrespective of countries (Lee et al., 2000).This culture also links the manufacturing capabilities to market needs for the betterment of organizational performance and develops

potentiality to generate new knowledge adding tangible value for the firm (Kickul et al., 2011). Therefore:

H9a. Effective TMS motivates EC of the firm.

H9b. As EC increases, NPD success of the firm is enhanced.

This theoretical background helps in framing the comprehensive research model exploring the above hypotheses that examine cascading effect of drivers (i.e. TMS) and outcomes(i.e. economic measures) of management actions based on the context on NPD. Figure 6.1 depicts the path model of TMS on NPD success linked by the management actions for a firm's performance development where path H1a-H9a depicts the managerial control on management actions and H1b-H9b portrays the effect of management actions on NPD success.

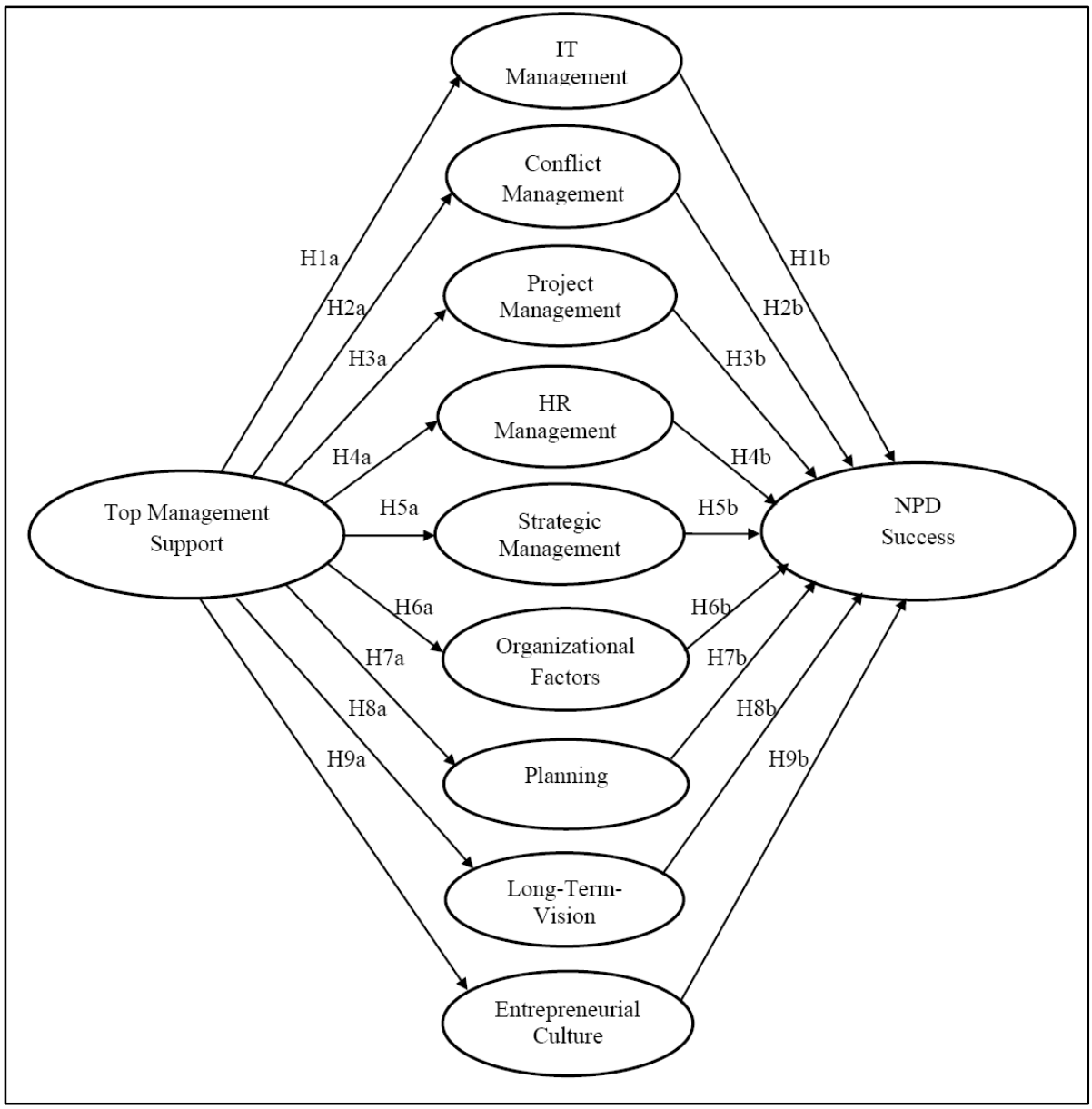

Figure 6.1 Path model of constructs depicting the cascading effect of TMS to control management actions in turn the NPD success

6.5 Results & Discussions

Structural equation modeling (SEM) is a methodology for representing, estimating, and testing relationships between latent constructs and measured variables, which are used to describe those latent constructs (Rigdon, 1998). SEM is a statistical approach for analyzing the hypotheses about relations among the latent constructs, which have been developed from

previous literatures and collected data from company experts. In this study, the role of TMS to control the management practices for encouraging NPD success in terms of economic measures is analyzed by the SEM approach based on the data collected from NPD personnel and managers of Indian manufacturing industries. An extensive semi-structured questionnaire covering the input (TMP along with all management actions as previously mentioned) and output (NPD success) constructs including their manifests are developed. The questionnaire acquires the information about the degree of importance in implementation of the manifest variables to measure the respective constructs. As per experts' opinion, the additional manifest variables help in measuring the constructs which are not mentioned in the questionnaire is accumulated. The information regarding the rate of output manifest variables to measure the NPD success is also gathered. The interview protocol containing the description of latent variables is enlisted in Appendix D. The reliability of the obtained data has been checkered by composite reliability (CR), average variance extracted (AVE) and Cronbach's α reliability test using IBM SPSS 21.0. EFA has been performed to extract the features in the data which is again important to discover the innovative patterns among the constructs. The factors having the loading values of less than 0.6 are rejected as per the conventional practice. SEM approach is performed by using IBM SPSS AMOS 21.0 software packages to structure the framework portraying the cascading effect of TMS to influence management actions which in turn escalate the NPD success of the firm through developing cost effective new products.

6.5.1 Analysis of Measurement Validity

Exploratory factor analysis (EFA) has been performed for reduction technique which selects 50 numbers of manifests among 98, as the loading values of less than 0.6 are rejected as per conventional practice as shown in Table 6.1. The validity and reliability of the obtained data are performed by using average variance extracted (AVE), composite reliability (CR) and Cronbach's α reliability testing by using the IBM SPSS 21.0 (Ong et al., 2004). The values of CR, AVE, and α for each construct are enlisted in Table 6.1. As the values are either greater or equal to the desired value, which is the threshold value, it delineates that the collected data are reliable and can be used for further analysis (Nunnally, 1978; Ong et al., 2004). After that, the framework structuring the impact of TMS on NPD

success through management actions is analyzed by the SEM approach using IBM SPSS AMOS 21.0 software packages.

6.5.2 Measurement Model Results

Confirmatory factor analysis has been performed for testing the uni-dimensionality of the scales and for estimating the model fit. The model has good model-data fit (χ^2=609.054,df=408, χ^2/df=1.493, RMSEA=0.052, GFI=0.886, AGFI=0.851) (Hair et al., 1995).The selected factor loadings (FLs) of the resulting model ranged from 0.603 to 0.923 and standardized regression weights (SRWs) of the selected manifests ranged from 0.52 to 0.96(see Table 6.1). CRs, AVE, and α reliability test results are also enlisted in this Table. CR is one of the methods of measuring measurement reliability which ranged from 0.73 to 0.94 indicating sufficient level of reliability; AVE also ranges from 0.44 to 0.68, and α values for this analysis also ranges from 0.752 to 0.907 which are also satisfactory for using the data for future analysis.

Table 6.1 List of latent constructs along with their manifest variables of TMS and management actions including path estimates and reliability testing

Constructs and their manifests including CR, AVE and α values	FL	SRW	t values
Top Management Support (TMS)[CR=0.84; AVE= 0.56; α=0.820]	-	-	-
As per literatures available:			
1. Support and motivation from senior management (m1)	**0.892**	0.87	_a
2. Willingness of Management in taking risk on NPD (m2)	**0.722**	0.88	9.603
3. Frequency of annual meeting with participation of all level employees	0.589		
4. Commitment of Senior Management throughout development process	0.586		
5. Delegation of Top Management	0.526		
6. Leadership by example	0.429		
7. Support for entrepreneurship culture	0.407		
As per experts opinion:			
8. Continuous investments despite of failures (m3)	**0.821**	0.71	11.880
9. Assimilation of resources as per their requirements (m4)	**0.731**	0.69	9.945

Constructs and their manifests including CR, AVE and α values	FL	SRW	t values
Top Management Support (TMS)[CR=0.84; AVE= 0.56; α=0.820]	-	-	-
As per experts opinion:			
10. Belief in new ideas and encouragement to shape them	0.580		
11. Identification of viability of the project	0.488		
IT Management (ITM)[CR=0.73; AVE= 0.44; α=0.752]	-	-	-
As per literatures available:			
12. Expenditure on IT Management in your company (m5)	**0.901**	0.74	_a
13. Communication using fiber-optic cables (m6)	**0.865**	0.87	12.554
14.Efficient correction of product problem areas as customers' views	0.524		
15. Active use of in house database in development process	0.518		
16.Usage Groupware	0.504		
17. Identification of customers' buying pattern using Big-Data Analytics	0.476		
18. Applications of enterprise solutions	0.435		
19. Efficient detection of product problem areas as per customers' views	0.427		
20. Incorporation of pre-launch for lessons required for full-scale launch	0.401		
21. Post-launch, chances of technical error compared to competitors	0.392		
22. Overall, products had fewer problems than normal in the industry	0.347		
As per experts opinion:			
23. Security to preserve the documents (m7)	**0.792**	0.82	9.501
24. Making HR job easier by ITM (m8)	**0.698**	0.78	8.423
Conflict Management (CM) [CR=0.85; AVE= 0.59; α=0.827]	-	-	-
As per literatures available:			
25.Application of improved conflict handling process (m9)	**0.891**	0.91	_a
26.Mutual understanding of company objectives (m10)	**0.827**	0.90	10.747
27.Commitment to collaboration (m11)	**0.743**	0.72	9.194
28.Effectiveness of conflict handling teams	0.489		
29.Effectiveness of communication management	0.411		
30.Conflict management culture in the firm	0.371		
As per experts opinion:			
31.Overcome language barrier (m12)	**0.689**	0.78	8.650

Constructs and their manifests including CR, AVE and α values	FL	SRW	t values
Project Management (PM) [CR=0.77; AVE= 0.49; α=0.792]	-	-	-
As per literatures available:			
32. Project funding amount (m13)	**0.781**	0.88	_a
33. Sense of responsibility of project manager (m14)	**0.624**	0.70	8.041
34. Proper monitoring of scheduled projects (m15)	**0.605**	0.83	7.992
35. Efficiency of project manager to deal with design engineers	0.587		
36. Effort to reduce Cost & Time overrun	0.582		
37. Standardized skill set of project managers	0.524		
38. Usage of sophisticated software	0.511		
39. Stringent/strict management of Project portfolios	0.495		
40. Executive commitment to project management	0.492		
41. Corporate understanding of project management	0.467		
42. Control over line management for both resources and staffs	0.428		
As per experts opinion:			
43. Continuous learning and training for key success (m16)	**0.611**	0.92	8.208
HR Management (HRM) [CR=0.86; AVE= 0.61; α=0.828]	-	-	-
As per literatures available:			
44. Tradition of working as a team (m17)	**0.923**	0.70	_a
45. Effective use of manufacturing engineering skills (m18)	**0.708**	0.72	9.521
46. Communication and cooperation within NPD team members (m19)	**0.627**	0.89	8.067
47. Communication and cooperation in different NPD teams	0.536		
48. Exchange of experience of key personnel among various NPD teams	0.514		
49. Updating NPD work procedures on regular basis	0.493		
50. Adoption of team-based appraisal system	0.488		
51. Training in problem-solving skills of NPD personnel	0.432		
As per experts opinion:			
52. Appoint best expertise for any special process (m20)	**0.786**	0.85	8.446
Strategic Management (SM) [CR=0.91; AVE= 0.65; α=0.904]	-	-	-
As per literatures available:			
53. Long term planning (m21)	**0.704**	0.85	_a
54. Effort to reduce product development cost (m22)	**0.656**	0.89	7.378
55. Correct forecasting of technology trend (m23)	**0.629**	0.76	7.012

Constructs and their manifests including CR, AVE and α values	FL	SRW	t values
Strategic Management (SM) [CR=0.91; AVE= 0.65; α=0.904]	-	-	-
As per literatures available:			
56. Emphasis on clearly defined strategic target (m24)	**0.608**	0.92	8.981
57. Effort in behaviour analysis of the competitors	0.542		
As per experts opinion:			
58. Effect of performance of controlling authority	0.597		
Organizational Factors (OF) [CR=0.76; AVE= 0.48; α=0.790]	-	-	-
As per literatures available:			
59. Responsiveness to change (m25)	**0.790**	0.96	_a
60. In house development of technology related to product (m26)	**0.657**	0.85	0.885
61. Focus on Core competency areas within the organization (m27)	**0.621**	0.95	0.795
62. Availability of production resources	0.529		
63. Involvement of project leaders in different activities at working level	0.486		
64. Availability of qualified human resources	0.428		
As per experts opinion:			
65.Multi-skill in competency	0.575		
Planning (P)[CR=0.81; AVE= 0.53; α=0.818]	-	-	-
As per literatures available:			
66. Planning of the entire NPD process in your company (m28)	**0.729**	0.91	_a
67. Organized strategic planning for coordinating NPD (m29)	**0.705**	0.74	0.845
68. Plan and choose space distribution for components and structure	0.566		
As per experts opinion:			
69. Bridging the gap in micro-planning and overall planning	0.511		
70.Independence of alternate resource selection (m30)	**0.683**	0.74	0.829
Long-Term-Vision (LTV) [CR=0.90; AVE= 0.63; α=0.892]	-	-	-
As per literatures available:			
71. Clearly mentioned relative priority of each project target (m31)	**0.821**	0.86	_a
72. Project target trade-offs between performance and cost (m32)	**0.744**	0.53	8.650
73. Specified project targets trade-offs between time and cost (m33)	**0.654**	0.93	7.962
74.Specified project targets trade-offs between quality and cost	0.592		

Constructs and their manifests including CR, AVE and α values	FL	SRW	t values
Entrepreneurial Culture (EC)[CR=0.94; AVE= 0.68; α=0.907]	-	-	-
As per literatures available:			
75. Risk taking capability which enhances probability (m34)	**0.822**	0.96	_a
76. Emphasis on development of new and innovative products (m35)	**0.807**	0.87	8.354
77. Emphasis on R&D, technological leadership, and innovations	0.542		
78. Development of many new lines of products or services	0.535		
79. Initiative actions to which competitors then respond	0.521		
80. First to introduce new products/services, techniques, technologies	0.478		
81. Adoption of very competitive, "undo-the-competitors" posture	0.454		
82. Bold, wide-ranging acts to achieve the firm's objectives	0.411		
83. Adoption of bold, aggressive posture for exploiting opportunities	0.366		
As per experts opinion:			
84. New culture awareness and training (m36)	**0.626**	0.75	7.036
NPD Success (NPD Success) [CR=0.87; AVE= 0.64; α=0.868]	-	-	-
85. Profit margin (m37)	**0.921**	0.94	_a
86. Domestic market share (m38)	**0.899**	0.91	10.524
87. International market share (m39)	**0.878**	0.90	10.223
88: Percentage of sales by NPD (m40)	**0.853**	0.92	9.689
89: Development cost (m41)	**0.804**	0.85	7.581
90: Attain return on investment (m42)	**0.762**	0.78	9.570
91: Attain profitability goal (m43)	**0.684**	0.85	7.744
92: Attain margin goal (m44)	**0.665**	0.89	7.567
93: Meet unit share goal (m45)	**0.642**	0.96	8.287
94: Revenue growth (m46)	**0.627**	0.96	8.315
95: Meet revenue growth (m47)	**0.616**	0.88	8.204
96: Profitability relative to competitors (m48)	**0.610**	0.79	7.848
97: Profitability relative to spending (m49)	**0.608**	0.87	9.541
98: Net sales growth (m50)	**0.603**	0.82	9.704

Notes:

- ✓ [Principal component based EFA was performed for factor extraction based on loading values.

- ✓ CFA are performed to calculate the individual regression weights of extracted manifests.
- ✓ Maximum-likelihood methods are applied for measurement model estimation.
- ✓ _a indicates a initial parameter of t-values set at 1.0
- ✓ All t-values are significant to $p < 0.000$
- ✓ Model fit indices: $\chi^2 = 609.054$, degrees of freedom = 408, χ^2 /degrees of freedom = 1.493, RMSEA = 0.052, GFI = 0.886, AGFI = 0.851]

In case of measurement model, confirmatory factor analysis has been applied to validate the occurrence of manifest variables on their respective latent construct. Manifests are identified both from the available literature and experts' opinion from the manufacturing sector. In case of TMS construct, the indicators available in the literature are support and motivation from the senior management, willingness of the management in taking risk on NPD, frequency of annual meeting with participation of all level employees, commitment of senior management throughout the development process, delegation of top management, leadership by example, and support for entrepreneur culture. Indicators recognized by experts are continuous investments despite of failures, assimilation of resources as per their requirements, belief in new ideas and encouragement to shape them and identification of viability of the project. Based on the values of FLs obtained from factor analysis by IBMSPSS 21.0 software, it has been observed that there are few indicators whose loading values are greater than 0.6 which can be considered for further model development. Among the aforesaid indicators of TMS, support and motivation from the senior management (m1), willingness of the management in taking risk on NPD (m2) among the identified variables from the literature and continuous investments despite failures (m3), assimilation of resources as per their requirements (m4) from experts' opinion are considered for model development. Similarly, for each construct of management actions and also for NPD success, the factor analysis is performed for validating the occurrence of manifest variables. By following this process, finally, a total of 50 measures (m1-m50) were identified for framework development. The SEM approach is conducted on the basis of selected manifest variables of the constructs and the SRWs are calculated. The regression analysis provides linkage values of predictor variables to the dependent variables and the positive values are considerable for further analyzing the structural model. Table 6.1 shows the manifests

obtained both from literatures and experts' opinion along with their FLs and SRWs as obtained through the analysis.

6.5.3 Structural Model Results

After analyzing the measurement model, the structural model is examined. The results suggest the appropriate model-to-data fit (χ^2=654.993, df=434, χ^2/df=1.509, RMSEA=0.048, GFI=0.912, AGFI=0.876) (Hair et al., 1995). The structural model showing the hypothesized relationships between constructs developed by using the IBM SPSS AMOS21.0 software is shown in Fig.6.2. Table 6.2 shows the path estimates from 0.50 to 0.97 depict that the proposed hypotheses are supported.

Table 6.2 Statistics of path estimates representing the interrelationships of top management support and management actions for NPD success

Path Description	Hypothesis	Estimate	t values
TMS ⟶ ITM	H1a	0.97 (***)	7.351
ITM ⟶ NPD Success	H1b	0.79 (***)	6.227
TMS ⟶ CM	H2a	0.96 (***)	7.051
CM ⟶ NPD Success	H2b	0.69 (***)	5.316
TMS ⟶ PM	H3a	0.91 (***)	6.705
PM ⟶ NPD Success	H3b	0.72 (***)	5.884
TMS ⟶ HRM	H4a	0.88 (***)	6.324
HRM ⟶ NPD Success	H4b	0.83 (***)	6.008
TMS ⟶ SM	H5a	0.53 (***)	5.782
SM ⟶ NPD Success	H5b	0.65 (***)	6.535
TMS ⟶ OF	H6a	0.88 (***)	7.309
OF ⟶ NPD Success	H6b	0.72 (***)	6.512
TMS ⟶ P	H7a	0.95 (***)	7.634
P ⟶ NPD Success	H7b	0.89 (***)	7.516
TMS ⟶ LTV	H8a	0.89 (***)	7.608
LTV ⟶ NPD Success	H8b	0.50 (***)	4.284
TMS ⟶ EC	H9a	0.80 (***)	6.589
EC ⟶ NPD Success	H9b	0.61 (***)	5.804

Notes:

- ✓ [*** indicate the significance at p value <0.01
- ✓ Model fit indices: $\chi 2 = 654.993$, degrees of freedom = 434, $\chi 2$ /degrees of freedom = 1.509, RMSEA = 0.048, GFI = 0.912, AGFI = 0.876]

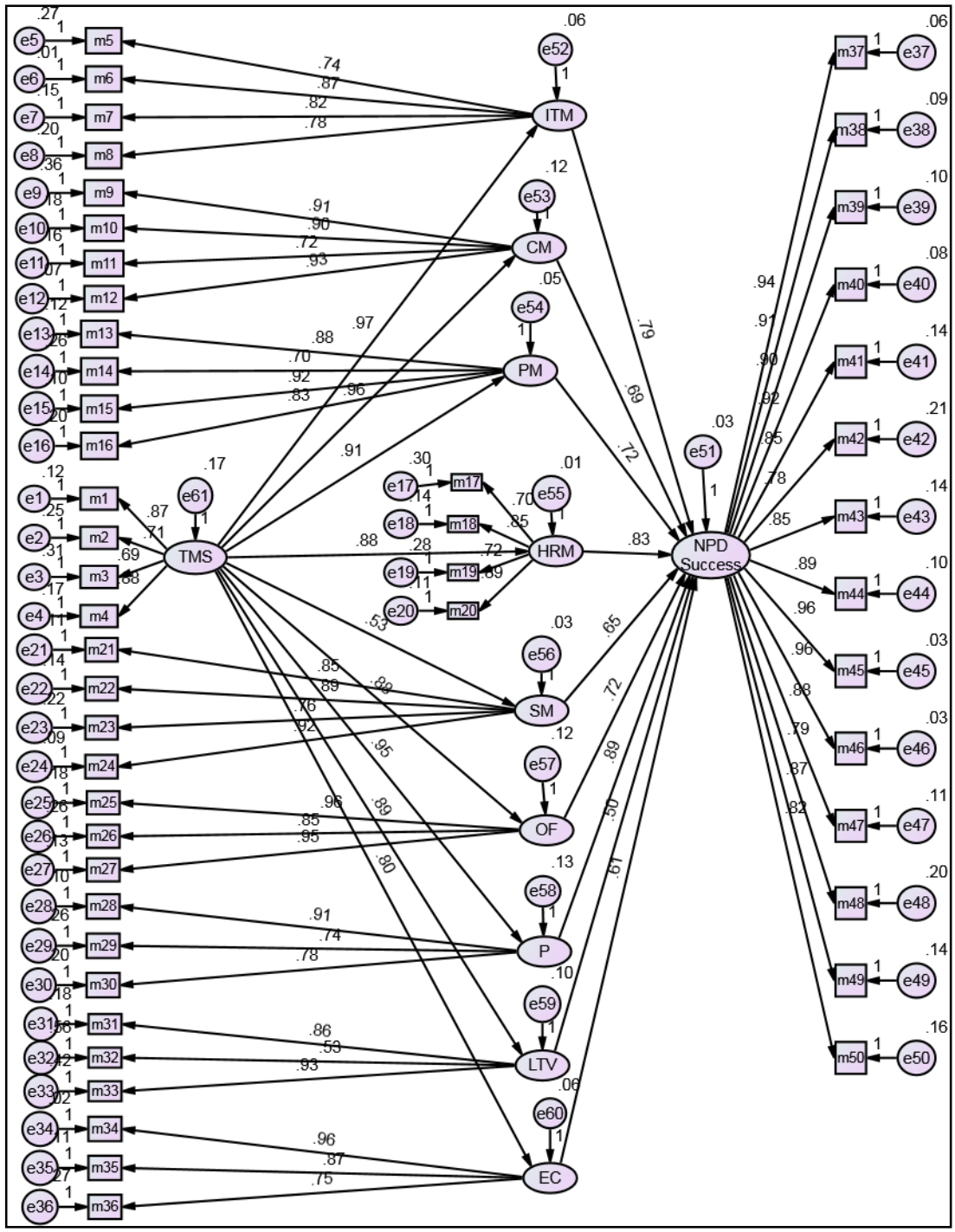

Figure 6.2 SEM model after execution portraying the cascading effect of managerial support on management actions for NPD success

Here, Fig.6.2 symbolizes a detailed framework consisting of both measurement model as well as structural model combining the latent constructs along with their indicators. This model shows both regression weights of manifest variables as shown in Table 6.1 and the path estimates as shown in Table 6.2. The standardized error associated with each manifest variable is represented through the error terms mentioned in the model as e1-e50.The error for individual path coefficient for each latent construct is mentioned as e51-e61.The arrows also have a high relevance in the model as these represent the direction explaining which construct has impact on the other construct. In case of a latent construct and its indicators, the direction of the arrows is from the construct toward the indicators such as describing the connection of the manifest variables with the respective latent construct. This figure shows the critical linkages of TMS and management actions to escalate NPD success through financial and economic developments.

The structural model, discussed above, will be very useful for the NPD practitioners in the manufacturing sectors by utilizing TMS for integrating the management practices for successful development of cost-effective new products. Adoption of the aforementioned management actions entails successful functioning of the available resources for fulfilling customer requirements and for achieving organizational goals. This requires the identification of an exhaustive list of management actions and their inputs influenced by managerial support for NPD success. The list of constructs and their manifests for both inputs (TMS and management actions) and outputs (NPD success) are mentioned in Table 6.1, which will help the NPD practitioners to realize the effect of implementation of this model in a practical field. The justifications of the developed hypotheses from the results of path estimates as obtained from multiple regression analysis as listed in Table 6.2 are discussed below.

As observed in the existing literature, IT capabilities of an organization are treated as one of the management actions for a successful adoption of the ITM that significantly enhances the NPD success (Kawakami et al., 2015). The information gathered from the advanced IT helps in managing the developed process collecting data used as a potential source of information (Relich and Pawlewski, 2018). These senior-level managers promote continuous upgradation of the existing technologies ensuring NPD success (Kawakami et

al., 2015). The present study develops a model representing the importance of managerial support for successful adoption of ITM in a firm (H1a) since the TMS is found to be positively related to ITM (path estimate=0.97, $p<0.01$). The influencing role of ITM for successful NPD (H1b) is also being supported through the positive path values between the ITM and NPD success (path estimates=0.79, $p<0.01$). As the managerial support influences ITM which in turn promotes NPD success it can be described as cascading effects for successful development of new products.

Conflict generates the interferences among the team members of the firm hindering the smooth flow of development process (Barki and Hartwick, 2001). This may affect the outcome in different ways by failing to deliver products within the scheduled time and estimated cost as well (Liu et al., 2011). Top managers enhance the teamwork culture within the firm by continuous monitoring of the conflict that arises due to the demographic diversity and their tact of solving the issues improves NPD success (Liang et al., 2012). The present research studies the significance of managerial control on CM (H2a) as the standardized path estimates of TMS and CM is quite high which support the developed hypothesis (path estimates=0.96, $p<0.01$). The influential role of CM for escalating NPD success (H2b) is also being justified by the positive path estimate value as mentioned in Table 6.2 (path estimates=0.69, $p<0.01$). This enlightens the cascading effect of managerial support for CM to achieve NPD success.

Like other management actions, PM has become one of the essential functions to increase productivity (Mir and Pinnington, 2014; Kenny, 2003). The study of Mir and Pinnington (2014) empirically evidence the positive influence of PM on project success to develop new products. The effectiveness of PM requires leadership of managers to develop the products by combining the technical competencies (Hyväri, 2002). On the basis of the interpretations of the above discussions, this study attempts to structure a linking model presenting the effect of PM cascaded from TMP for NPD success. The hypotheses (H3a and H3b) drawn in the present study showing the positive influence of TMS on PM (path estimates=0.91, $p<0.01$) and similarly PM on NPD success (path estimates=0.72, $p<0.01$) are supported successfully and thus complements the previous literature.

HRM practices significantly increases the probability of NPD (Haneda and Ito, 2018). High-quality HRM practices implemented as a bunch of management actions has an overall positive impact on NPD. Senior managers promote HRM efforts, its capabilities of strategy development as organizational needs for better NPD performance (Maxwell and Farquharson, 2008). In conjunction with the view of previous researchers, this study also support the hypotheses (H4a and H4b) showing the positive impact of TMS on HRM (value=0.88, $p<0.01$), which in turn escalates NPD success (value=0.83, $p<0.01$). This provides the cascading effect of managerial support to implement HRM practice for achieving NPD success.

SM is the ability of flexible use of resources for new courses of action as well as completing the existing commitments (Dai et al., 2018). The strategic flexibility provides competence of changing the direction of development and reconstructs their resources swiftly as per needs (Fine, 1998). This practice requires the direct association of top managers to make substantial decisions raises the burden of top management for coordination (Dai et al., 2017). The findings of this research provide empirical evidence for the argument (H5a and H5b) that TMS escalates the SM practice of the firm (path estimates=0.53, $p<0.01$) which successively influences NPD success (path estimates=0.65, $p<0.01$) demonstrating the cascading effect.

The organizational changes can accelerate NPD success through innovation-oriented strategies (Teece, 1996). Organizational factors are one of the key decision makers of a firm's effectiveness. Controlling of these factors is dependent on managerial assistance to pursue risks for meeting innovation objectives (Bower and Gilbert, 2005). In the present study, the significance of TMS for improving organizational factors (H6a) which again positively influences NPD success (H6b) is supported by the positive value path estimates calculated 0.88 and 0.72, respectively, significant for $p<0.01$.

The procedure of product development requires a systematic planning from the very early stage (March-Chorda et al., 2002; Aschehoug and Boks, 2013). Excellent planning and monitoring the execution of the defined plans shapes the development process of a successful practice (Yeh et al., 2014). Managerial support and participation from the

preplanning phase is useful for the firms to develop new products successfully (Small, 2007). The present study structures a framework presenting the impact of TMP for developing a well-defined plan at the very preliminary stage of NPD (H7a) since the TMS is found to have a positive effect on planning (P) (path estimate=0.95, $p<0.01$) which further escalates NPD success supporting the H7b (path estimate=0.89, $p<0.01$) inferring the cascading effect as well.

LTV depends on the priority of the targeted customers and their needs. Volatility in customer demand changes in the market environment necessitates setting of a vision on long-term basis with assistance of good advice as per observations. A concrete organizational vision ensures the ability to succeed by escalating NPD performance (Lynn and Akgun, 2001). Vaughan (1997) emphasizes on managerial support for successful implementation of LTV for a firm's success. From the aforesaid discussion the link of TMS for a setting a LTV positively influencing the NPD success is clear. In this present research, the hypotheses (H8a and H8b) are supported as the positive values of path estimates in between the TMS and LTV (value=0.89, $p<0.01$) and LTV and NPD success (value=0.50, $p<0.01$) are obtained.

EC is a tendency to acquire innovativeness and proactiveness along with the risk-taking tendency. The exploration of a new product is influenced by EC escalating the willingness to change for developing new products (Dayan et al., 2016).The EC depends on the preferences, beliefs, and behaviors of the top-level managers for profitability and organizational growth. The developed hypotheses(H9a and H9b) are based on enough evidences of the past literature; this present study also sustains that TMS influences EC which in turn escalates NPD success as resulted from the obtained path values of 0.80 ($p<0.01$) and 0.61 ($p<0.01$), respectively.

The crucial and novel contribution of this study is that it highlights the integrative perspective of management actions for NPD success cascaded from TMS. The nine constructs related to management actions (namely, IT, CM, PM, HRM, SM, OF, P, LTV, and EC), which have emerged from our analysis need to be addressed cascaded from the managerial support for successful NPD. The more comprehensive the process is, the better

will be the realization of NPD practice for a firm's success. The developed comprehensive framework represents the linkage of TMS to improve management actions for NPD success. This NPD success, the latent output, is actually the financial and economic improvements, which will ultimately help to decide a firm's sustainability from a global perspective.

6.6 Conclusion

6.6.1 Theoretical Contribution

This empirical research has made important contributions to the theory on the cascading effects of TMS in an organization for improving the management actions, which in turn leads to the NPD success in the Indian manufacturing sector. First, the management actions and their antecedents relative to the NPD activities are recognized. Second, the impact of TMS to escalate these management actions are verified which incorporates the identification of indicators of TMS as well. Third, the effect of management actions cascaded from managerial support on financial and economic developments for NPD success is framed, which results in better realization of these constructs in a practical field.

6.6.2 Managerial Implications

The interpretations of this empirical study provide the essentiality of NPD success for industrial sustainability through the management actions cascaded from managerial support. These results contribute significant managerial implications.

First, the management actions need to be emphasized for smooth continuation of NPD activities through optimal utilization of available resources for creating new products. ITM, conflict handling, project planning, HRM, strategy development, controlling organizational factors, proper planning, LTV for expansion, and mounting EC are recognized as the management actions for NPD in a dynamic market environment. Along with the identified manifests from the available literatures managers imply the significance of the constructs through sharing the antecedents they have faced during implementing the respective constructs at some point in the development process. Managers portray the significance of a security system in preserving the documents and making the HR job easier through IT for better quantification of ITM constructs as well as fixing the threat of data loss. Similarly,

overcoming the language barrier is mentioned as one of the indicators for handling conflict necessary to be managed for better CM. In case of PM, continuous learning and training for attaining key success is a suggested area of concern for successful completion of projects. Utilization of HRs not only depends on trained labors and their skills, it also requires appointment of best expertise for any special process. Application of experts' idea and skills are identified for successful application of HRM. In case of SM, effects of the performance of the controlling authority lead to better implementation of SM. Multi-skill in competency helps in promoting the organizational factors for NPD success. Planning requires independence in alternate resource selection and bridging the gap in micro-planning and overall planning. But among these variables, independence of alternate resource selection provides a higher FL for further application in structural model development. Awareness of a new culture and training that leads toward an enhanced EC for introducing new ideas helps in NPD.

Second, managerial contribution is an inevitable resource of NPD essential for successful implementation of management actions. This study surmises that the affirmative attitude of top managers cascaded through management actions will enhance the NPD success rate as well as sustainability of the enterprise in the milieu of global competition. Continuous investment despite failures is one of the most inspiring motivations from the top management. It helps in developing innovative ideas in spite of associated risks of failure. Assimilation of resources as per their requirements is another approach of top managers by which the culture of managerial support gets enriched helping in motivating management actions for NPD success.

Finally, organizations need to manage innovative product development to deliver cost effective products as per customers' requirements for achieving success. The economic and financial measures, for the NPD success, namely profit margin, domestic and international market share, percentage of sales out of NPD, development cost, return on investment, attaining profitability goal or meeting the unit share revenue growth goal, profitability relative to competitors, profitability relative to spending, and net sales growth have been utilized to quantify the former.

The developed model in this study has highlighted the critical linkage of TMS and NPD success clearly manifesting the motivating role of top management, by way of controlling the management actions, toward NPD success, which in turn helps to achieve better performance and success as well as the survival of enterprises.

Chapter Summary

This chapter has provided:

- A structural framework depicting the cascading effect of TMS for controlling the integrative managerial actions for enhancing NPD success by developing cost effective new products for firm's success.
- The quantification of factors as well as their indicators has also been performed for realizing their impacts on NPD success.
- Managerial implications have been drawn to aid in enhancement of NPD success by implementing management actions with managerial support which helps in future goal achievement.

Thesis work reported in this chapter has been published (Journal / Book Chapter) in the following reference:

Roy, S., Dan, P. K., & Modak, N. (2018). Cascading effects of management actions on NPD in the manufacturing sector: The Indian context. *Journal of Manufacturing Technology Management*, Emerald, **SCIE** (Article in Press).

The next chapter draws the framework realizing the impact of environmental factors for successful NPD and the role of TMS to control the EC to implement the environmental factors for developing the new products with less hazardous effects on environment.

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CHAPTER 7

ENVIRONMENTAL ASPECTS ON NPD

7.1 Preamble

Globalization leads towards the development of new products practice for small to large scale companies to survive and compete in the next level challenges. Recently 'Make in India' concept highlights the necessity of developments of innovative products rather being developing the conventional ones which are already existing in the market. Environmental concern is one of the vital but barely neglected constituent which companies are less bothered. But the scenario has been changing rapidly and environmental impacts have become inseparable part of new product development (NPD), every company are craving for. Proper managerial support from top managers' helps to develop the better working environment in the firm which is again motivates the entrepreneurial culture. Entrepreneurship is such a culture which encourages the new and innovative ideas to be welcomed in the company and also implemented for better NPD performance. Entrepreneurial culture enhances the idea of caring environmental factors which are essential for successful NPD. This study draws the interrelationship among these factors and also depicts their effects on NPD success which in turn be quantified by environmental concern. The structural equation modeling (SEM) approach has been used to develop the interrelationship model by using IBM SPSS AMOS 21.0 software. A detailed questionnaire survey has been performed to collect the primary data from 263 experts of Indian manufacturing industries for analysis purpose. Composite reliability, average variance extracted and Cronbach's alpha reliability testing are performed to test the reliability of the survey data by using IBM SPSS 21.0 software. The interpretation from the developed model clearly states the role of top management support to escalates the entrepreneurial culture of the company which is again positively influences the environmental factors for NPD success which in turn be measured by environmental aspects like reduced cost, healthy relationship with investors, regulatory approvals, life-cycle analysis and customer satisfaction.

7.2 Background

Globalization leads the industries to a competitive market environment which challenges their industrial sustainability according to their capability (Buyukozkan and Arsenyan, 2012). The NPD practice is one of those characteristics which provide the competitive advantage to sustain in the competition. There are various constituents which play a vital role to control the NPD practice and which are critical to success. These constituents are famously introduced as critical success factors (CSFs) (Bhuiyan, 2011). Depending upon the requirements, the factors controlling NPD success, their effects on NPD success and also their interrelationships change. The identification of those factors as well as their effects are equally challenging job to be performed. There are number of researches portraying the very common and mostly discussed factors like technology (Lau, 2011; Mendes and Ganga, 2013). There are research and development (R&D) (Cooper and Kleinschmidt, 2007; Fain et al., 2011; Wang and Lestari, 2013), collaborative culture (Cooper and Kleinschmidt, 2007) and many more for developing effects on NPD success. Top management support and motivation is one of the vital factors which is closely associated with NPD success irrespective of time and type of companies (Cooper and Kleinschmidt, 2007; Lynn et al., 2000; March-Chorda et al., 2002; Felekoglu and Moultrie, 2014). Senior management can provide all necessary components for NPD success which confirms firm's success and survival. In this present era, entrepreneurial culture (EC) has become an inseparable entity for industrial sustainability in highly competitive market environment (Matsuno et al., 2014). Significance of EC in established firms for improving performance and ensuring profitability is empirically evident. Strong support from top management for developing successful EC helps to rejuvenate the firms for exploring innovative ideas and developing strategic vision for successful implementation of entrepreneurial behaviour (Antoncic, 2007). This entrepreneurial behaviour within the firm able to develop the concern about the environmental impacts and motivates the team members to successfully develop environment friendly products. Environmental impacts on NPD success is already been an established phenomenon which is getting importance day by day in all over the world (Deniz, 2002; Bevilacqua et al., 2012; Kastensson, 2014). Now-a-days, the main objective of the firms has become not only developing successful new products, but also to produce the products which are less harmful to the environment (Gouda et al., 2016, Roy et al., 2018). Specifically, this study

investigates the environmental impacts on sustainable development of new products. Not only that, it identifies the factors which directly controlling the environmental impacts for betterment of NPD success. It studies the role of top management for motivating to establish the EC in the firm which is again responsible for providing better environmental impacts for NPD success. Like success factors, there are number of success measures used to quantify the NPD success. Researchers identified market success, meeting budgets & schedules, speed-to-market (Sivasubramaniam et al., 2012),customer acceptance, customer satisfaction, meet revenue goal, break-even time, development cost, launch on time (Huang et al., 2004) as manifests to measure NPD success. In this study, environment related measures have been used to quantify NPD success.

This article builds a structural model depicting the role of top management to develop EC in the firm which is again responsible for controlling environmental factors positively which ensures NPD success. Structural equation modeling (SEM) approach has been used to develop this framework using IBM SPSS AMOS 21.0 software packages.

7.3 Objective

The objective of this study is the development of new products with less hazardous effect on environment by strong managerial control for developing the practice of entrepreneurship to handle the environmental impacts for successful NPD in Indian manufacturing firms. The identification of indicators for measuring the environmental factors as well as the controlling factors are carried out and the antecedents for success measures are also recognized which is manifested by environmental measures as well. A detailed questionnaire survey has been performed by accumulating the primary data from 263 experts of Indian manufacturing companies for data analysis.

7.4 Conceptual Framework for Hypotheses Development

Concentration on environmental impacts is growing rapidly as it becomes essential to count the environmental factors for developing products with less hazardous effect on environment. Though in recent era, the environmental factors are in limelight but by concerning the gaps, this research identifies the role of top management support to encourage the entrepreneurial culture for controlling environmental factors essential for developing new products with less hazardous

impacts. A valid theoretical background develops hypotheses interpreting the relationships of these constituents for successful NPD.

Entrepreneurial culture (EC) is the tendency to encourage innovative ideas and shape them to develop the final product used by the end users. It comprises innovativeness, proactiveness, and risk-taking attitude of a firm's top-level managers for ensuring a firm's growth and profitability (Rauch et al., 2009). Sustainable entrepreneurship is a process which encourages the activities for achieving the environmental goals (O'Neill et al., 2009). Direct effect of entrepreneurial orientation in a firm's growth rate through risk-taking capability helps to accept the unidentified substances with proper strategy and tact (Miller and Friesen, 1978). Motivation from the top management influences the risk-taking behavior of the firm in developing new products, needed for growth and survival. Managerial skills, their motivation to enhance the organizational capabilities are essential for developing EC within the organization for NPD success (Lee et al., 2000). The support and motivation from top management bodies increases the potentiality to generate new knowledge adding tangible value for the firm (Kickul et al., 2011). The connection between entrepreneurial activities and environmental goals is discussed in the available literature (Matos and Hall, 2007). EC helps to reduce the environmental pollution and preserve the ecosystem. As per research, this practice could be solution to various environmental issues (Senge et al., 2007; Hall et al., 2010). Entrepreneurship is identified as the solution of the environmental degradation (York and Venkataraman, 2010). Therefore, as per the above discussion, this can be interpreted that:

H1: Top management support (TMS) positively influences the entrepreneurial culture (EC).

H2: Entrepreneurial culture (EC) has a positive impact on environmental factors (EF).

H3: Environmental factor (EF) positively influences NPD Success which is again measured by environmental measures.

This theoretical background helps in framing the research model exploring the developed hypotheses that examine the impact of TMS for escalating EC of the firm to control the EF for

NPD success by developing products having less hazardous effects for environment. A path model of constructs is structured as shown in Fig.7.1.

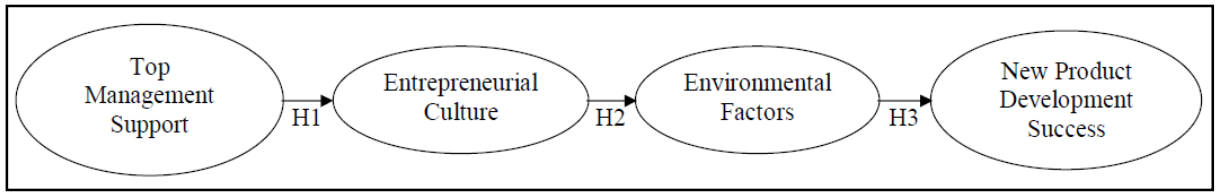

Figure 7.1 Path model of constructs depicting the role of TMS to develop EC for controlling environmental factor for NPD success

7.5 Results & Discussions

Structural equation modeling (SEM), a general statistical modeling technique, which is the combination of factor analysis and path analysis is used for developing the structural framework linking the constructs as well as their indicators. This methodology helps to signify, estimate and test a theoretical network of (mostly) linear relations between latent and manifest variables (Rigdon, 1998). These relationships between theoretical constructs are represented by path coefficients between the factors. SEM analyzes the hypotheses among the latent and manifest variables to establish the existing relationship among them (Hoyle, 1995). This study concerns about the role of top management to support the EC which is again control the environmental impacts which in turn escalates NPD success of the firm. The hypotheses among these latent constructs are been developed to measure the ultimate NPD success by quantifying the environment related measures. The primary data have been collected from 263 experts, mainly NPD personnel and design & development experts of Indian manufacturing industries. The validity and reliability of the survey data has been tested by average variance extracted (AVE), composite reliability (CR) and Cronbach's alpha reliability technique by using IBM SPSS 21.0 software. SEM approach has been used to build the interrelationship model representing the role of managerial support to establish EC in the firm which can control the environmental impacts for NPD success which is again quantified by environment related measures. IBM SPSS AMOS 21.0 software package has been used to develop the structural model.

7.5.1 Analysis of Measurement Validity

This empirical research utilizes the data from Indian manufacturing industries for accomplishing the research objectives. The latent constructs have been quantified by the manifest variables describing the degree of importance of these constructs in implementing them in practical field. The addition manifest variables which have not been mentioned in the questionnaire are also been accumulated along with their degree of importance based on the experts' opinion. The description of the latent constructs mentioned in the developed semi-structure questionnaire for primary data collection is mentioned in Appendix E at the end of this thesis. This adds a novelty to the developed model. EFA has been used for dimension reduction selecting the factors having loading values greater than 0.60 as per the conventional practice. In Table 7.1, the list of constructs along with the factor loadings of their indicators is précised by each principal component. In this case it is observed that all the indicators of the factors having loading values greater than the desired value. So, all the mentioned variables are used for framework development. The reliability of the survey data has been performed by composite reliability (CR), average variance extracted (AVE) and Cronbach's Alpha Reliability testing using IBM SPSS 21.0 software package and their values have been listed in Table 7.1. The values of CR greater than 0.5 depict high reliability whereas from 0.3 to 0.5 denotes moderate reliability and values of AVE greater than 0.5 are considered as reliable (Holmes and Smith, 2001). Similarly, values of α for all the variables greater than the threshold value which is 0.8 have been considered as highly reliable (Ong et al., 2004). From this empirical data the structural model depicting the interrelationship of the constructs have been developed by SEM using IBM SPSS AMOS 21.0 software package.

7.5.2 Measurement Model Results

For testing uni-dimensionality of the scale and estimating model fit, confirmatory factor analysis has been performed. The model fitness can also be analyzed by multiple fitness tests such as chi-square including degree of freedom (Hu and Bentler, 1998), goodness-of-fit (GFI), adjusted-goodness-of-fit (AGFI) and root mean square of error approximation (RMSEA) (Chen, 2016). As per the fitness testing, model has the good model-data fit as the values of χ^2=398.270, χ^2/degrees of freedom=1.861, RMSEA=0.055, GFI=0.820 and AGFI=0.736. All the values are

within permissible range as listed in Table 7.2. In Table 7.1, the values of reliability indices have been listed which shows that CR values ranges from 0.55 to 0.75 which means highly reliable data. Similarly, AVE values ranges from 0.43 to 0.57 which is quite reliable. The α values are also from 0.693 to 0.836 which can be considered as reliable. The standardized regression weights (SRWs) of the manifests have also been listed in Table 7.1 which shows that their values range from 0.46 to 0.97 which depicts the feasibility of the estimated relationships among the latent and manifest variables.

Table 7.1 Latent constructs and indicators of TMS, EC, EF and NPD success including factor loadings, standardized regression weights, validity and reliability indices

Latent Constructs and Their Indicators	Factor Loadings	SRWs	t Values
Top Management Support (TMS) [CR=0.55; AVE= 0.43; α=0.693]	-	-	-
1. Support and motivation from top management (TMS1)	.816	0.60	_a
2. Commitment throughout development (TMS2)	.789	0.89	7.334
3. Frequency of annual meeting (TMS3)	.739	0.93	8.825
4. Delegation of top management (TMS4)	.726	0.67	10.108
5. Leadership by example (TMS5)	.716	0.76	8.964
6. Willingness of taking risk of NPD (TMS6)	.695	0.86	8.339
7. Support for entrepreneurial culture (TMS7)	.681	0.77	6.922
8. Planning and objective (TMS8)	.655	0.68	7.819
Entrepreneurial Culture (EC) [CR=0.69; AVE= 0.49; α=0.724]	-	-	-
1. Risk taking capability (EC1)	.984	0.87	_a
2. New product development culture (EC2)	.925	0.97	11.386
3. Technological leadership for R&D and innovation (EC3)	.919	0.53	11.501
4. Development of many new lines of products (EC4)	.867	0.69	7.900
5. Initiative actions (EC5)	.846	0.88	10.825
6. First-to-market (EC6)	.822	0.54	6.348
7. Highly competitive approach (EC7)	.801	0.39	11.881
8. Productivity for high risk projects (EC8)	.798	0.46	10.951
9. Bold and wide-ranging acts (EC9)	.723	0.51	9.454
10. Exploration of opportunities (EC10)	.691	0.73	9.004

Latent Constructs and Their Indicators	Factor Loadings	SRWs	t Values
Environmental Factor (EF) [CR=0.75; AVE= 0.57; α=0.836]	-	-	-
1. Eco friendliness of the product (EF1)	.866	0.84	_a
2. Adverse effect of the product on environment (EF2)	.813	0.71	10.020
3. Sustainability of the product (EF3)	.788	0.89	8.564
4. Environmental goal achievement rate of the new green products (EF4)	.753	0.62	7.540
5. Compliance of new green products with the consumers' preference (EF5)	.731	0.67	10.01
6. Meeting Government policies for product development (EF6)	.699	0.80	9.771
7. Recycling rate of the new green products (EF7)	.672	0.80	9.308
8. Hiring responsible employees (EF8)	.630	0.91	7.351
New Product Development Success (NPD Success) [CR=0.71; AVE= 0.54; α=0.801]	-	-	-
1. Reduced cost (PDS1)	.922	0.61	_a
2. Healthy relationship with investors (PDS2)	.891	0.73	8.749
3. Regulatory approvals (PDS3)	.858	0.69	8.288
4. Life-cycle analysis (PDS4)	.810	0.78	9.341
5. Customer satisfaction (PDS5)	.795	0.55	11.202

Notes:

- ✓ [EFA was performed for factor extraction based on loading values.
- ✓ CFA are performed to calculate the individual regression weights of extracted manifests.
- ✓ Maximum-likelihood methods are applied for measurement model estimation.
- ✓ _a indicates an initial parameter of t-values set at 1.0
- ✓ All t-values are significant to $p < 0.01$
- ✓ Model fit indices: $\chi^2 = 3.98.270$, degrees of freedom = 214, χ^2 /degrees of freedom = 1.861, RMSEA = 0.055, GFI = 0.820, AGFI = 0.736]

Table 7.2 Fitting indices (adopted from Hair et al., 2010)

Fit Indices	Desired Range
χ^2 /degrees of freedom	≤ 2.00
RMSEA(Root Mean Square Error of Approximation)	Values less than 0.05 show good fit Values as high as 0.08 represent reasonable fit Values from 0.08 to 0.10 show mediocre fit Values > 1.0 show poor fit
Goodness-of-fit index (GFI)	$\geq .90$
Average Goodness-of-fit index (AGFI)	$\geq .90$

In measurement model analysis, the exploratory factor analysis is conducted on both input and output manifests to identify the measures with high loadings comparing others for data reduction purpose. The measures, with loading values greater than 0.60, are considered for further analysis. IBM SPSS 21.0 is used for this extraction purpose. In case of TMS, support and motivation from top management (TMS1), commitment throughout development (TMS2), frequency of annual meeting (TMS3), delegation of top management (TMS4), leadership by example (TMS5), willingness of taking risk of NPD (TMS6), support for entrepreneurial culture (TMS7) and planning and objective (TMS8) are identified variable to quantify the TMS. As per the FEA performed, all the measures have the loadings >0.60. So, all the indicators are utilized to measure the construct TMS. Similarly, for EC is quantified by risk taking capability of the management bodies (EC1), new product development culture within the firm (EC2), technological leadership for R&D and innovation (EC3), development of many new lines of products (EC4), initiative actions (EC5), first-to-market (EC6), highly competitive approach (EC7), productivity for high risk projects (EC8), bold and wide-ranging acts (EC9) and exploration of opportunities (EC10) having the loading values >0.60. In case of environmental factors, eco friendliness of the product (EF1), adverse effect of the product on environment (EF2), sustainability of the product (EF3), the environmental goal achievement rate of the new green products (EF4), compliance of new green products with the consumers' preference (EF5), meeting Government policies for product development (EF6), recycling rate of the new green products (EF7) and hiring responsible employees (EF8) are used to measure the factor as having the factor loadings >0.60. For NPD success, the indicators are reduced cost (PDS1), healthy

relationship with investors (PDS2), regulatory approvals (PDS3), life-cycle analysis (PDS4) and customer satisfaction (PDS5). These indicators are found to be having the factor loadings >0.60. After EFA, the standardized regression weights (SRWs) of recognized manifests are calculated. The positive values of regression coefficients depict the positive linkage of indicators with their respective latent constructs. The t values of the identified manifest are also estimated to find out their significance.

7.5.3 Structural Model Results

Formation of measurement model is followed by the structural model formation. In this case, the fitness tests are performed. The values of these tests also show the appropriate model-to-data fit as χ^2=432.096, χ^2/degrees of freedom=1.830, RMSEA=0.048, GFI=0.856 and AGFI=0.780 (Hair et al., 2010). This structural model defines the role of top management support to enrich the EC of the firm which in turn enhances to highlight the environmental factors which is again escalates NPD success of the firm. This NPD success is quantified by environmental measures like reduced cost, healthy relationship with investors, regulatory approvals, life-cycle analysis and customer satisfaction. IBM SPSS AMOS 21.0 software has been used to develop the structural model as shown in Fig.7.2. The results show the values of path estimates between the constructs are positive and quite satisfactory. These values are enlisted in Table 7.3. This depicts that the positive attitude of senior management for innovation develops the entrepreneurial behaviour in the firm which also motivates to control environmental factors for successful NPD.

Table 7.3 Statistics of path estimates showing the path values among the constructs such as TMS, EC, EF and NPD success

Path Description	Hypotheses	Standardized Estimates	t-Values
TMS ⟶ EC	H1	0.82 (***)	8.183
EC ⟶ EF	H2	0.90 (***)	12.588
EF ⟶ PD Success	H3	0.96 (***)	9.363

Notes:

- ✓ [*** indicate the significance at p value <0.01
- ✓ Model fit indices: χ^2= 432.096, degrees of freedom = 236, χ^2 /degrees of freedom = 1.830, RMSEA = 0.048, GFI = 0.856, AGFI = 0.780]

The structural model as shown in Fig. 7.2 represents the impact of the TMS on EC for controlling environmental factors to analyze the developed hypotheses based on theoretical background. Before assessing the path estimates the fitness of the developed structural model is performed as discussed earlier. According to the estimated path values represented in Table 7.3, it has been observed that the path estimates between TMS and EC is positive (path estimate=0.82, $p<0.01$), EC and EF is positive (path estimate=0.90, $p<0.01$) and EF and NPD success is also positive (path estimate=0.96, $p<0.01$). These values confirm the significance of the linkages among the factors as discussed.

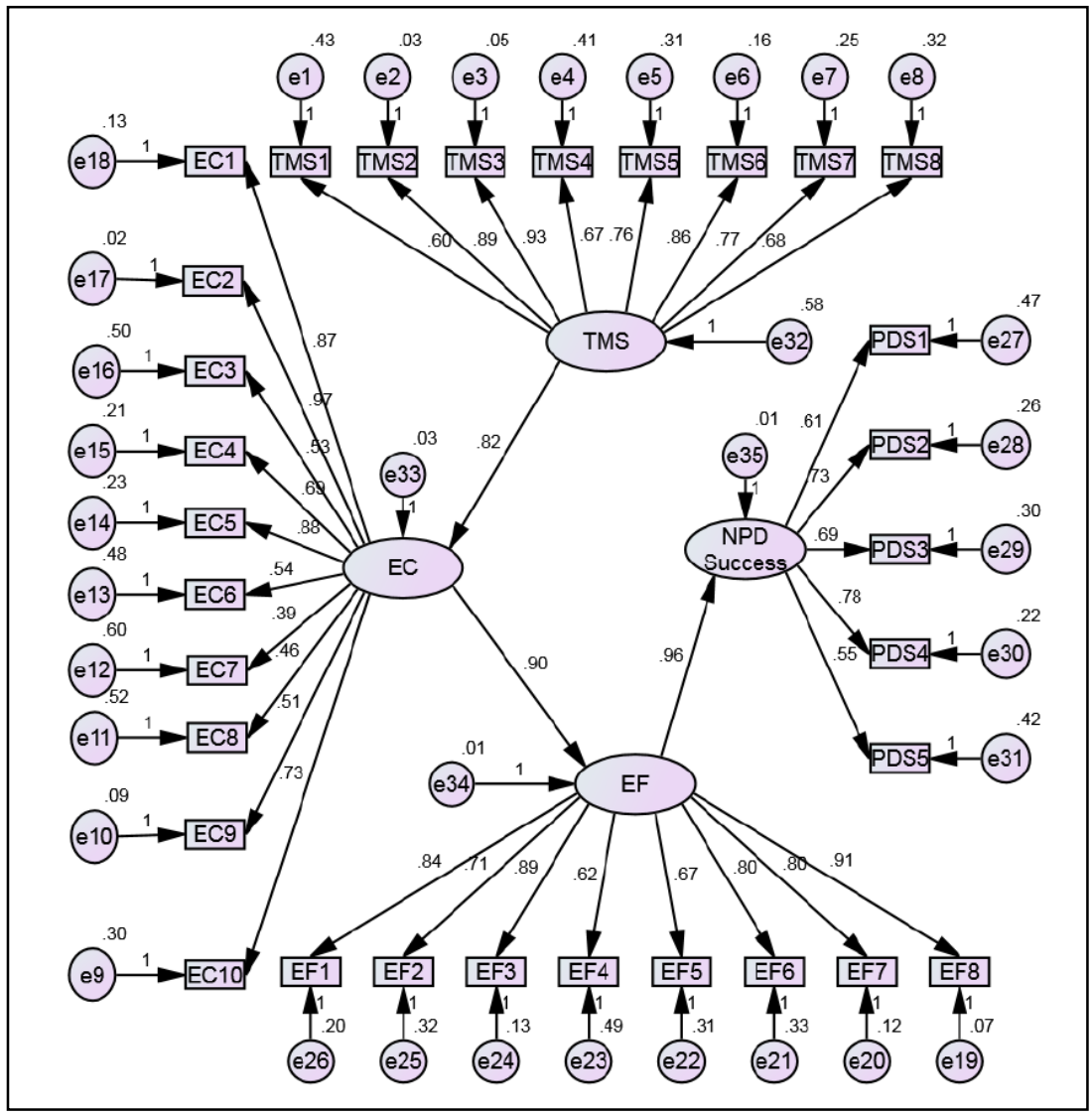

Figure 7.2 SEM model showing the impact of top management support on entrepreneurial culture for controlling environmental factor for NPD success

Figure 7.2 symbolizes the detailed framework of the linkages of TMS to enhance the EC of the firm. This EC encourages the firm to consider the environmental impact of the newly developed product. The SRWs clearly show the positive contribution of the indicators to measure the constructs as shown in Table 7.1. The values of path estimates depict the positive impact of factors for achieving NPD success as listed in Table 7.3. The standardized errors in the developed model associated with latent constructs and their indicators represent the difference between the actual and estimated path values for individual path coefficients.

7.6 Conclusion

7.6.1 Theoretical Contribution

This research highlighted the requirement of controlling environmental factors for successfully developing new products. It recognizes the role of managerial support and motivation for escalating the culture of entrepreneurship within the firm for developing the products with less hazardous impact on environment. In this study, the environmental measures are utilized for quantifying the NPD success of the firm. The developed framework is helpful to draw the managerial implications to achieve NPD success in Indian manufacturing companies.

7.6.2 Managerial Implications

The interpretations of this empirical study provide the essentiality of NPD success for industrial sustainability through the adopting the environmental factors developed by managerial support through enriching EC in practical field. These results contribute significant managerial implications.

Association of industrial sustainability and NPD is an inevitable phenomenon. Likewise the environmental impact for NPD success is undoubtedly necessary. Though this fact is well established, but the awareness about environmental hazards occurring due to industrial developments is remained unexplored. This study identifies the impact of environmental impacts on NPD success in Indian manufacturing industries. Moreover, it explores the constituents controls the environmental factors to escalate the NPD success. Primary data from the 263 design and development experts from Indian manufacturing companies shapes this study as a practical one to establish the framework for NPD. This research shows the strong managerial

support can develop strong entrepreneur behaviour in the firm. Top management support is a practice of the senior managers to provide strong support and motivation for innovation, commitment throughout development, frequently arranging annual meetings, delegation of top management, providing strong leadership, willingness of taking risk of NPD, support for entrepreneurial culture and finally proper strategic planning. This support can develop the qualities like risk taking capability, NPD culture, leadership for R&D and innovation, development of many lines of products, initiative actions, first-to-market, competitive approach, productivity for high risk projects, bold and wide-ranging acts and finally the exploration of opportunities. These qualities are treated as EC of the firm which is again can control the environmental impacts by concerning about the eco-friendliness of the product, adverse effect of the product on environment, sustainability of the product, the environmental goal achievement rate of the new green products, compliance of new green products with consumers' preference, meeting Government policies for product development, recycling rate of the new green products and hiring responsible employees. These variables in turn positively influence the NPD success by reducing cost of development with lesser environmental risks, maintaining healthy relationship with investors, availing ease of regulatory approvals, life-cycle analysis and better customer satisfaction. Though the environmental impact is one of the vital constituents for NPD of the industries but there are very few number of Government approved eco-waste recycler in India. But in the present era, Government has become highly conscious about restricting the environmental hazards for the survival of the humanity.

Chapter Summary

This chapter has provided:

- A structural framework depicting role of managerial support and motivation for developing EC within the firm for controlling environmental factors for sustainable NPD.
- The quantification of factors as well as their indicators has also been performed for realizing their impacts on NPD success.

- The developed structural model helps in drawing the managerial implications to aid the enhancement of NPD success by encouraging the environmental factors for achieving success.

Thesis work reported in this chapter has been published (Journal / Book Chapter) in the following references:

Roy, S., Modak, N., & Dan, P. K. Managerial Support to Control Entrepreneurial Culture in Integrating Environmental Impacts for Sustainable New Product Development. In S. K. Ghosh (Ed.), Sustainable Waste Management: Policies and Case Studies. Springer (Accepted).

Roy, S., Modak, N., & Dan, P. K. A Framework of Strategic Role for Developing Sustainable Products: Structural Equation Modeling Approach. In S. K. Ghosh (Ed.), Sustainable Waste Management: Policies and Case Studies. Springer (Accepted).

Roy, S., Modak, N., & Dan, P. K. (2018). Integration of Environmental Impacts in Sustainable New Product Development. In S. K. Ghosh (Ed.), Waste Management and Resource Efficiency. Singapore: Springer. ISBN: 978-981-10-7289-5.

The next chapter draws the framework realizing the impact of teamwork based culture and its associated factors for successful NPD by enhancing the NPD team's capability.

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CHAPTER

8

TEAM CULTURE FOR NPD

8.1 Preamble

Team culture, for competitive advantage, involving techno-socio-cultural aspects of organizations for engineering developments, is gaining importance rather rapidly due to advent of globalization. The purpose of this study is to identify the importance of team culture or teamwork culture for new product development (NPD) success through enriching the NPD team's capability in Indian manufacturing industries. It accumulates the teamwork culture dynamics and practices, their interrelationships and their combined impact on NPD team's capability in terms of technological developments for NPD success. This practical analysis collects primary data from 263 design and development experts from Indian engineering manufacturing companies. Structural equation modeling (SEM) approach is applied to investigate the interrelationship among associated variables of teamwork culture and NPD team's capability for NPD success. Concurrent engineering team (CET), communication infrastructure (CI), system integration (SI) and result orientation (RO) have been recognized as allied factors of teamwork culture. Successful adoption of associated variables ensures NPD success through influencing NPD team's capability which in turn articulated by technological developments. The realization of combined impact of teamwork and its allied variables escalates technological developments which in turn enriches NPD team's capability assuring organizational success. The result indicates that both CI and SI support CET for accelerating NPD team's capability through technological developments. Besides, CET motivates innovation orientation most precisely referred as RO for escalating NPD team's capability through technological developments for innovation.

8.2 Background

Organizations embodying enriched culture generally value systems with strong beliefs leading to a society with acceptable behaviours (Early, 2006). Culture is a well-defined term as shared

views of a group of people about priorities and building appropriate attitudes towards required developments (Beamer and Varner, 2001). Organizational culture motivates the innovative behaviour by creating a strong commitment among the members of an organization leading towards a vivid teamwork culture in terms of believing in innovation as an organizational value (Rodríguez-Pinto et al., 2012). The performance of the team can justify the probability of achieving goals in all aspects including NPD (Hoegl et al., 2003). Teamwork is the cooperation among employees of different functions essential for organizational sustainability (Felekoglu et al., 2013). Though talent, experience and skill are essential but the lack of teamwork culture that is working with the dissimilar people embracing the unfamiliar situation for organizational benefit arise conflicts. Teamwork behavior, team climate for innovation (Bain et al., 2003) for team performance has been discussed in the available researches. Teamwork culture leads to the positive outcomes beneficial for team performance for innovation (Strubler and York, 2007). For developing team based culture, synchronization of the functional groups is essential for continuation of concurrent activities of the firm (Cleetus, 1992). Allocation of required resources for NPD needs to be carried out for simultaneous interdependent activities of groups which develop an environment of concurrent engineering (CE) (Chen et al., 2013). Sharing information and ideas are the best way to achieve higher concurrency level among interdisciplinary groups which can be achieved through meetings with different teams as per regular basis (Mousavi and Darvishi, 2014). This cut down the probability of risks in CE as well as product development. Moreover, knowledge sharing is a necessary cultural phenomenon which requires building the teamwork culture within the organization to synchronize between the existing culture and the developing culture for organizational success (Friesl et al., 2011). Cross-functional team (CFT) offers harmonization among team members to overcome conflicts and differences occurred during the project completion (Green et al., 2000). The cross-cultural differences among the teams affect the success of the innovation oriented projects (Ghauri and Rosendo-Rios, 2016). Entrenched relationships of top managers of CFT with team members help in resolving conflicts, which could occur within the team (Anthony et al., 2014) and motivates to develop innovative products through concurrent development activities. The collaboration among the interdisciplinary teams proposes better team performance utilizing the diverse team qualities (Saji, 2004). In interdisciplinary team culture, managers' activities mediate the functional heterogeneity among the teams for team effectiveness (Benoliel and Somech, 2014). The

concurrent engineering team (CET) with cross-functional activities develops a suitable environment for NPD. But there is a virtual barrier between the different teams working in a firm which can only be bridged through interactions and communication heading towards cooperative teamwork (Felekoglu et al., 2013). Proper integration among CET can be attained by providing proper communication infrastructure (CI) which helps in decision making as well as problem solving in challenging situations. Communication is a type of internal collaboration where information and idea sharing take place for better IPD performance (Everettet al., 2002). Concrete infrastructure for communication helps in bridging the functional teams for optimal use of individual competencies. Sustainability of innovative product development is conquered through optimal utilization of the organizational resources and existing skills (Tushman and Anderson, 1997). Including the obtainability of system competencies, integration of these competences are correspondingly important for NPD success (Hitt et al., 2000). There is a need of clear governance of organizational systems including integration with strategic objectives and structuring of work teams (Nagono et al., 2014). Result orientation (RO) popularly termed as strategic orientation of a firm is a combination of innovation orientation and market orientation where innovation orientation is the technological dominance. This enhances the new product success in terms of profitability and sales growth (Crawford and Di Benedetto, 2000; Atuahene-Gima et al., 2005). Result orientation defines by interrelationship of time, costs, quality, people and organization for assuring better NPD performance.

Teamwork culture among the organization helps to socialize the creativity of the team members for technological innovations. This helps to develop products that are fundamentally different for creating competitive advantage (Hoegl and Parboteeah, 2007). Attaining the desired cost, quality and time objectives of the newly developed products offer enriched team performance (Lechler, 1997) essential for product innovation. Efficiency and effectiveness are the ultimate matter of concern for quantifying team performance and its effect on NPD (Hoegl and Parboteeah, 2003). For the present study, NPD team's capability has been considered as the constituent for measuring NPD success and technological developments are the manifest variables for quantifying the NPD team's capability for engineering development of the organization. This approach connects the effectiveness of teamwork culture as an organizational aspect which escalates NPD team's capability through technological developments of the innovative products ensuring the NPD success. The role of all the variants of teamwork culture

in a firm is undoubtedly important but their implementation in practical field is somehow challenging due to presence of obstacles and difficulties created in internal and external ambience. Though the existence of the teamwork factors existed in the previous literatures but was not comprehensively explained in a single framework. Besides, the effort of linking these factors for the sake of NPD is also unnoticed. This framework is a novel approach towards the successful developments of innovative products.

The research adds originality by identifying the gaps and adding up the features: (1) development of comprehensive interrelationship model concerning all the variants of teamwork culture for enhancement of NPD team's capability as technological developments; (2) consideration of importance in implementation of the constructs associated with teamwork culture in practical scenario; (3) exploration of teamwork culture in Indian manufacturing industries using the primary data base from design and development experts; (4) finally and most importantly, realizing the need for teamwork culture among multidisciplinary teams and groups within the organization for NPD team's capability in terms of technological developments fostering for innovation.

8.3 Objective

The main aim of team culture for NPD research is to identify of teamwork practice based on success factors from theoretical background and determine the importance in implementation of these teamwork constituents based on the experts' opinion from Indian manufacturing industries. At the same time the additional manifest variables used to quantify the identified success factors which are not previously recognized in the available researches are assimilated for attaining more precised and detailed measurement. In this way the present study identifies the degree of importance in implementation of these factors in the firm by overcoming the practical obstacles is framed using the real-life data collected from the market survey. Finally, the role of technological developments based success measures in quantifying NPD team's capability for NPD success is established depending on the empirical survey in Indian manufacturing industries.

8.4 Conceptual Framework for Hypotheses Development

Teamwork culture requires an environment that fosters learning, creativity and innovation for NPD (Estrada et al., 2013). Though the teamwork practice is established as critically vital for NPD success, the identification of all constituents of this practice and their interrelationships are being untouched. At the same time, their effects on NPD team's capability in terms of technological development for NPD success are also unidentified as per best knowledge. Derivation of two streams of theory sources develops the main theoretical basis of the study: (1) identification of constructs of teamwork based practices, (2) interrelationships of these constructs and their impact on NPD team's capability for achieving NPD success. Based on this theoretical background hypotheses have been developed to construct the interrelationship model.

8.4.1 Effect of CET on NPD Team's Capability and RO

Concurrent engineering team (CET) is a group of members associated with the CE practice for developing products within scheduled time. CE is the method of performing the processes of the firm concurrently for reducing development time of the product to attain competitive advantages. The development time gets reduced as the planning, designs, manufacturing all are occurring in parallel manner associating the uncertainties in interdependent processes. In case of CE the multidirectional exchange of information, decision making, and data sharing among various functional groups takes place for developing economic products within estimated time more easily and efficiently. CET introduces the idea of CFT culture which is the nature and attitude of working together among team members which again helps in developing sharing quality and the nature of problem solving together which is one of the most positive approach of the firm for achieving success (DeVries et al., 2006). Researchers identify that for NPD the planning and concurrency is essential for problem solving which is inspired by cross-functional integration. Adoption of CET culture motivates the concurrency in NPD processes for enhancing NPD team's capability. CET ensures cooperation, trust and sharing among teams for developing products concurrently in a synchronous manner to achieve NPD success. CET offers integration of various functional groups to overcome the functional barriers and

difficulties for strategic orientation among the team members for innovation (Berthon et al., 2004) which can be better stated as result orientation. The assumptions from the above discussions can be drawn that:

Hypothesis 1a (H1a): CET has a positive effect on NPD team's capability of the firm.

Hypothesis 1b (H1b): The efficiency of CET enhances the RO among the NPD teams.

8.4.2 Effect of CI on NPD Team's Capability and CET

Teamwork is a firm's practice of working together with various functional groups to overcome problems arises in each steps and successfully develop new products. The best way of achieving success is communication and interaction among the various teams (Kleinsmann et al., 2010). CI is one of the main features of internal as well as external integration for NPD (Johnson and Filippini, 2013). Bi-directional communication approach is always encouraged the ideas and information flow from senior management to employees and vice versa (Felekoglu et al., 2013). Usefulness of CI policy for NPD team's performance is been recognized by researches (Tsai et al., 2011). Communication enhances the better cooperation, coordination, sharing of information among teams leading towards better decisive capability of the teams in the firms in difficult conditions (Poole and Hirokawa, 1996). CI has a salient bond with another vital constituent of teamwork culture which is CET. The CET quality is closely associated with the excellent communication culture among the teams to complete the task uninterruptedly (Kennedy et al., 2011). Enriched coordination among CET lowers the communication barrier among teams and helping to circulate information which accelerates better decision making ability (Anthony et al., 2014). From the above discussions the statements can be drawn:

Hypothesis 2a (H2a): A better CI increases the probability of NPD team's capability.

Hypothesis 2b (H2b): The efficiency of CET will be enhanced by strong CI among the team members.

8.4.3 Effect of SI on NPD Team's Capability, CET and RO

System integration (SI) is the incorporation of resources of several functional groups for efficient development of innovative products. There are various types of required resources for development of products. The integration category differs depending on the types of resources available. Knowledge is one of the resources essential for NPD team's capability for innovation. Accumulation of internal and external knowledge for innovative product development helps to achieve the competitive advantage (Gu et al., 2016; Leitman, 2011). In practical field, integration of internal capabilities such as various functional groups working together and the external relations like supplier and customer involvement are equally imperative for NPD success (Johnson and Filippini, 2013). The effective integration of ideas, strategies, operational activities and commercialization procedure leads to the success of innovative product development (Sun et al., 2012). The very early stage of NPD consists of idea, screening and implementation phases which must be performed concurrently and as per time passes, these stages concurrently changed based on the practical environment (Nihtila, 1999). There are number of researches concerning the integration of various types of systems such as integration in the manufacturing systems (Lindstrom and Winroth, 2010), integration of cross-functional teams, integration of R&D activities, and integration in system level and production level (O'Sullivan, 2003). This integration accelerates NPD team's capability for achieving success. Besides, integration of various systems associated with NPD activities motivates strategic orientation of the firm ensuring technological developments. It correlates time, costs, quality, people and organization for better innovative product development activity. The implications from this discussion can be set that:

Hypothesis 3a (H3a): An effort of SI escalates the NPD team's capability of the firm.

Hypothesis 3b (H3b): SI motivates CET culture of the firm.

Hypothesis3c (H3c): SI positively encourages RO among the NPD teams within the firm.

8.4.4 Effect of RO on NPD Team's Capability and SI

Result orientation (RO) is practically the strategic orientations consisting of innovation and market orientation (Chou and Yang, 2011). The innovation orientations convey the technological improvements whereas, market orientation is the identification of customer need to develop new products as per demand. The effective interfaces between these two types of orientations can be achieved by integration among the employees of various functional groups of the firms to overcome the functional barriers and difficulties (Berthonet al., 2004). This may be explained as the strategic orientation among the quality, cost, time, people and organization for enhancement for better NPD success through enhancement of NPD team's capability. The above discussion signifies that:

Hypothesis 4 (H4): The betterment of RO motivates the NPD team's capability of the firm.

The insufficiency of the empirical researches in previous literature to recognize and develop a comprehensive framework considering the teamwork practices in Indian scenarios and by collecting the valuable responses from engineers of manufacturing industries of various parts on India creates a need to do this research. Moreover, the implementation of teamwork culture in small and medium enterprises in India is not satisfactory due to the socio economic structure (Leitner, 2011). This attitude leads to the decay in future growth due to incompetence with respect to the global perspective. This research is an effort to develop a comprehensive structural model depicting teamwork culture to achieve NPD success through enriching NPD team's capability by alarming the need of this practice in Indian manufacturing industries. Figure8.1 represents the path model of interrelationships of the teamwork culture based constructs and their impacts on escalating NPD team's capability for NPD success.

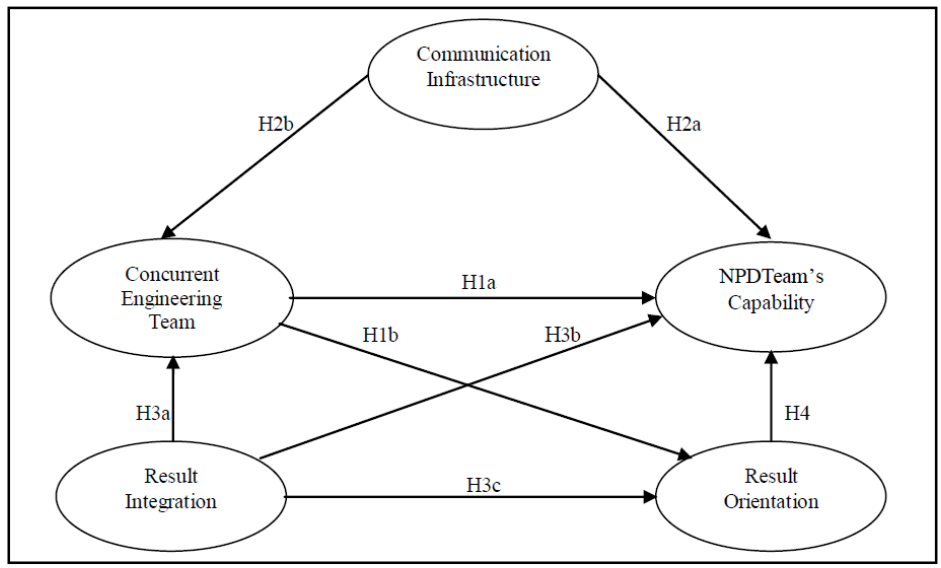

Figure 8.1 Path model of constructs representing combined effect of teamwork and its associated factors on NPD team's capability

8.5 Results & Discussions

Significance of incessant NPD practice of the firm for sustaining in global competitive environment is an established statement. There are number of theoretical and empirical researches regarding this fact. Teamwork as an organizational perspective mobilizes the innovative developments by enriching the team's capability for enhanced engineering activities. The close association of teamwork culture in governing the new product success is also inevitable. This study fulfill the gap in the research of NPD by accumulating the factors involved in articulating the teamwork culture of the firm to structure a model involving these teamwork based success factors and the NPD team's capability for technological developments within scheduled time as success measures. A semi-structured questionnaire is formed and primary data is collected from design and development engineering experts of Indian manufacturing companies developing engineering products. The description of the latent constructs as mentioned in the questionnaire is enlisted in Appendix F. The reliability of the accumulated data have been tested using composite reliability (CR), average variance extracted (AVE) and Cronbach's Alpha reliability testing by using IBM SPSS 21.0 software. After the reliability testing, EFA has been performed to identify the indicators having higher contribution (>0.60) for measuring the respective

constructs. Finally, SEM has been applied to structure the interplay of the constructs of teamwork culture and also to recognize their combined impact to enhance NPD team's capability by using IBMS SPSS AMOS 21.0 software packages.

8.5.1 Analysis of Measurement Validity

Exploratory factor analysis (EFA) has been performed to find out the loading values of the indicators to measure the respective factor. The loading values of less than 0.6 are rejected as per conventional practice. In this study, factor loadings of all indicators are listed in Table 8.1. The values of reliability indices (CR, AVE and α) are enlisted in the same table also which shows that the values are either greater or equal to the desired value, which is the threshold value, it delineates that the collected data are reliable and can be used for further analysis (Nunnally, 1978; Ong et al., 2004).

8.5.2 Measurement Model Results

Confirmatory factor analysis has been performed for estimating the standardized regression weights (SRWs) of individual manifest variables and the model fit. The crucial step of SEM is the estimation of path values for analyzing the model fitness. Besides, there are multiple methods of assessing the model fitness such as chi-square including degree of freedom (Hu and Bentler, 1995), goodness-of-fit (GFI), adjusted-goodness-of-fit (AGFI) and root mean square of error approximation (RMSEA) (Chen, 2016). As per the fitness test the model fitting values are within the desired range as χ^2= 488.598, degrees of freedom = 242, χ^2 /degrees of freedom = 2.019, RMSEA = 0.052, GFI = 0.864, AGFI = 0.836 (Hair et al., 2010). The SRWs of the manifests of the input and output constructs range from 0.31 to 0.93 to as listed in Table 8.1. Values of reliability indices such as CR and AVE values range from 0.729 to 0.910 and 0.45 to 0.68. Again another vital reliability index α values range from 0.748 to 0.967, mostly greater than 0.8, depicts the satisfactory data reliability for future analysis.

Table 8.1 List of latent constructs along with their manifest variables of associated factors of teamwork culture including factor loadings, regression weights and reliability indices

Latent Constructs and Their Indicators	Factor loadings	SRWs	t values
Concurrent engineering team (CET):	-	-	-
[CR=0.72; AVE= 0.45; α=0.748]			
1. Collaborative culture (m1)	.914	0.48	_a
2. Knowledge integration (m2)	.902	0.34	12.723
3. Early stage involvement of functional groups (m3)	.891	0.39	10.323
4. Early stage manufacturing activities (m4)	.875	0.73	11.088
5. Concurrency of process and product design in same group (m5)	.833	0.61	9.759
6. Concurrency of process and product design in different groups (m6)	.794	0.49	9.336
7. Sharing of information (m7)	.736	0.74	8.845
8. Idea generation and sharing (m8)	.715	0.51	8.694
9. Coordination to achieve the target (m9)	.712	0.43	11.418
10. Strategic consideration (m10)	.696	0.60	9.317
11. Inter department opinion sharing (m11)	.678	0.53	9.774
12. Solving disagreements (m12)	.655	0.82	8.925
13. Managerial support and motivation (m13)	.651	0.64	8.318
Communication Infrastructure (CI)	-	-	-
[CR=0.78; AVE= 0.47; α=0.801]			
14. Regular meeting for problem-solving (m14)	.886	0.74	_a
15. Virtual communication (m15)	.832	0.57	9.236
16. Video conference (m16)	.781	0.82	11.514
17. NPD database system (m17)	.726	0.76	10.344
18. Internet-based telecommunication tools (m18)	.704	0.93	9.142
19. Face-to-face meetings in between virtual teams (m19)	.692	0.86	8.554
System Integration (SI)	-	-	-
[CR=0.79; AVE= 0.52; α=0.838]			
20. Formal department for system integration (m20)	0.908	0.58	_a
21. Experienced engineers for system integration (m21)	0.872	0.80	11.531
22. Availability of middle management (m22)	0.835	0.73	8.989
23. Presence of a product manager for system integration (m23)	0.798	0.61	9.568

Latent Constructs and Their Indicators	Factor loadings	SRWs	t values
Result Orientation (RO)	-	-	-
[CR=0.91; AVE= 0.68; α=0.967]			
24. Interrelationships of time, costs, quality, people and organization (m24)	0.946	0.42	_a
25. Consideration of different times associated (m25)	0.871	0.71	10.512
26. Consideration of various cost associated (m26)	0.836	0.63	11.225
27. Focus on quality factors (m27)	0.759	0.34	8.341
28. Consideration of factors related to people and market (m28)	0.722	0.87	7.985
29. Accumulation of both financial and non-financial results (m29)	0.695	0.83	9.256
NPD Team's Capability	-	-	-
[CR=0.91; AVE= 0.68; α=0.913]			
30. Technological developments (m30)	.915	0.79	_a
31. Expansion of product family (m31)	.872	0.36	10.710
32. Scheduled product launching frequency (m32)	.843	0.71	10.522
33. Reduction of failure rate (m33)	.787	0.31	9.736
34. Time associated for development	.529		

Notes:

- ✓ [Maximum-likelihood method is applied for measurement model estimation.
- ✓ _a indicates an initial parameter of t-values set at 1.0
- ✓ All t-values are significant to $p < 0.000$
- ✓ Model fit indices: $\chi^2 = 488.598$, degrees of freedom = 242, χ^2 /degrees of freedom = 2.019, RMSEA = 0.052, GFI = 0.864, AGFI = 0.836]

The validation of the occurrence of manifest variables on their respective latent construct has been performed using confirmatory factor analysis for both input and output measurement models. In case of input measurement model, concurrent engineering team (CET), communication infrastructure (CI), system integration (SI) and result orientation (RO) have been treated as latent constructs while in output measurement model, NPD Team's Capability as output construct. CET is quantified by collaborative culture among the team, knowledge integration among various teams within the organization, early stage involvement of functional

groups, early stage manufacturing activities, concurrency of process and product design in same group, concurrency of process and product design in different groups, information sharing, idea generation and sharing, coordination to achieve the target, strategic consideration, inter-department opinion sharing, solving disagreements and support and motivation from top management. In case of communication infrastructure (CI), meeting on the regular basis for problem solving, virtual communication, video conference, NPD database system, internet-based telecommunication tools and face-to-face meetings in between virtual teams are used to measure the communication practice in the organization. For SI, availability of formal department for system integration, number of experienced engineers, availability of middle management and presence of a product manager make this practice feasible to measure in the practical scenario. The RO among the teams are measured by interrelationships of time, costs, quality, people and organization, consideration of different times associated, consideration of various cost associated, focus on quality factors, consideration of factors related to people and accumulation of both financial and non-financial results. Like input constructs, the output construct which is NPD team's capability is quantified by technological developments, expansion of product family, scheduled product launching frequency and reduction of failure rate. The SRWs i.e. the loading values obtained from the maximum-likelihood method are all positive and mostly greater than 0.45 (Hair et al., 2009). Few of them are less than 0.45 but those can be considerable to develop the measurement model for both input and output constructs. These SRWs along with the values of CR, AVE and α for measuring the composite reliability, convergent validity and internal consistency of each construct respectively are listed in Table 8.1. This shows that values of CR, AVE and α are within the acceptable range to use the empirical data for future analysis.

8.5.3 Structural Model Results

Analysis of measurement model is followed by the structural model formation. In case of structural model also the fitness tests are performed showing the appropriate model-to-data fit as χ^2 = 474.39, degrees of freedom = 251, χ^2 /degrees of freedom = 1.89, RMSEA = 0.047, GFI = 0.891, AGFI = 0.847 (Hair et al., 2010). The structural model representing the hypothesized relationships between constituents of teamwork culture as input constructs and NPD team's capability as output construct and their indicators developed by using IBM

SPSS AMOS 21.0 software is shown in Fig. 8.2. Most of the path estimates between the constructs for both input and output ranges from 0.38 to 0.69 depicting that proposed hypotheses are supported. Only one path estimate is showing negative value as -0.04 which depicts the assumed hypothesis unsupported. The values of path estimates are listed in Table 8.2.

Table 8.2 Statistics of path estimates showing the path values among associated factors of teamwork culture and NPD team's capability

Path Description	Hypotheses	Standardized Coefficient	t values
CET ⟶ NPD Team's Capability	H1a	0.80 (***)	12.505
CET ⟶ RO	H1b	0.58 (***)	11.576
CI ⟶ NPD Team's Capability	H2a	0.48 (***)	9.842
CI ⟶ CET	H2b	0.69 (***)	7.959
SI ⟶ NPD Team's Capability	H3a	0.39 (***)	10.531
SI ⟶ CET	H3b	0.38 (***)	11.334
SI ⟶ RO	H3c	-0.04 (n.s)	8.415
RO ⟶ NPD Team's Capability	H4	0.43 (***)	12.754

Notes:

- ✓ [*** indicates the significance at p value <0.01
- ✓ n.s. stands for not significant
- ✓ Model Fit Indices: χ^2 = 474.39, degrees of freedom = 251, χ2/degrees of freedom = 1.89, RMSEA = 0.047, GFI = 0.891, AGFI = 0.847.]

Structural model represents the interrelationship among the latent constructs for analyzing the hypotheses among the constructs developed from the available literatures. The path values in between the constructs are calculated by multiple regression analysis by using SEM. The results of structural model are exhibited in Table 8.2 which explains the relationship among the constructs as per developed hypotheses. The concurrent engineering team (CET), communication infrastructure (CI), system integration (SI) and result orientation (RO) positively influence the NPD team's capability as the path values between them are positive such as 0.80, 0.48, 0.39 and 0.43 respectively. The CET is escalated by CI and SI as obtained from the

standardized coefficients of path estimates such as 0.69 and 0.38 respectively. Again CET positively motivates RO as depicted by the path estimates between them is 0.58. But in case of effect of SI on RO, the Table 8.2 shows that path estimates between them is -0.04 which is not significant. That means there is no positive relationship in between SI and RO which depicts that the developed hypothesis in between SI and RO is proven insignificant.

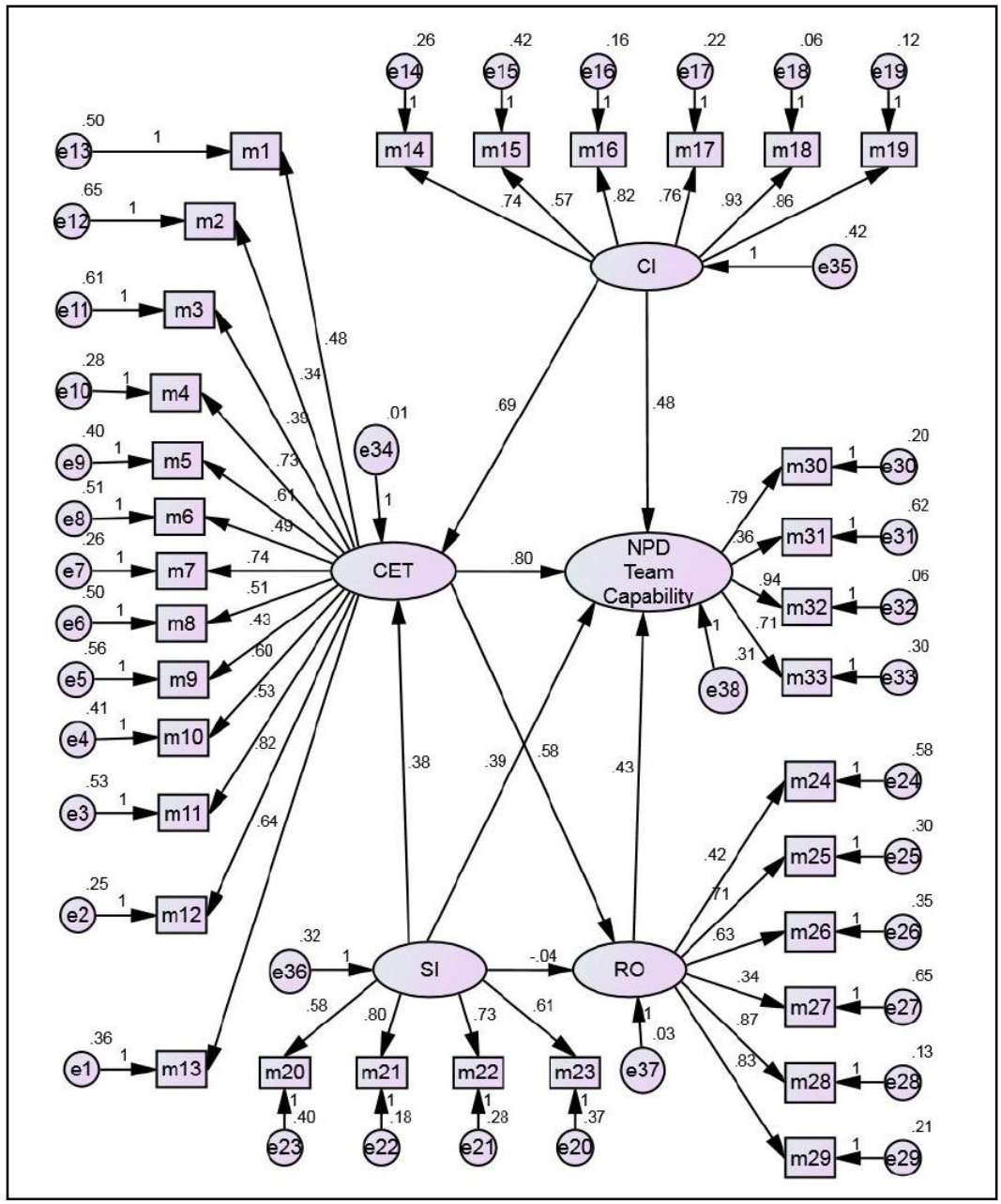

Figure 8.2 SEM portraying the combined impact of teamwork culture and its associated factors on NPD team's capability

The Fig. 8.2, is developed on the basis of the path model as shown in Fig.8.1, consisting of both measurement model as well as structural model combining the input and output latent constructs and their measures. This model represents the regression weights of manifest variables to quantify the latent constructs as shown in Table 8.1 and the standardized path coefficients that are the path estimates as shown in Table 8.2. The values in between the constructs and their indicators are fixed at 1.0 initially. There is error term associated with each manifest variable and also with each latent construct. The difference between the actual values and the desired values are calculated by the error terms associated with each indicator. Along with the values, the direction of the arrow heads is also crucial for complete significance of the framework. The arrow heading from one construct to another depicts the impact of those particular factors on the construct to which the arrow is directed.

The structural model, discussed above, enriches NPD team's capability through developing a healthy teamwork culture within the firm and makes the NPD activities easier. Adoption of the discussed factors associated with teamwork culture entails the collaborative nature among the teams for ensuring the better NPD performance overcoming the differences among the various teams within the firm. The list of constructs and their indicators as mentioned in Table 8.1 is beneficial for NPD practitioners to realize the effect of this model in practical field. The linkages among the constructs are identified by the path estimates as listed in Table 8.2. The justifications of the hypotheses are discussed below by relating the obtained path estimates from multiple regression analysis to the available academic literature.

As observed in the existing literature, the positive impact of CET for escalating NPD team's capability is well discussed. The cross-functional integration among the various NPD teams introduces CET approach as one of the essential phenomenon for problem solving (Arosnson et al., 2006). The practice of CET within the firm connects the functional areas such as manufacturing, financing, marketing which make the functional orientation easier (Savic and Kayis, 2006). This leads towards better development of economic products offering multi-dimensional exchange of information. The present study develops a model representing the positive impact of CET on NPD team's capability (H1a) since having the positive path value (path estimate=0.80, $p<0.01$). The influencing role of CET for escalating

RO (H1b) is also being supported by the positive path value between CET and RO (path estimate=0.58, $p<0.01$). This clearly portrays the positive role of CET for enhancing NPD team's capability as well as RO of the firm.

Interaction among the various functional teams is enriched through communication among the team members assuring internal as well as external linkages among the team members essential for NPD (Kleinsmann et al., 2010, Johnson and Filippini, 2013). The communication practice closely associated with the CET culture enriching the cooperation and coordination helps in sharing information among the teams essential for managerial decision-making (Poole and Hirokawa, 1996; Kennedy et al., 2011). This empirical study portrays the influential role of CI for better NPD team's capability (H2a) having the positive path estimate between CI and NPD team's capability (path value=0.48, $p<0.01$). Similarly, in case of the impact of CI on CET (H2b), it has been observed that the path estimate in between these two constructs is also positive (path value=0.69, $p<0.01$). This discussion interprets that better communication within the firm enhances the NPD team's capability as well as ensuring better CET culture within the firm.

Innovative product development necessitates the accumulation of various resources. Knowledge is one of the vital resources offering competitive advantages to the firm also influencing collaborative culture (Gu et al., 2016; Leitman, 2011). This integration of resources comprises of ideas, strategies, operational activities of NPD success (Sun et al., 2012). It also incorporates the integration of several systems highlighting the SI for NPD team's success. Like the CET culture, SI also motivates the RO of the firm through trading off among time, cost, quality, people and organization. The present study portrays a framework depicting the positive impact of SI on NPD team's capability (H3a) by the value of the path estimate between SI and NPD team's capability (path value=0.39, $p<0.01$). Similarly, it shows that the SI also has a positive effect on CET (H3b) as having the positive path value such as 0.38 ($p<0.01$). But in case of positive effect of SI on RO (H3c), the set hypothesis is not justified as the path estimates between these two constructs are negative (path value=-0.04, not significant). For this, it can be stated that the SI motivates the NPD team's capability and CET culture of the firm but it does not have the positive influence on RO.

As previously discussed RO is the integration of the various functional groups to overcome the functional barrier (Berthon et al., 2004). It actually is the strategic orientation (Chou and Yang, 2011). In this study, the hypothesis has been set stating as the positive role of RO to influence NPD team's capability (H4) has been verified as correct as the value of path estimate between RO and NPD team's capability is positive (path value=0.43, $p<0.01$). Finally among this interprets that RO motivates the NPD team's capability of the firm in turn NPD success.

The crucial and novel contribution of this study is that it highlights the teamwork culture of the firm and interprets the impact of the associated factors of the teamwork culture for NPD success. It shows that CET is the vital practice for teamwork culture followed by the CI, SI and RO. It comprehensively depicts the interplay among these factors and their combined impact on NPD team's capability for NPD success.

8.6 Conclusion

8.6.1 Theoretical Contribution

This empirical research has made important contributions to the theory on the effect of success factors of teamwork culture. These are used to influence the NPD team's capability for successful NPD. First, the factors related to teamwork culture and their antecedents are relative to NPD activities are recognized. Second, interplay of these identified factors is framed. Third, the combined impact of these factors on NPD team's capability are recognized, resulting the better realization of the constructs in practical field for NPD success.

8.6.2 Managerial Implications

A detailed study of success factors of teamwork culture and their indicators enrich the NPD team's capability to for successful development of new products. Firstly, it recognizes CET as a crucial factor of teamwork culture which is an approach where various functional groups both internal and external work together to develop new products uninterruptedly by sharing ideas and information as well as solving problem together by overcoming the differences. Collaborative culture within the team is the most important phenomenon having higher

contribution for measuring CET. This CET again is controlled by the CI among the individual team members. A better communication practice not only enriches the CET culture but also contributes to NPD team's capability for technological developments by generating the common decision making culture in the organization. The most vital measuring indicator of CI is the regular meeting for problem-solving conducted for synchronizing the team actions with proper communication practice. CET again influences the RO of the firm for accumulating and interrelating time, cost, quality, people and organization for NPD team's capability. The integration of all the processes under the system is termed as SI which escalates the CET culture as well as NPD team's capability for NPD success by integrating all kinds of available resources, like qualities, innovative ideas, of various functional teams. Formal department for SI within the organization develops the integration practice within the firm. This integrating quality accelerates the CET culture by providing all possible resources for development which is essential for concurrent work flow. Finally, RO is another factor of teamwork culture which practically depicts the strategic orientation which controls the NPD team's capability of the firm by strategically integrating the individual results of all processes. It relates the time, cost, quality, people and organization for control on NPD. But the analysis from the developed structural model shows that RO is not positively influenced by SI which depicts that assumed interrelationship of SI on RO is unsupported. This study identifies the teamwork as an organizational culture helps to structure the roadmap for selection, development and support the appropriate innovative ideas for engineers while merging the non-technical parameters to pure technical parameters in technological developments and necessarily is considered as an important issue in engineering studies. The association of teamwork culture for technological developments enriches the NPD team's capability supporting the vitality of small team culture for NPD success. CET is identified as the most vital factor among the others helps in developing the teamwork culture within the firm.

The main aim of the teamwork is to develop high-tech products within scheduled time to avoid the cost overrun. Technological developments within scheduled time have been used as a measure for the NPD team's capability for NPD success that obviates time overrun. Organization should be concerned about the break-even-time of the newly developed product and try to expand the product family for generating better profit and ultimate success, while they also need

to be careful about the consistency of scheduled product launching frequency by ensuring lowered rate of product failure.

The developed interrelationship model clearly realizes the significance of the teamwork culture within the organization for creating innovative ideas and fulfilling those ideas by providing a suitable atmosphere fostering the NPD team's capability for NPD success in terms of technological developments within scheduled time ensuring organizational success.

Chapter Summary

This chapter has provided:

- A structural framework comprising of teamwork culture based factors to portray their interplay and their combined impact on NPD team's capability for escalating NPD success of the firm.
- The quantification of factors as well as their indicators has also been performedfor realizing their impacts on NPD success.
- Managerial implications have been drawn to aid in enhancement of NPD success by implementing the factors associated with teamwork culture helps in achieving the future objectives.

Thesis work reported in this chapter has been published (Journal / Book Chapter) in the following reference:

Roy, S., Dan, P., & Modak, N. (2018). Effect of teamwork culture on NPD team's capability in Indian engineering manufacturing sector. *Management Science Letters*, *8*(7), 767-784, **Scopus**.

The next chapter draws the conclusions of the research, containing the research findings along with the managerial implications to aid in the enhancement of NPD success in Indian manufacturing industries developing engineering products. Limitations and future scope are also been discussed.

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CHAPTER 9

CONCLUSION & SCOPE OF FUTURE WORK

The summary of chapters is presented at the end of each of those. A consolidated form of those is presented here.

The first chapter refers to the idea on NPD along with the available reports on its critical success factors (CSFs) as well as its success measures. Based on this, the grouping of CSFs and success measures has also been performed. It incorporates the selection of the suitable group of success measure to each group of CSFs helps in framework development. The research gaps in earlier investigations are traced out to set present research objectives. Chapter 2 reports the methodology used for prioritizing the group of CSFs as well as methodology of framework development used for identifying their combined impact on NPD success. This chapter also associates the development of questionnaires along with the list of respondents took the part in this research from Indian manufacturing industries developing the engineering products. The chapter 3 deals with prioritization of CSFs using fuzzy extent analysis method which suggests that R&D activities is the most critical group of CSFs is succeeded by product development process (PDP), management actions, environmental factors and teamwork culture. Chapter 4 represents the structural framework portraying the interrelationships of factors directly and indirectly related to R&D along with their combined impact on technological development for NPD success. The summary of chapter 5 refers to the framework of group of PDP as well as its associated factors and their interplay to develop high quality new products for successful NPD. Chapter 6 introduces the cascading effect of management actions on NPD success by developing cost effective new products. The developed structural model also shows the role of top management support for enhancing management actions. Chapter 7 represents the impact of managerial support for encouraging entrepreneurial culture to influence the environmental factor for developing the products having less hazardous environmental impacts. The summary of chapter 8 portrays the interplay of teamwork culture and its associated factors for enhancing NPD team's capability which in turn assures NPD success of the firm.

9.1 Conclusion

This empirical investigation on NPD success factors and measures for new engineering products has led to the following specific conclusions:

1. Prioritization of groups of CSFs represents R&D activity as the most important group of CSFs, which motivates the NPD success of the firm. It is succeeded by PDP, management sections, environmental factor and teamwork culture. Adoption of these factors as per their prioritization ensures the successful NPD in Indian manufacturing industries developing engineering products.

2. It is observed that R&D practice has the highest contribution for NPD success followed by intellectual capital, technology, learning, FFEA and improvisation. R&D practice of the firm is also influenced by technology, learning and intellectual capital. Learning also motivates the intellectual capital of the firm for NPD success. Though fuzzy front end (FFE) activities and improvisation are not directly related to R&D practice but it indirectly influences the R&D activities of the firm and help in developing high-tech products for NPD success.

3. For the group of PDP and its associated factors, the product quality measures the NPD success. In this case, PDP has the highest impact on developing high quality products followed by product feature, external collaboration, modular product design and market analysis. The PDP is also influenced by external collaboration and market analysis, whereas modular product design also motivates the product feature for NPD success.

4. The management actions for smooth continuation of NPD activities are supported by managerial contribution acts as an inevitable resource for NPD. TMS has the highest impact on IT management followed by conflict management, planning, project management, long-term-vision, HR management, organizational factors, entrepreneurial culture and strategic management. These management actions again influence the NPD success as planning has the highest contribution succeeded by HR management, IT management, project management, organizational factors, conflict management and strategic management. Implementation of these management actions along with the managerial support motivates NPD success for developing cost effective new products.

5. TMS and entrepreneurial culture is identified as the strong influencing phenomenon for environmental factor to develop new products with less hazardous impact on environment. TMS enriches the entrepreneurial culture which in turn controls environmental factor for developing environment friendly new products.

6. The group of teamwork culture based factors comprises the constituents such as concurrent engineering team, communication infrastructure, system integration and result orientation which motivate NPD team's capability. Concurrent engineering team has the highest contribution on NPD team's capability followed by communication infrastructure, result orientation and system integration. Communication infrastructure and system integration motivate the concurrent engineering team of the firm which in turn positively influence the result orientation. This study also depicts that system integration does not have any impact on result orientation for enhancing NPD team's capability.

7. Summarizing the managerial implications drawn from the developed models for each group helps to emphasize the success factors as per their priorities to influence the NPD success for the firm. Adoption of these factors also incorporates the realization of the manifest variables of the respective factors as identified from their standardized regression weights. Finally, adoption of the structural models in practical field holistically aids in implementation of NPD and in enhancement of its success in the Indian manufacturing industries involved in new engineering product development.

9.2 Limitations

Every research is limited within a scope or confine, so is for this empirical study as well.

- The reliability of responses in empirical studies is often a matter of concern which is true for this study, where the proposed approach requires a large number of samples for statistical analysis and to derive results. The collection of responses from huge number of industry experts is a difficult task.

- The criticality involves in identification and removal of erratic responses which are vital before using them for arriving at the final results.

- The data could be collected, based on practical and logistics reasons, from some strategic locations where the industry concentration is high, while this study excludes many which are not in the major cities.

- It is hard to have a sampling frame from where true random selection is possible and therefore the study has to resort to its own sampling process moderated by convenience.

- The study is based on few information providers selected by the organizations, whose respondents are only to be considered to be truly representative for the organizations.

9.3 Scope of Future Work

The present research work leaves a wide scope for future investigators to explore many other aspects of success factors of NPD. Some recommendations for future research include:

- This work can be extended in other industry sectors apart from industries producing engineering products. These findings, though modelled in Indian context may, however be also explored in similar or other settings.

- The work here has been carried out at the sectorial level, broadly as engineering, however, detailed exploration for sub-sectorial levels may well be attempted.

- Study on large, medium and small scale industries for CSFs may be conducted separately which however would need a large quantum of data from each segment.

- The study has been done purely from Indian manufacturing industries. The comparison of CSFs can also be done with industries of the other countries.

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Appendix A

- Questionnaire to rank the groups of CSFs using Extent Analysis on Fuzzy AHP:
- The abbreviated forms of the factors are given below for convenience
- Put the tick mark (√) to the given boxes as per the importance of the factors in your opinion.
- Put intermediate value (if any in your opinion) in the given "Intermediate Value" box.

[Product Development Process= PDP; Teamwork Culture= TC; Management Actions= M; Environmental Factor= EF; R&D Activities= R&D]

Absolutely Imp (9)	Strongly Imp (7)	Fairly Imp (5)	Weakly Imp (3)	Factors	Equally Imp (1)	Factors	Weakly Imp (1/3)	Fairly Imp (1/5)	Strongly Imp (1/7)	Absolutely Imp (1/9)	Inter-Mediate Value
				PDP		TC					
				PDP		M					
				PDP		EF					
				PDP		R&D					
				TC		M					
				TC		EF					
				TC		R&D					
				M		EF					
				M		R&D					
				EF		R&D					

Appendix B

- Interview Protocol with description of latent variables related to R&D activities and their effect on technological developments of newly developed engineering products:
  - ***Research and Development (R&D):***

    - Number of R&D persons (m1): Number of persons associated with the R&D activities.

    - Experience of R&D team members (m2): Experience of the R&D team members which helps in the new product development.

    - Qualification of R&D team member (m3): Qualification of the R&D team members which affects the continuous flow of the product development.

    - Investment for R&D (m4): Investment in R&D infrastructure and methods for sustainable product development.

    - R&D management vision and direction: The vision of the R&D management and the direction as well for implementing R&D activities in the firm.

    - Number of patents: Number of patents of the company.

    - R&D oriented culture: The culture of the firm to perform research activities and implement the innovative ideas developed in practical field.

    - Investment in cleaner technology research: Investment for cleaner technology research for developing the products with less hazardous effects on environment.

  - ***Technology (T):***

    - Investment made to upgrade the technological infrastructure (m6): Investment for upgrading the technological infrastructure of the company better R&D activities.

    - Technology forecasting (m7): Implementation of technology forecasting to trace the difficulties.

- Usage of CAD/CAM (m8): Usage of CAD/CAM and various state-of-the-art technologies and newly launched technologies.
- Group technology/Cellular manufacturing (m9): Degree of implementation of Group technology/Cellular manufacturing.
- Lean manufacturing (m10): Implementation of lean manufacturing practices
- Flexible manufacturing system (m11): Presence of Flexible manufacturing system.
- Design for manufacturability and assembly (DFMA): Degree of adoption of Design for manufacturability and assembly.
- Enterprise resource planning systems (ERP): Use of Enterprise systems (ERP) for product data management.

➢ ***Learning (L)***

- Debriefing of all NPD experiences (m12): Tradition of debriefing of all NPD experiences of NPD team members including maintenance of NPD records of major incidents, decisions.
- Well-defined process (m13): Adoption of well-defined process to guide NPD project.
- NPD manuals to assist managerial decision-making (m14): Adoption of NPD manuals to assist managerial decision-making while managing NPD activities.
- Collective review (m15): Collective review to assess the progress and performance of NPD projects.
- In-house training (m16): Trend of attending in-house training
- On-the-job training (m17): Providing on-the-job training to individuals managing NPD.
- Reporting: Reporting about progress of NPD projects.

- Maintenance of database: Maintenance of database containing factual information on each of its NPD projects.

- Contact list of potential persons: Maintenance of contact list of potential persons (insiders/outsiders) to assist NPD.

- Guidelines for managerial decision-making: Development of guidelines to assist managerial decision-making and actions.

- Updation of management guidelines: Frequent updating of NPD management guidelines or manuals.

- Participation of managers: Managers' participation in committees to expand knowledge.

- Managers' attendance in meetings and seminars: Managers' attendance in meetings and seminars to exchange NPD-related information.

- Informal sharing and exchange of information: Managers' informal sharing and exchange of NPD-related information.

- Rotation of managers: Rotation of managers, with substantial prior experience in managing NPD projects.

- Incentive schemes: Adoption of managerial incentive schemes.

- External training programs: Trend of attending externally conducted training programs related to NPD management.

- Managerial access: Managers' accessibility of documented and codified information.

➢ ***Intellectual Capital (IC)***

- Enrichment of human capital (m18): Enrichment of company's human capital by employees' and managers' competence, experience, knowledge, skills, attitude, commitment and wisdom.

- Enhancement of company's process capital (m19): Enhancement of company's process capital by workflow, operation processes, specific methods, business development plans, information technology systems and cooperative culture.

- Improvement of company's innovation capital (m20): Improvement of company's innovation capital by intellectual properties such as patents, copyrights, trademarks, and know-how

- Level of relational capital (m21): Level of relational capital which includes all value of stakeholders, customers, and supplier relations.

➢ ***Improvisation (I):***

- Figuring out of new product-development process (m22): Figuring out of new product-development process as it went along versus following a rigid well-defined plan.

- Improvisation of team in developing the product (m23): Improvisation of team in developing this product versus strictly following the plan.

- Improvisation of team in commercializing the product (m24): Improvisation of team in commercializing this product versus strictly following the plan.

➢ ***FFE Activities (FFE Activities):***

- Interdisciplinary idea generation and screening (m25): Interdisciplinary idea generation and screening ideas by historical analogy.

- Interdisciplinary idea selection (m26): Selection of interdisciplinary idea.

- Idea selection (m27): Idea selection during meeting.

- Intensity of initial planning (m28): Performing the intensity of initial planning.

- Level of communication (m29): Level of communication in early phases of product development.

- Effort to reduce market uncertainty: Reduction of market uncertainty.

- Target market and users need: Understanding of target market and users need.

➢ ***Technological Development of Product for NPD Success (NPD Success):***

- Technological breakthrough (m30): Technological breakthrough the company achieved.
- Beating competition technologically (m31): Technological superiority of the product than the competitors.
- Expanding product family (m32): Innovating varieties types of a same product.
- Rate of failure (m33): Failure rate of the product.
- Frequency of product launching (m34): Number of new products launched in a year.
- Reduction of risks (m35): Reduction of the risk of failure associated with the NPD.
- Beating competition to market: Higher competitive advantages than competitors.
- Cannibalization effect: Risk of product failure due to development of same kind of products by the company like the existing one.

Appendix C

- Interview Protocol with description of latent variables
  - *Product Development Process (PDP):*

    - Product development performance (m1): Performance of development process and the consistency of NPD rate of the company.

    - Investment in PDP (m2): Fund investment for completion of the process of new product development.

    - Updated technological innovations (m3): Eagerness for technological innovations by applying updated tools and techniques.

    - Training for NPD management (m4): Arrangement of systematic training programs for successful management of new product development.

    - Concurrent workflow (m5): Concurrent workflow of product development activities.

    - Hands-on-working-experience (m6): Adoption of knowledge or skill through doing something in hand by the people themselves who have involved in development process.

    - Early involvement of manufacturing (m7): Involvement of manufacturing department from the very beginning of the concept development for sharing their views about the feasibility of the creative ideas.

    - Developmental time and cost (m8): Time required for developing the product and the cost associated for development.

    - Testing of products (m9): Availability of both internal and external testing for quality assurance and quality control teams for checking the product quality.

    - Adoption of TQM (m10): Managerial approach for achieving long-term success through improving processes and products in the field respective field they work.

- Advanced product development methods (m11): Adoption of advanced product development methods like failure-mode-effect-analysis (FMEA), design for manufacturability (DFM), lean manufacturing, and Just-in-Time (JIT) culture.

- Frequency of Product review (m12): Performing frequent product review on the basis of consumers' opinion.

- Team collaboration and concurrent engineering (m13): Application of team collaboration practices through integration among internal NPD teams through high level transparency, mindfulness and synergies in participants' interactions.

- Marketing research in PDP (m14): Involvement of activities for gathering information about the customers' demand and preferences.

➢ *Product Feature (PF):*

- Product performance rating (m15): Competitiveness of the developed product is analyzed by product performance rating which is obtained from consumer reports.

- Technical comparative of products (m16): Technical superiority of products in some characteristics with respect to its competitive products.

- Product failure chance (m17): Chance of failure to meet customers' requirements and fail to achieve the targeted performance.

- Product Uniqueness (m18): Innovativeness of the product including the superiority than its competitors. It also includes extrinsic rewards society provides to products as they are somehow different from others and also intrinsic satisfaction derived from the perception that they are separable from the crowd.

➢ *External Collaboration (EC)*

- Involvement of customers in NPD (m19): Customer involvement during the development process to fulfill the customer needs identified by regular meetings and intensive discussions and providing quick response to their requirements. This involves the

expenditure on market research and intelligence to acquire information and the changing needs of current and potential customers.

- Involvement of suppliers in NPD (m20): Collaboration trend of suppliers with product development team including frequent meetings and discussions, expenditure on vendor development and adoption of intelligent systems in monitoring vendor database. Emphasis on supplier relationship management is given to avoid uncertainty in safety due to exposing the technological information with suppliers and providing sufficient synchronization time required to involve with the development process.

- Collaboration for knowhow (m21): Collaboration with experts from other companies to acquire practical knowledge and skills.

➢ *Modular Product Design (MPD)*

- Adoption of Modular product design (m22): Idea generation of developing a product through assimilating a set of small products designed independently functioning together as a whole.

- Increase in product variety (m23): Varieties of products are developed by assembling the individual modular parts.

- System reliability improvement (m24): Improvement of system reliability through developing the final product by assembling the modular parts.

- Product component commonality (m25): Reusing common components in a range of products.

➢ *Market Analysis (MA):*

- Market plan generation (m26): Well-established market plan generation involves activities in accomplishing the specific marketing objectives within a set of time frame.

- Customer satisfaction (m27): Identification of customers' needs for providing high-end customer satisfaction.

- Requirement and consumption pattern (m28): Identification of need of the product and the rate of consumption.

- Target market and growth pattern (m29): Identification of particular group of consumers at which a product is aimed and the growth pattern as well.

- Market testing (m30): Experiments conducted before commercializing the new products to the open market to test its scope of the success.

- Market research (m31): Activities for assimilation of information about customer needs.

- Advertisement and promotion (m32): Expenditure on advertisement and frequent campaigning activities. It also includes active use of customer relationship management.

- Competitor monitoring (m33): Keen monitoring on competitors' activities to track their future trend of developments.

➢ *Quality Assurance for NPD Success (Q):*

- Meeting quality guidelines (m34): Achievement of quality of the new products as previously specified.

- Achieved product performance goal (m35): Attainment of product specifications as per customer demand.

- Achievement of design goal (m36): Attainment of design specifications.

Appendix D

- Interview Protocol with description of latent variables
  - *Top Management Support (TMS):*

a. Indicators as per available literature:

- Support and motivation from senior management (m1): Support and motivation from senior management in case of failures (from past experience)

- Willingness of the management in taking risk on NPD (m2): The risk taking attitude of management bodies for NPD.

- Frequency of annual meeting with participation of all level employees: The frequent meetings are conducted with all level of employees for synchronization in NPD activities.

- Commitment of senior management throughout the development process: The senior management is committed enough to perform NPD activities from idea generation to commercialization of the newly developed products.

- Delegation of top management: Representatives of top management are always be there to share their valuable ideas when required.

- Leadership by example: Strong leadership in top management.

- Support for entrepreneurship culture: Support for entrepreneurial culture to build the risk taking attitude in the firm.

b. Indicators as per experts' opinion:

- Continuous investments despite failures (m3): Despite of failures for adoption of new ideas, the funds are invested in continuous manner for the urge of success.

- Assimilation of resources as per their requirements (m4): Resources are assimilated as it required.

- Belief in new ideas and encouragement to shape them: New ideas are always believed and encouraged for successful development of new products.

- Identification of viability of the project: The viability of the project must be tested.

➢ *IT Management (ITM):*

a. Indicators as per available literature:

- Expenditure on IT management in your company (m5): Fund allotted for adopting IT infrastructure within the firm.

- Communication using fiber-optic cables (m6): Usage of fiber-optic cables for communication.

- Efficient correction of product problem areas as per customers' views: Efficiency of correcting product problem areas with which customers were dissatisfied

- Active use of in house database in the development process: In house database are used for the successful product development process.

- Usage of groupware: Use of groupware for adoption of IT in the firm.

- Identification of customers' buying pattern using Big-Data Analytics: Adoption of Big-Data Analytics to identify customer needs and extract their buying pattern.

- Applications of enterprise solutions: Applications of enterprise solutions for NPD.

- Efficient detection of product problem areas as per customers' views: The product problems areas have been detected as per the problems faced by the customers.

- Incorporation of pre-launch for lessons required for full-scale launch: The pre-launch is incorporated before the full-scale launch of the final product for NPD success.

- Post-launch, chances of technical error compared to competitors: Comparison of chances of failure with respect to the competitors after launching the product.

- Overall, products had fewer problems than normal in the industry: The problems associated with the product after full-scale launch.

b. Indicators as per experts' opinion:

- Security to preserve the documents (m7): A strong security of the documents is maintained in the firm for avoiding the cyber theft.

- Making the HR job easier by ITM (m8): Adoption of IT management system helps to make the HR job easier.

➢ *Conflict Management (CM):*

a. Indicators as per available literature:

- Application of improved conflict handling process (m9): Adoption of conflict handling process to avoid the conflicts arises during NPD process.

- Mutual understanding of company objectives (m10): Understanding of company objectives for achieving the goal.

- Commitment to collaboration (m11): Commitment to collaboration overcoming the conflict among the teams.

- Effectiveness of conflict handling teams: The effectiveness of conflict handling team to tackle the conflicting situations within the organization.

- Effectiveness of communication management: Effectiveness of communication management among various teams for conflict handling.

- Conflict management culture in the firm: The practice of handling management within the firm.

b. Indicators as per experts' opinion:

- Overcome language barrier (m12): Overcome the language barrier by learning the local languages as the basic employees are used to the local languages.

- *Project Management (PM):*

a. Indicators as per available literature:

- Project funding amount (m13): The fund allotment for project management.
- Sense of responsibility of the project manager (m14): Responsible project manager for successful completion of the project.
- Proper monitoring of scheduled projects (m15): Monitoring of the projects to be completed within the scheduled time.
- Efficiency of the project manager to deal with design engineers: Efficient project manager for dealing with the design engineers.
- Effort to reduce cost and time overrun: The effort to produce the product within estimated time and cost.
- Standardized skill set of project managers: Set the standardized skill of project manager to manage the product development activities efficiently.
- Usage of sophisticated software: Usage of high-tech software.
- Stringent/strict management of project portfolios: Strict project manager to control the project activities.
- Executive commitment to project management: Commitment of executive for managing the project efficiently.
- Corporate understanding of project management: Corporate understanding of project management for successful NPD.
- Control over line management for both resources and staffs: Control over line management related to both resources and project management staffs.

b. *Indicators as per experts' opinion:*

- Continuous learning and training for key success (m16): Continuous learning and training for adopting the activities for key success.

➢ *Human Resource Management (HRM):*

a. *Indicators as per available literature:*

- Tradition of working as a team (m17): Working as a team for successful NPD.
- Effective use of manufacturing engineering skills (m18): Effective use of manufacturing engineering skills to develop high quality products.
- Communication and cooperation within the NPD team members (m19): Communication and cooperation within the NPD team members in the firm.
- Communication and cooperation in different NPD teams: Communication and cooperation in different NPD teams helps in bridging the gap through sharing.
- Exchange of experience of the key personnel among various NPD teams: Exchange the experience of key personnel for effective use of their suggestion and opinion for successful NPD.
- Updating NPD work procedures on a regular basis: Updation of the work procedures applied for NPD.
- Adoption of a team-based appraisal system: The team-based appraisal system is adopted to encourage the team to perform better in future.
- Training in the problem-solving skills of NPD personnel: Training provided for enriching problem-solving skills of NPD personnel.

b. *Indicators as per experts' opinion:*

- Appoint best expertise for any special process (m20): Appointment of expertise as per the criteria required for performing the special process.

- *Strategic Management (SM):*

a. Indicators as per available literature:

- Long-term planning (m21): Lon-term planning to avoid the problems which can be predicted earlier.
- Effort to reduce product development cost (m22): The development cost of the product is tried to get reduced as much as possible.
- Correct forecasting of technology trend (m23): Forecasting of technology trend to track the future direction of the market.
- Emphasis on clearly defined strategic target (m24): Emphasis on clearly defined strategic target for successful completion of the NPD.
- Effort in behavior analysis of the competitors: The behaviour analysis of the competitors to trace their intension.

b. Indicators as per experts' opinion:

- Effect of performance of controlling authority: Performance of controlling authority foe effective NPD.

- *Organizational Factors (OF):*

a. Indicators as per available literature:

- Responsiveness to change (m25): Quick response to the change occurs during the development process.
- In-house development of technology related to the product (m26): In-house development of Technology required for supporting the NPD activities.
- Focus on core competency areas within the organization (m27): Highlighting the core competency areas of the organization.
- Availability of production resources: Availability of resources required for producing new products.
- Involvement of project leaders in different activities at the working level: Involvement of project leaders at every level of product development ensuring the support when it is required.
- Availability of qualified human resources: Availability of qualified human resources necessary for NPD activities.

b. Indicators as per experts' opinion:

- Multi-skilled competency: Multi-skilled competency in the field of NPD.

➢ *Planning (P):*

a. Indicators as per available literature:

- Planning of the entire NPD process in your company (m28): Detailed planning of the development activities from idea generation to commercialization.
- Organized strategic planning for coordinating NPD (m29): Organized strategic planning for coordinating NPD activities for successful development of new products.
- Plan and choose space distribution for components and structure: Plan for the space required for the components, structures and choose the ideal space for the fitment.

b. Indicators as per experts' opinion:

- Bridging the gap in micro-planning and overall planning: Bridging the gap in micro-planning and overall planning for avoiding the obstacles occurred due to the lack of micro-planning.
- Independence of alternate resource selection (m30): Managers having the independence to alternate resource selection for product development activities.

➢ *Long-term Vision (LTV):*

a. Indicators as per available literature:

- Clearly mentioned relative priority of each project target (m31): Prioritization of the projects associated with the firm as per requirements.
- Project target trade-offs between performance and cost (m32): Trading-off between the performance and cost of development.
- Specified project targets trade-offs between time and cost (m33): Trading-off between the time and cost of development.
- Specified project targets trade-offs between quality and cost: Trading-off between the quality and cost of development.

➢ *Entrepreneurial Culture (EC):*

a. Indicators as per available literature:

- Risk-taking capability which enhances probability (m34): Risk-taking capability which enhances probability of making profit.

- Emphasis on the development of new and innovative products (m35): Emphasizing the activities for NPD.
- Emphasis on R&D, technological leadership, and innovations: Emphasizing on R&D activities, technological leadership, and innovations for NPD success.
- Development of many new lines of products or services: Innovating new lines of products and services for firm's success.
- Initiative actions to which competitors then respond: Initiative actions taken by the firm which is then followed by the competitors.
- First to introduce new products/services, techniques, technologies: Number of products/services, techniques, technologies first introduced by the firm.
- Adoption of very competitive, "undo-the-competitors" posture: Adoption of competitive behaviour and far more superior then the competitors.
- Bold, wide-ranging acts to achieve the firm's objectives: Bold, wide-ranging acts to achieve the firm's objectives for NPD.
- Adoption of a bold, aggressive posture for exploiting opportunities: Adoption of a bold, aggressive posture for making full use of the scope and make benefit from it.

b. Indicators as per experts' opinion:

- New culture awareness and training (m36): Training for the adoption of new culture for smooth operation.

➢ *New Product Development Success (NPD Success):*

a. Indicators as per available literature:

- Profit margin (m37): Profit margin of the firm for the developed new product.
- Domestic market share (m38): Domestic market share of the firm of the developed new product.
- International market share (m39): International market share of the product.
- Percentage of sales by NPD (m40): Percentage of sales by developing the new product.
- Development cost (m41): Total development cost of the product.
- Attain return on investment (m42): Attain ROI after selling the product.
- Attain profitability goal (m43): Achievement of profitability goal after selling the product.
- Attain margin goal (m44): Attainment of the margin goal.

- Meet unit share goal (m45): The unit share goal achievement.
- Revenue growth (m46): The revenue growth of the company after selling the product.
- Meet revenue growth (m47): Rate of meeting the revenue growth by the company.
- Profitability relative to competitors (m48): The profitability of the firm in comparison with the competitors.
- Profitability relative to spending (m49): profitability relative to the spending of the product development.
- Net sales growth (m50): Net sales growth after selling the newly developed product.

Appendix E

- Interview Protocol with description of latent variables
  - *Top Management Support (TMS):*

    - Support and motivation from senior management (TMS1): Support and motivation from senior management in case of failures (from past experience)

    - Commitment of senior management throughout the development process (TMS2): The senior management is committed enough to perform NPD activities from idea generation to commercialization of the newly developed products.

    - Frequency of annual meeting with participation of all level employees (TMS3): The frequent meetings are conducted with all level of employees for synchronization in NPD activities.

    - Delegation of top management (TMS4): Representatives of top management are always being there to share their valuable ideas when required.

    - Leadership by example (TMS5): Strong leadership in top management.

    - Willingness of the management in taking risk on NPD (TMS6): The risk taking attitude of management bodies for NPD.

    - Support for entrepreneurship culture (TMS7): Support for entrepreneurial culture to build the risk taking attitude in the firm.

    - Planning and objective (TMS8): Planning as per the firm's objectives as set by the top management bodies.

  - *Entrepreneurial Culture (EC):*
    - Risk-taking capability which enhances probability (EC1): Risk-taking capability which enhances probability of making profit.
    - New product development culture (EC2): Emphasis on the development of new and innovative products.

- Technological leadership for R&D and innovation (EC3): Emphasizing on R&D activities, technological leadership, and innovations for NPD success.
- Development of many new lines of products or services (EC4): Innovating new lines of products and services for firm's success.
- Initiative actions to which competitors then respond (EC5): Initiative actions taken by the firm which is then followed by the competitors.
- First to introduce new products/services, techniques, technologies (EC6): Number of products/services, techniques, technologies first introduced by the firm.
- Highly competitive approach (EC7): Adoption of competitive behaviour and far more superior then the competitors.
- Productivity for high risk projects (EC8): Degree of productivity in high risk projects.
- Bold and wide-ranging acts (EC9): Bold, wide-ranging acts to achieve the firm's objectives for NPD.
- Exploration of opportunities (EC10): Adoption of a bold, aggressive posture for making full use of the scope and make benefit from it.

➢ *Environmental Factors (EF):*

- Eco friendliness of the product (EF1): Degree of suitability of the product on the basis of the environmental impact.
- Adverse effect of the product on environment (EF2): Degree of adverse effect of the product on environment.
- Sustainability of the product (EF3): Degree of sustainability of the newly developed products.
- The environmental goal achievement rate of the new green products (EF4): Rate of achieving the environmental goal.
- Compliance of new green products with the consumers' preference (EF5): Development of the green products as per the requirement of the customers.
- Meeting Government policies for product development (EF6): Development of the products abiding by the Government policies.
- Recycling rate of the new green products (EF7): Rate of recycling of the new green products developed by the company.

- Hiring responsible employees (EF8): Employment of responsible employees for developing new products.

➢ *New Product Development Success (NPD Success):*

- Reduced cost (PDS1): Reduction in the development cost of the product.
- Healthy relationship with investors (PDS2): Maintaining a healthy relationship with investors for performing the NPD activities more efficiently.
- Regulatory approvals (PDS3): Regulatory approvals from Government or the respective authorities.
- Life-cycle analysis (PDS4): Life-cycle analysis of the developed new product to check the estimated duration of product being in the market.
- Customer satisfaction (PDS5): Rate of customer satisfaction achieved by developing the products as per customer requirements.

Appendix F

- **Interview Protocol with description of latent variables**

Latent variables and description of their manifests of teamwork as organizational culture:

- *Concurrent Engineering Team (CET):*

- Collaborative culture (m1): Company culture of working together of innovative product development project team, marketing, R&D and manufacturing department as a collaborative team

- Knowledge integration (m2): Integration of technological knowledge and marketing knowledge for innovative product development

- Early stage involvement of functional groups (m3): Involvement of various discipline from early stages of new product development

- Early stage manufacturing activities (m4): Occurrence of manufacturing activities from early stages of product development

- Concurrency of process and product design in same group (m5): Degree of process design is done concurrently with product design

- Concurrency of process and product design in different groups (m6): Designs of product and process development are established concurrently by a group of employees from various disciplines

- Sharing of information (m7): Sharing of information among different departments

- Idea generation and sharing (m8): Degree of operation in generating new product ideas and sharing information

- Co-ordination to achieve targets (m9): Willingness to coordinate to achieve the target of innovative product development

- Strategic consideration (m10): Willingness to coordinate for strategic consideration
- Inter department opinion sharing (m11): Sharing of information among different product development groups
- Solving disagreements (m12): Degree of exchanging complete and accurate information for problem-solving
- Managerial support and motivation (m13): Degree of motivation and support of top managers

➢ *Communication Infrastructure (CI):*

- Regular meeting for problem solving (m14):Arrangement of direct, face-to-face meetings and problem solving between co-located teams (almost every day)
- Virtual communication (m15): Availability of E-mail, messenger, shared database supporting face-to-face communications (on a continuous base) facilities in your company
- Video conference (m16): Regular video conferencing (on average 10-20 times for the entire NPD process) between virtual teams are arranged in your company
- NPD database system (m17): Usage of NPD database system is available on a continuous base in your company
- Internet-based telecommunication tools (m18): Availabilities of internet-based telecommunication tools for the file sharing on-line real-time communications in your company on a continuous base
- Face-to-face meeting of virtual teams (m19): Irregular face-to-face meetings in between virtual teams are arranged in your company for periodic adjustments (typically, 1-2 times per project)

- *System Integration (SI):*

- Formal department for system integration (m20): Availability of formal department that manages the system integration

- Experienced engineers for system integration (m21): Possession of experienced engineers with product knowledge in the system integration department who help to integrate several teams working on separate modules

- Availability of middle management (m22): Availability of middle management, with operational skills and understanding of corporate strategy, to handle system integration activities

- Presence of a product manager for system integration (m23): Necessity of a product manager for system integration

- *Result Orientation (RO)*

- Interrelationships of time, costs, quality, people and organization (m24): Interrelationships among various backgrounds like time, costs, quality, people and organization for better innovative product development activity

- Consideration of different times associated (m25): In case of time, consideration of time for idea generation, speed, cycle time and delivery time

- Consideration of various cost associated(m26):In case of costs, consideration of operations cost and cost savings

- Focus on quality factors (m27): Focus on customer satisfaction, service, reliability and safety for quality purpose

- Consideration of factors related to people and market (m28): In case of people, use of teaching, appreciation and involvement as sub factors and for market concern about revenue, market shares, status, organizational knowledge and change in culture for result orientation

- Accumulation of both financial and non-financial results (m29):Overall, accumulation of both financial and non-financial results together for result orientation purpose

➢ *NPD Team's Capability*

- Technological developments (m30): Concern about the idea of break-even-time and technological breakthrough to beat the competition technologically

- Expansion of product family (m31): Expansion of product family by innovating different added features to the existing products and introduce them to the market in proper time to reduce the cannibalization effect which means the obsolescence of their own products due to introduction of new one by themselves

- Scheduled product launching frequency (m32): Sustain frequency of new product launching time to maintain the launch-on-time by controlling the development time of products

- Reduction of failure rate (m33): Reduction of risks which helps to decrease the failure rate of the developed products

- Time associated for development: Time to develop the new products.

Journals

I. Roy, S., Dan, P. K., & Modak, N. (2019). Leveraging New Product Innovation through R&D Practices in Engineering Manufacturing Sector: A Study in Indian Context. *International Journal of Innovation and Sustainable Development*, Inderscience, **ESCI** (Article in Press).

Leveraging new product innovation through R&D practices in engineering manufacturing sector: a study in Indian context

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Abstract: This paper presents a framework for scrutinising the interrelationship and impact of constituents of Research & Development (R&D) Practices on new product innovation (PI) success, besides identifying those. Such cited factors, deemed to be critical, are R&D investment, technology, learning, intellectual capital as well as the fuzzy front end (FFE) activities followed by improvisation for innovation. Product innovation has grown into a compelling strategy of manufacturing industries for confronting volatility and rapid changes of market due to globalisation. The aforementioned practices lead to the technological developments of the firm resulting in PI success. An interrelationship framework considering factors of R&D practices and technological improvement is developed, in this work, using structural equation modelling (SEM) approach. The magnitude of the interrelationship, investigated indicates that technology, learning and intellectual capital directly influence R&D effort, which in turn escalates PI. The other constituents, namely FFE activities and improvisation promotes PI success as well.

Keywords: PI; product innovation; R&D; research & development; technological developments; SEM; structural equation modelling.

II. Roy, S., Dan, P. K., &Modak, N. (2018). Cascading effects of management actions on NPD in the manufacturing sector: The Indian context. *Journal of Manufacturing Technology Management*, Emerald, **SCIE** (Article in Press).

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Cascading effects of management actions on NPD in the manufacturing sector

The Indian context

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Abstract

Purpose – The purpose of this paper is to study the cascading effect of management actions on new product development (NPD) for achieving success in Indian manufacturing industries. The critical linkage of managerial support for establishing management actions has been explored to realize the NPD success in terms of financial and economic measures.

Design/methodology/approach – The structural equation modeling approach is used to investigate the relationship depicting the managerial control on management practices for NPD success. Primary data from 263 experts of Indian manufacturing industries have been collected for the purpose of this analysis.

Findings – Senior management motivation, risk-taking attitude, problem-solving capacity, awareness in novel development cascade the management actions such as information technology management, conflict management, project management, human resource management, strategic management, organizational factors, planning, long-term vision, and entrepreneurial culture to escalate the NPD success, which in turn be articulated by financial and economic terms.

Practical implications – The findings suggest that managerial support influences the adoption of management actions leading toward NPD success. The developed framework realizes the necessity of implementation of these management actions cascaded from the top management support (TMS) for influencing the financial and economic measures of NPD success.

Originality/value – The cascaded framework depicting the TMS for implementing management actions for NPD success in Indian manufacturing sectors adds novelty to the available literature. Moreover, this study uses a semi-structured questionnaire which incorporates the practical experiences of the experts for quantifying the constructs in a more detailed manner than available in the previous literature. Besides, the realization of comprehensive management actions along with the support from senior management escalates the implementation of the developed framework for NPD success in near future.

Keywords New product development, Modelling, Management control

Paper type Research paper

Introduction

Escalation of the competition in the global market entails manufacturers to improve their product development capabilities for industrial sustainability. New product development (NPD) activities have eventuated as a decisive approach for strengthening the position in the competitive market environment. According to the perspective provided by Buyukozkan and Arsenyan (2012), NPD performance has become a decisive characteristic of a firm's success and survival. Despite difficulties and complexities associated with the NPD task, it has turned out to be a major determinant of the endurance of the firm (Sarja, 2015). There are numerous factors related to the technology, market, and research and development (Ernst, 2002; Bhuiyan, 2011), which are critical for the success of the firm, termed as critical success factors (CSFs), influencers in controlling the NPD performance, for

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Effect of teamwork culture on NPD team's capability in Indian engineering manufacturing sector

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A B S T R A C T

Teamwork, for competitive advantage, involving techno-socio-cultural aspects of organizations for engineering developments, is gaining importance rather rapidly due to advent of globalization. The purpose of this study is to identify the importance of teamwork culture for new product development (NPD) success through enriching the NPD team's capability in Indian manufacturing industries. It accumulates the teamwork culture dynamics and practices, their interrelationships and their combined impact on NPD team's capability in terms of technological developments for NPD success. This practical analysis collects primary data from 263 design and development experts from Indian engineering manufacturing companies. Structural equation modeling (SEM) approach is applied to investigate the interrelationship among associated variables of teamwork culture and NPD team's capability for NPD success. Concurrent engineering team (CET), communication infrastructure (CI), system integration (SI) and result orientation (RO) have been recognized as allied factors of teamwork culture. Successful adoption of associated variables ensures NPD success through influencing NPD team's capability which in turn articulated by technological developments. The realization of combined impact of teamwork and its allied variables escalates technological developments which in turn enriches NPD team's capability assuring organizational success. The result indicates that both CI and SI support CET for accelerating NPD team's capability through technological developments. Besides, CET motivates innovation orientation most precisely referred as RO for escalating NPD team's capability through technological developments for innovation.

1. Introduction

The progression of globalization leads to social, cultural and political linkage worldwide making industrial success and sustainability uncertain. Technological innovation upgrades organizational innovativeness through new product development (NPD) (Nikakhtar et al., 2014; Nagano et al., 2014; Parthasarthy & Hammond, 2002). This evolves the companies to produce new ideas and strategies for securing their future prospect. Though continuous improvement is a difficult task to be performed (Hailu et al., 2018) but NPD is an effective way for revitalizing the success of the firm by providing new products with the features as per the customers' demand (Bhuiyan, 2011). From NPD strategy to commercialization there are numerous factors influencing the ultimate growth of the firm by performing innovative activities (Chen et al., 2014; Azad et al., 2013; De Sousa Mendes & Ganga, 2013). Difference in social, economic

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Product Quality as Factors and Measures for New Product Development Success in Indian Manufacturing Industries

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Abstract

The key purpose of this study is the identification of factors governing the quality of newly developed products to recognize the importance of control over the product quality in Indian manufacturing industries. The quality measures such as meet quality guidelines, achieved product performance goal and achievement of design goals, have also been considered as the success measures of new product development success. The Structural Equation Modeling (SEM) approach has been used to build a causal relationship between success factors and measures by using AMOS 5.0 software package along with SPSS.

Selection and peer-review under responsibility of Conference Committee Members of 5th International Conference of Materials Processing and Characterization (ICMPC 2016).

*Keywords:*Critical success factors, success measures, new product development(NPD), product quality, product development success, structural equation modeling (SEM);

1. Introduction

Various constituents affecting firm's performance and plays a vital role for their success and survival is termed as critical success factors in previous literaturesby Ernst [1] and Bhuiyan [2]. As per Buyukozkan and Arsenyan [3] new product development (NPD) activity has become indispensiblefor betterment of firm's performance for sustaining in the volatile and competitive market environment in the global perspective. According to empirical study of previous researchers NPD success can be influenced by various factors such as market analysis which have been discussed by Medeiros et al. [4] and Sadeghi et al. [5], top management support by Felekoglu and Moultrie [6] and Yeh et al. [7], cross functional team by Yeh et al. [7] and Lau [8], planning by Sadeghi et al. [5] and Tsai [9], HR management by Medeiros et al. [4] and Sadeghi et al. [5], strategic management by Medeiros et al. [4] andBuyukozkan and Arsenyan [3], technological improvements such as integration of rapid prototyping and manufacturing with CAD/CAM to improve the capability of rapid product development in SMEs by Matta et al.

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Identification of Success Factors of Products and Services for Industrial Sustainability: A Structural Equation Modeling Approach

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Abstract—*Globalization leads towards innovations which in turn escalates market volatility. New product development (NPD) is one of the vital characteristic of the firm for achieving competitive advantage in this crucial environment. Similarly, service development is also established as an addition feature in the present era. Identification of factors critical for success and survival of the company becomes inevitable phenomenon for sustaining in the competition. This empirical research develop a framework depicting the role of market analysis as a critical success factor for new product as well as service development and quality of product and service as a success measure using Structural Equation Modeling (SEM) approach.*

1. INTRODUCTION

Product development (NPD) has become a necessary and unavoidable phenomenon for firms and organizations to sustain in the competition of rapidly growing global market [5]. Same as the product, the trend of increasing attention of management practitioners and researchers towards service development has been observed in recent days [12]. The importance of various factors controlling the firm's improvements, famously known as critical success factors, has been proven by previous literatures [4, 12]. Empirical researches strengthen the inevitable role of these factors for the success and survival of any firm both in product and service development field. In case of product development there are various factors considered by previous researchers which are critical to success, such a technology [25, 29, 38], research and development (R&D) [14, 37, 38], cross-functional team collaboration [9, 10, 13, 34], market analysis [28, 32], top management support [16, 38], planning [32, 35], HR management [28, 32, 35], strategic management [5, 28]. Likewise the product developments there are various success factors in service development impacted on success of the firm. These factors influence the decision making of the firm for service development for providing better service [1]. As per literatures success factors for service development are customer requirements [1, 20, 24], stakeholders participation [3, 30], communication and collaboration [8, 22]. Same as the various success factors, numerous measures of product and service development success indexed in previous literatures [17, 19, 23, 27] are essential for measuring the final success of the firm. This success can be expressed in different perspectives like time, cost, quality, customer, technology and additional features as per experts' opinion of various industries.

The objective of this research is to segment the factors of product and service development in three sections such as social factors, environmental factors and business & economic factors. After clustering success factors into aforesaid divisions the very next step is to develop a framework concerning the factors of each sections such as framework for social variants, environmental variants and business & economic variants. In this study a framework has been developed concerning the importance of market analysis as a success factor and quality related success measures for both in product and service field and analyze the effects of the factors on product and service development by hypotheses testing using Structural Equation Modeling (SEM) approach.

2. METHODOLOGY

The Structural equation modelling (SEM) approach is used here to build the relationship among those factors which are critical for organizational success and survival and correlate them with the new product development. SEM is a methodology for representing, estimating, and testing a theoretical network of (mostly) linear relations between variables. It is a comprehensive statistical approach for testing hypotheses about relations among observed and latent variables. In this paper a SEM model has been developed using the above mentioned factor which is technological improvements and hypothesis to relate with the product development success for industrial sustainability. Here, manufacturing industries in India are chosen for the survey purpose and data are collected from their NPD personnel and managers. The statistic used in this work is obtained from the

VI. Roy, S., Modak, N., & Dan, P. K. (2016). A new product development framework: combining analytic hierarchy process & structural equation modeling approach. *Indian Journal of Engineering: An International Journal*, *13*(33), 401-407.

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A NEW PRODUCT DEVELOPMENT FRAMEWORK: COMBINING ANALYTIC HIERARCHY PROCESS & STRUCTURAL EQUATION MODELING APPROACH

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Abstract

Identification of factors contributing to product development success in Indian manufacturing firms becomes essential for every organization to sustain in the competitive and volatile market environment which in turn reflects the ultimate achievement of the company. This study concerns about the identification of success factors and as well as success measures of new product development (NPD) in Indian manufacturing firms. Previous researches proves the importance of management related factors such as market analysis (MA), top management support (TMS), cross functional team (CFT), planning (P), human resource management (HRM), strategic management (SM) for successful product design and development. Accordingly, various aspects of success measures has been identified and segmented by experts in six different groups based on their characteristics such as measures related to time (C1), cost (C2), quality (C3), customer (C4), technological improvements (C5) and additional features (C6). Weights of clustered success measures have been calculated using Analytic Hierarchy Process (AHP). As the weight of the quality related measures is higher than others, so this has been used as success measure for this study. The manifests of the quality related measures are meet quality guidelines, achieved product performance goal and achievement of design goals. This empirical study is based on the data collected from 29 engineering manufacturing industries in India, involved in product design and development activities. The reliability of the data has been tested by applying Cronbach's Alpha reliability test using IBM SPSS software. The main objective of this study is to develop a framework using structural equation modeling approach (SEM) to analyse the effects of the all six management related constructs on product development success which can be expressed by quality related constructs. The model is structured using IBM SPSS AMOS 22.0 software for analysis purpose. The hypothesis testing performed by using SEM approach proves that each factor has positive impact on product development success.

Keywords: Critical success factors, success measures, AHP, Structural Equation Modeling

Book Chapters

I. Roy, S., Modak, N., & Dan, P. K. (2018). Integration of Environmental Impacts in Sustainable New Product Development.In S. K. Ghosh (Ed.),Waste Management and Resource Efficiency. Singapore: Springer. ISBN: 978-981-10-7289-5.

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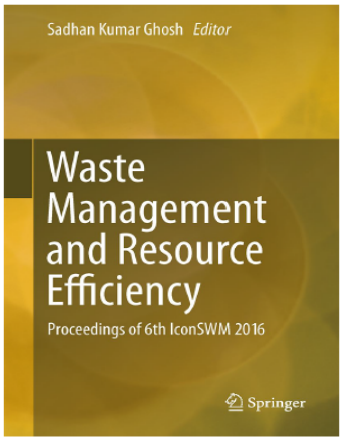

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Ghosh, Sadhan Kumar (Ed.), Professor, Dept. of Mechanical Engg. Jadavpur University, Kolkata

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Integration of Environmental Impacts in Sustainable New Product Development

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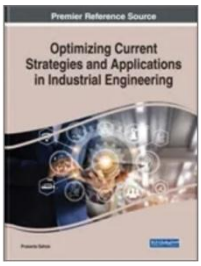
ABSTRACT *Introduction of new products has become a strategic area globally for sustaining a competitive advantage. There are several factors contributing to new product development (NPD) success are known as critical success factors which are essential for firms' ultimate success. As per the survey environmental concern should greatly be increased in magnitude in Indian manufacturing companies for success and survival. This study concerns about the identification of manifests used to signify the environmental impacts on NPD success where the success of firms have also been expressed by the environmental aspects. As empirical data and experiences have accumulated manifests of environmental factor are eco friendliness of the product, adverse effect of the product on environment, sustainability of the product, the environmental goal achievement rate of the new green products, compliance of new green products with the consumers' preference, meeting Government policies for product development, recycling rate of the new green products and hiring responsible employees. Same as the factor, environment related measure is expressed by reduced cost, healthy relationship with investors, regulatory approvals, life-cycle analysis and customer satisfaction. A semi-structured questionnaire has been developed and detailed research interviews have been collected from design and development experts of Indian manufacturing companies. Reliability of the survey data has been tested by Cronbach's Alpha reliability testing using IBM SPSS 21.0 software. The main objective of this study is to develop a framework using structural equation modeling approach (SEM) by IBM SPSS AMOS 21.0 software to analyse the effects of environmental impacts on NPD success. The hypothesis testing performed by using SEM approach proves that that environmental impact is positively related to product development success. In addition, identification of obstacles faced by manufacturing companies to implement environmental factor adds an extra novelty in this empirical research which will help to overcome the problems in future days.*

Keywords: *New product development, critical success factors, success measures, environmental impact, Structural Equation Modeling;*

II. Roy, S., Dan, P. K., & Modak, N. (2019). Role of R&D Practices for Effective Product Development Process in NPD. In *Optimizing Current Strategies and Applications in Industrial Engineering* (pp. 140-159). IGI Global. DOI: 10.4018/978-1-5225-8223-6.ch006.



Role of R&D Practices for Effective Product Development Process in NPD

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Abstract

The necessity of new product development (NPD) in the global competition is a well-established fact. Imperativeness of research and development (R&D) practices and product development process (PDP) in NPD are inevitable. In case of R&D practices, fuzzy-front-end (FFE) activities and improvisation are the two sub-factors which are not directly related to R&D but motivate it indirectly with their actions. For PDP, modular product development (MPD) and market analysis are recognized as the factors directly influencing the PDP of the firm for NPD success. This chapter considers product quality and technological developments as performance attributes for development of comprehensive framework by structural equation modeling (SEM) approach. Primary data from 263 experts of Indian manufacturing industries has been collected for analysis purpose. This empirical research portrays the role of R&D practices along with its indirectly related success factors for effectively controlling PDP along with its sub-factors for developing high quality products with technological developments.

Introduction

New product development (NPD) is an essential activity each firm be involved to guarantee success and survival in competitive market environment (Sholeh et al., 2018). Globalization brings the world in a single platform and widens the scope of selecting the products as per the requirements and choice of end-users. This enforces the firms to develop new products by optimal utilization of available resources (Roy et al., 2018). SME sector is the backbone of Indian economy by contributing almost 6.11% of manufacturing GDP (www.cii.in). It provides resilience to economic adversities and protract in global competition. This evinces the necessity of NPD activities in SMEs for sustaining in dynamic manufacturing environment by producing innovative concepts and strategies for future growth (Roy et al., 2018). NPD success is a very rare target to be attained due to associated high costs, requirement of updated knowledgebase about customers' demand, adoption of state-of-the-art technologies and sound experience on NPD activities for fulfilment of NPD objectives (Largosen, 2005).Though involvement in NPD activities and setting policies for success increases in all types of industries, NPD effort somehow fails at the final stage due to lack of systematic approach from the early stage of development (Florén et al., 2018). NPD is a series of activities every firm involves for developing new products (Bhuiyan, 2011). It consists of seven stages from strategy development followed by generation of initial ideas, screening and evaluation of those developed ideas, design and development evolves structuring of the developed idea into a product that is producible, testing and finally the commercialization (Booz et al., 1982). Control of various parameters on NPD activities during the development process is well-noticed. Role of these parameters are critically vital and must be taken

III. Roy, S., Modak, N., & Dan, P. K. (2018, January). Entrepreneurial Culture-Driven Improvement of Technical Facets for Product Quality and Customer Satisfaction. In *International Conference on Mechanical Engineering* (pp. 713-732). Springer, Cham.

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Entrepreneurial Culture-Driven Improvement of Technical Facets for Product Quality and Customer Satisfaction

Authors Authors and affiliations

Sudeshna Roy, Nipu Modak, Pranab K. Dan

Abstract

Globalization widens the platform of small-, medium- and large-scale industries for achieving success by exploring their competitive advantages for continual development. New product development (NPD) is one of those constituents which enrich the competence of companies for industrial sustainability. In today's era, entrepreneurship has become one of the essential cultures of the company to support and develop innovative products by encouraging the NPD activities. This empirical study accumulates primary data from 76 Indian manufacturing companies and identifies the role of entrepreneurial culture to promote the technical improvements which again accelerate the NPD success by developing quality products as per customer demand. Interrelationship model of these constructs is developed by structural equation modelling (SEM) approach using IBM SPSS Amos 21.0 software packages. This model developed from the experts' opinion depicts that entrepreneurial culture positively encourages the technological advancement of companies which helps to develop innovative products of better quality to attain customer satisfaction and in turn the NPD success.

Keywords

New product development Entrepreneurial culture Technical improvement
Structural equation modelling

IV. Roy, S., Modak, N., & Dan, P. K. (2018, January). Managerial Support in R&D Operations and Practices for Realizing Technological developments. In *International Conference on Mechanical Engineering* (pp. 733-756). Springer, Cham.

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Managerial Support in R&D Operations and Practices for Realizing Technological developments

Authors | Authors and affiliations

Sudeshna Roy, Nipu Modak, Pranab K. Dan

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ABSTRACT

New product development (NPD) has become inevitable constituent of the various scales of industries for industrial sustainability. Global market introduces an enormous scope for exploring new products and expanding product families for developing competitive advantage. This approach not only brings innovativeness to the companies but also accompanied by challenging environment for success and survival. Support from top managers motivates research and development (R&D) operations and practices in the company which helps to develop new and innovative products by proper utilization of available resources. This empirical study identifies the influential role of top management to control the R&D activities in optimal way to develop new products with technological advancement. The primary data have been collected from 76 Indian manufacturing companies to depict the role of top management support to expand R&D operations and practices for technological developments which in turn accelerate NPD success. Structural equation modeling (SEM) approach has been used to develop the structural model using IBM SPSS AMOS 21.0 software package.

Keywords

New product development | Top management support | Research and development | Technological development | Structural equation modeling

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Determinants of Sustainable New Product Development and Their Impacts in Manufacturing Companies

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Necessity of sustainable new product development (S-NPD) has becoming increasingly relevant in the present era for sustaining in the global competition. Though S-NPD has been neglected earlier but its' vital role in business and academic perspectives indulges the companies to be involved in S-NPD for their own sake. This research identifies seven critical success factors (CSFs) of S-NPD and their indicators as well. After recognition, it realizes the importance for implementation of these factors in Indian manufacturing companies. It recognizes the CSFs such as structural configuration, learning practice, strategic configuration, internal perspectives, external issues, PLC analysis and additional performance for S-NPD. This S-NPD can be achieved by effort to reduce cost and increase profitability, achieving resource efficiency, customer satisfaction, reduction of environmental pollution created by the product, health and safety aspects, social aspects and life cycle analysis. This study accumulates the primary data from 255 manufacturing experts mainly from design and development team for data analysis. The structural equation modeling (SEM) approach is been employed to analyse the combined impact of these CSFs on sustainable NPD by using IBM SPSS AMOS 21.0 software. This study interprets that all the CSFs have positive impact on sustainable product development for enhancing the S-NPD. Strategic configuration has been identified as the most impacted success factor for S-NPD. Among success measures, customer satisfaction is recognized as the most vital measure followed by health and safety aspects, life cycle analysis, social aspects, resource efficiency, reduction of environmental pollution created by the product and reduced cost and increase profitability. This empirical research helps to draw the managerial implications for highlighting the success factors and measures as per their importance for S-NPD.

Keywords: *Sustainable new product development (S-NPD), Critical success factors(CSFs), Structural equation modeling (SEM).*

1.0 INTRODUCTION

New product development (NPD) is a process of introducing products completely new to market through series of activities for fulfilling the customers' need [1]. NPD influences cost, quality, development time, customer satisfaction and financial performance of the firm for achieving industrial sustainability. The idea of sustainability is incorporated with NPD focusing on sustainable new product development (S-NPD) by involving sustainability with each phase of NPD to value their customers [2]-[3]. Environmental issues adds a different dimension to NPD process of the firm which is often been neglected. Cleaner production, eco-innovation have been introduced, but these activities are remained as a 'term' for the small and medium scaled enterprises (SMEs) [4]. In this era of globalization, the NPD is not only an affair of developing something innovative, but to produce new products by considering its adverse effect on

VI. Roy, S., Modak, N., & Dan, P. K. Managerial Support to Control Entrepreneurial Culture in Integrating Environmental Impacts for Sustainable New Product Development. In S. K. Ghosh (Ed.), Sustainable Waste Management: Policies and Case Studies. Springer (Accepted).

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Managerial Support to Control Entrepreneurial Culture in Integrating Environmental Impacts for Sustainable New Product Development

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ABSTRACT *Globalization leads towards the development of new products practice for small to large scale companies to survive and compete in the next level challenges. Recently 'Make in India' concept highlights the necessity of developments of innovative products rather being developing the conventional ones which are already existing in the market. Environmental concern is one of the vital but barely neglected constituent which companies are less bothered. But the scenario has been changing rapidly and environmental impacts have become inseparable part of new product development (NPD), every company are craving for. Proper managerial support from top managers' helps to develop the better working environment in the firm which is again motivates the entrepreneurial culture. Entrepreneurship is such a culture which encourages the new and innovative ideas to be welcomed in the company and also implemented for better NPD performance. Entrepreneurial culture enhances the idea of caring environmental factors which are essential for successful NPD. This study draws the interrelationship among these factors and also depicts their effects on NPD success which in turn be quantified by environmental concern. The structural equation modeling (SEM) approach has been used to develop the interrelationship model by using IBM SPSS AMOS 21.0 software. A detailed questionnaire survey has been performed to collect the primary data from 72 experts of Indian manufacturing industries for analysis purpose. Composite reliability, average variance extracted and Cronbach's alpha reliability testing are performed to test the reliability of the survey data by using IBM SPSS 21.0 software. The interpretation from the developed model clearly states the role of top management support to escalates the entrepreneurial culture of the company which is again positively influences the environmental factors for NPD success which in turn be measured by environmental aspects like reduced cost, healthy relationship with investors, regulatory approvals, life-cycle analysis and customer satisfaction.*

Keywords: *New product development, top management support, entrepreneurial culture, environmental factors, Structural Equation Modeling;*

International Society of Waste Management, Air and Water

VII. Roy, S., Modak, N., & Dan, P. K. A Framework of Strategic Role for Developing Sustainable Products: Structural Equation Modeling Approach. In S. K. Ghosh (Ed.), Sustainable Waste Management: Policies and Case Studies. Springer (Accepted).

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A Framework of Strategic Role for Developing Sustainable Products: Structural Equation Modeling Approach

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ABSTRACT *Sustainability in global competitive market environment seeks development of innovative products for achieving overall success. New product development (NPD) has become an inevitable activity to all type of industries irrespective of their size and capacity. Recently, 'Swachh Bharat Abhiyan' has introduced as an enormous movement that seeks to create a Clean India. Cleanliness is not about cleaning the streets and surroundings. It is also about the effect of the new products developed for fulfilling customer needs and also the impact it lefts during the development process. In past era, environmental factors are one of those critically vital factors which have been mostly neglected during the product development process. In past few decades, the global warming reaches to the alarming condition which makes the world concern about the environmental hazards created by developed products and during their processes as well. Strategic management of managers and leaders are essential to make the firms aware of the environmental factors for NPD. Proper strategic planning helps to control the environmental factors for achieving NPD success. This study develops the structural model depicting the control of strategic management over environmental factors to achieve NPD success which in turn be measured by environmental aspects. Structural equation modeling approach has been applied to build the interrelationship model by using IBM SPSS AMOS 21.0 software. This empirical study has been followed by a detailed questionnaire survey which is performed by collecting primary data from 72 experts of Indian engineering manufacturing industries. The reliability of these real life data has been analyzed by composite reliability, average variance extracted and Cronbach's alpha reliability testing by using IBM SPSS 21.0 software. The developed model portrays the influential role of strategic management to control the environmental factors through tuning their antecedents which finally motivates NPD success which in turn be measured by environmental measures essential for sustainable NPD.*

Keywords: *New product development, strategic management, environmental factors, Structural Equation Modeling;*

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1.0 Introduction

Globalization gifts the opportunity to reach every single corner of the world and provide a huge platform to share innovative ideas crossing the geographical barrier. This scope is associated with competitive market environment which challenges the industrial sustainability [1]. Along

VIII. Roy, S., Modak, N., & Dan, P. K. (2016). Effects of technological improvements on new product development success in Indian manufacturing industries: Structural Equation Modeling Approach. In R. K. Jain & S. P. VK (Eds.), Decision Sciences for Business Excellence: A Cross-functional Perspective. New Delhi: Excel India Publishers. ISBN: 978-93-86256-21-8.

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Effects of Technological Improvements on New Product Development Success in Indian Manufacturing Industries: Structural Equation Modeling Approach

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Abstract—*New product development (NPD) is a challenge to the companies in recent competitive market environment to sustain in the global market. There are various types of factors critical to success which affects NPD performance of a company and also influences companies' success. This study considers technological improvements, one of the most important critical success factors, and identifies the measures controlling technological improvements and their effects on the product development success in Indian manufacturing industries. Analytic Hierarchy Process (AHP), one of the multi criteria decision making (MCDM) techniques, has been used to rank these controlling measures of success factors. Likewise the success factors, various aspects of success measures have also been recognized in previous literatures which are used to express the product development success of any firm. The measures related to technological improvements have been considered here to evaluate the NPD success. The main objective of this study is to develop a framework using structural equation modeling approach (SEM) considering technological improvements as success factors and measures as well.*

Paper Topic: Product development and commercialization

Keywords: *New Product Development (NPD), Success Factors, Success Measures, Analytic Hierarchy Process (AHP), Structural Equation Modeling Approach (SEM)*

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I. I. Roy, S., Modak, N., & Dan, P. K. (2019, April).Impact of Managerial Support for R&D and PDP activities in New Product Development using SEM and MCDM Approach. Proceedings of International Conference on Emerging Trends in Multidisciplinary Research (ICETMR-2019), National University Singapore, Singapore.

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Impact of Managerial Support for R&D and PDP activities in New Product Development using SEM and MCDM Approach

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Abstract

Globalization necessitates the need of new product development (NPD) activities for sustaining in the worldwide competition. Role of research & development (R&D) practices for developing innovative products is indispensible. It upgrades product development process (PDP) of the firm which is essential to develop new products. Top management support (TMS) and motivation encourages the R&D activities in turn the PDP to escalate NPD success. Success can be quantified in various aspects as per the requirements. This study considers product quality, development cost, customer satisfaction, technological developments and development time as performance attributes for development of comprehensive framework by structural equation modeling (SEM) approach using IBM SPSS AMOS 21.0 software packages. It accumulates primary data from 263 experts from Indian manufacturing industries for analyzing the results. Construct validity and reliability of the data has been tested using IBM SPSS 21.0. Weight calculation of the performance attributes has been performed by using analytic hierarchy process (AHP). Prioritization of these performance attributes has also been conducted by another multi-criteria-decision-making approach named as Technique of Order Preference by Similarity to Idea Solution (TOPSIS). This empirical research represents the influential role of TMS, R&D practices and PDP activities for escalating NPD success. It also portrays the interrelationship model depicting managerial support to enhance R&D practices as well as PDP for successful NPD. This study also identifies the significance of product quality as the vital most performance attribute which the firms must take care for industrial sustainability.

II. Roy, S., Modak, N., & Dan, P. K. (2019, April).*Impact of Collaborative Drivers of NPD on Quality Cost and Customer Satisfaction*. Proceedings of International Conference on Advances in Material and Manufacturing Engineering (ICAMME-2019), Kalinga Institute of Industrial Technology, Bhubaneswar, India.

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Impact of collaborative drivers of NPD on quality cost and customer satisfaction

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Abstract. MAKE IN INDIA' necessitates the collaborative approach in new product development (NPD) activities in Indian manufacturing industries for attaining global success. Collaboration nature is one of the phenomenon requires to be developed within the organization for industrial sustainability. This requires communication infrastructure (CI), conflict management (CM), concurrent engineering team (CET) and collaborative product design (CPD) for NPD success to produce cost effective quality products for customer satisfaction. Structural equation modeling (SEM) is employed to develop a framework depicting the interrelationship among the constructs based on the empirical data collected from 263 experts of Indian manufacturing companies. The analysis interprets that sound CI can improve NPD success along with better CET and CPD. It also able to smoothly handle the conflicts occurred within the firm. CM, CET and CPD have positive impact on NPD success among which CET motivates CPD for successful NPD.

Keywords: New product development, Concurrent engineering team, Cost, Quality, Customer satisfaction.

III. Roy, S., Modak, N., & Dan, P. K. (2018, December).*Role of Product Development Process for NPD Success in Indian Manufacturing Industries: Quality, Cost and Technological Aspects*. Proceedings of 7th International & 28th All India Manufacturing Technology, Design and Research Conference (AIMTDR-2018), Anna University, Chennai, India.

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Role of Product Development Process for NPD Success in Indian Manufacturing Industries: Quality, Cost and Technological Aspects

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Abstract. 'MAKE IN INDIA' necessitates the boost in Indian manufacturing industries to be involved in new product development (NPD) for achieving industrial sustainability. Product development process (PDP) is one of the most vital factors of NPD for developing new products as per customer demand. The successful adoption of PDP requires the top management support (TMS), external collaboration (EC) and market analysis (MA) to develop the suitable environment for successful NPD by producing the high quality products with technological developments in reduced cost. This study develops a framework comprising of the aforesaid factors and measures by structural equation modeling (SEM) approach with the primary data collected from 263 experts of Indian manufacturing companies. The analysis infers that PDP is escalated by TMS, EC and MA to develop new products trading off among product cost, quality and technological developments for NPD success. The positive influence of TMS on EC has also been explored.

Keywords: New product development; Product development process; Top management support; Quality.

1 Introduction

New product development (NPD) has become one of the key components in order to sustain in the competitive market environment. The rapid growth of the global market and the ever changing market environment endures firms to be involved in NPD activities [1]. There are several factors critically affecting the firm's performance of NPD is renowned as the critical success factors (CSFs). Product development process (PDP) is identified as one of the most essential factor of NPD to develop quality products at minimum cost as per customer demand [2]. Segmentation of PDP into several stages enhances the methods of NPD by utilizing the resources optimally for developing the products as per increasing demand. Top management support (TMS) is an inseparable part of different phases of NPD helps to overcome technologically turbulent environment [3]. The culture of external collaboration (EC) identifies the requirements and priorities of customers essential for PDP [4]. Similarly, market

IV. Roy, S., Modak, N., & Dan, P. K. (2018, February). *R&D Activities for Enhancing New Product Quality: A Combined Approach of Analytic Hierarchy Process and Structural Equation Modeling Approach*. Proceedings of National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM-2018), CSIR- Central Mechanical Engineering Research Institute, Durgapur, India. ISBN: 978-93-87480-56-8.

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R&D Activities for Enhancing New Product Quality: A Combined Approach of Analytic Hierarchy Process and Structural Equation Modeling Approach

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Abstract: *Make in India initiates of making India a global manufacturing hub by encouraging the large as well as small and medium enterprises (SMEs) to manufacture their own products within the country. The development of manufacturing sectors enlightens the necessity of new product development (NPD) for achieving competitive advantages in global perspectives. Research and development (R&D) activities has become an inevitable phenomenon to introduce new products for industrial sustainability. This study recognizes the fundamental factors such as technological advancement and intellectual capital closely associated with R&D activities and their impact on NPD success. Like success factors, cost, quality and development time of new products are identified as success measures to quantify the NPD success of the firm. Analytic hierarchy process (AHP) has been applied to prioritize the success factors as well as success measures depicting the R&D as the most important factor succeeded by technological developments and intellectual capital. Moreover, product quality is analyzed as the most vital measure among the three measures. This empirical study assimilates the primary data from 76 Indian manufacturing companies to develop the interrelationship model inferring the effect of R&D activities and its associated factors on the quality of the new product using structural equation modeling (SEM) approach. The result expresses the positive effect of R&D activities on product quality which is again be influenced by the technological developments and intellectual capital.*

Keywords: R&D activities, technological advancement, intellectual capital, AHP, SEM

1. Introduction

New product development (NPD) offers industrial sustainability of the firm by introducing innovative products as per market demand. It ensures better firm's performance for sustaining in the volatile and competitive market environment (Buyukozkan and Arsenyan, 2012). There are various crucial factors termed as critical success factors (CSFs) influence the NPD success of the firm which is again quantified by the success measures. Research and development (R&D) has been previously been discussed as one of the vital CSFs of the NPD for introducing new products. Continuous R&D practice helps to modify the existing products similarly innovates new products (Nicholas et al., 2015; Ernst 2010). Learning is considered as a secondary constituent of R&D activities which directly encourages R&D through sharing knowledge and creative ideas by overcoming cultural barriers (Medeiros et al., 2014;Roy and The´rin, 2008). The technological advancement helps to provide concrete platform to R&D by offering required technical resources for NPD(Mendes and Ganaga, 2013). Similarly, intellectual capital is the intangible asset mainly classified as human capital, relational capital and structural capital related to R&D activities of the firm (Chen et al., 2006) which indulges the NPD success through assuring high-end competitive advantages (Zhou and Fink, 2003). Like success factors there are success measures like cost, quality and development time of

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V. Roy, S., Modak, N., & Dan, P. K. (2018, January). *Entrepreneurial Culture in Technical Improvements for Product Quality and Customer Satisfaction in SME*. Proceedings of the 1st International Conference on Mechanical Engineering (INCOM-2018), Jadavpur University, Kolkata, India.

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ENTERPRENEURIAL CULTURE IN TECHNICAL IMPROVEMENTS FOR PRODUCT QUALITY AND CUSTOMERSATISFACTION IN SME

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ABSTRACT

Globalization widens the platform of small, medium and large scale industries for achieving success by exploring their competitive advantages for continual development. New product development (NPD) is one of those constituents which enriches the competence of companies for industrial sustainability. In today's era entrepreneurship has become one of the essential culture of the company to support and develop innovative products by encouraging the NPD activities. This empirical study accumulates primary data from 76 Indian manufacturing companies and identifies the role of entrepreneurial culture to promote the technical improvements which is again accelerate the NPD success by developing quality products as per customer demand. Interrelationship model of these constructs is developed by structural equation modelling (SEM) approach using IBM SPSS AMOS 21.0 software packages. This model developed from the experts' opinion depicts that entrepreneurial culture positively encourages the technological advancement of companies which helps to develop innovative products of better quality to attain customer satisfaction in turn the NPD success.

Keywords: *New product development, entrepreneurial culture, technical improvement, structural equation modeling*

1. INTRODUCTION

Globalization leads the firms towards an international competitive environment where they have to adop new and innovative strategies for industrial sustainability, e.g., Buyukozkan and Arsenyan[1].Successful development of new product is one of those strategies which are critically challenging for management, e.g., Tzokas et al. [2]. Development of new products as per customer requirements within the estimated budget can provide competitive advantage to the company, e.g.,Cooper andKleinschmidt [3]. Researchers over past few decades identified the factors which are critical to success for NPD which are famously known as critical success factors, e.g.,Ernst [4]. Previous studies recognized technology, research and development, market analysis, managerial support these are widely used success factors for NPD success. Innovation and entrepreneurial culture (EC) has become an inseparable entity for industrial growth in highly competitive market scenario, e.g.,Matsuno et al. [5].Specifically, this study investigates the impact of firm's EC for technical improvements within NPD framework in Indian scenario. To our knowledge, this effort is one of the few approaches that investigate the interrelationship of EC with technical improvements for NPD success which in turn be measured by quality of the newly developed products and the customer satisfaction.

Conceptually, this study departs from the previous available literatures in terms of the practical implementation of EC for technical improvements. Implementation of EC in small and medium scale industries (SMEs) has been unexplored. This research raise the questions about the importance of EC in SMEs. At the same time, the implementation of EC for technical improvements have been identified which in turn accelerates NPD success in terms of product quality and customer satisfaction. Structural equation modeling (SEM) approach has been used to develop this interrelationship model by using IBM SPSS AMOS 21.0 software packages.

2. METHODOLOGY

Structural equation modelling (SEM) is a methodology for representing, estimating, and testing a theoretical network of (mostly) linear relations between variables,e.g., Rigdon [6]. This approach is used here to build the relationship among these factors which are critical for organizational success and survival and correlate them with the new product development success. It is a comprehensive statistical approach to testing hypotheses about relations among manifest or observed and latent variables,e.g., Hoyle [7]. This paper focuses on the SEM model built by the input latent constructs those are EC and technical improvements and the output latent constructs which are product quality and customer satisfaction for achieving NPD success. These above mentioned factors and set hypotheses to relate with the new product development success help the firms to survive in the competitive market environment. In this research 76 engineering

VI. Roy, S., Modak, N., & Dan, P. K. (2018, January). *Managerial Support in R&D Practices for Achieving Technological Developments in SME*. Proceedings of the 1st International Conference on Mechanical Engineering (INCOM-2018), Jadavpur University, Kolkata, India.

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MANAGERIAL SUPPORT IN R&D PRACTICES FOR ACHIEVING TECHNOLOGICAL DEVELOPMENTS IN SME

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ABSTRACT

New product development (NPD) has become inevitable constituent of the various scale of industries for industrial sustainability. Global market introduces aenormous scope for exploring new products and expanding product families for developing competitive advantage. This approach not only brings innovativenesss to the companies but also accompanied by challenging environment for success and survival. Support from top managers motivate research and development (R&D) activities in the company which helps to develop new and innovative products by proper utilization of available resources. This empirical study identifies the influential role of top management to control the R&D activities in optimal way to develop new products with technological advancement. The primary data has been collected from 76 Indian manufacturing companies to depict the role of top management support to expandR&D activities for technological developments which in turn accelerates NPD success. Structural equataion modeling (SEM) approach has been used to develop the structural model using IBM SPSS AMOS 21.0 software package.

Keywords: *New product development, top management support, research and development, technological improvement, structural equation modeling*

1. INTRODUCTION

Successful development of new products has become one of the most compelling strategies for top management for sustaining in the competition, e.g.,Tzokas et al. [1].This competition becoming more challenging due to globalization insisting companies to adop innovative practices for industrial sustainability, e.g.,Buyukozkan and Arsenyan [2]. Availability of several constituents, critical for NPD success is famously known as critical success factors,e.g., Ernst [3],Bhuiyan [4], which help to develop new products as per customers' demand, e.g., Cooper andKleinschmidt [5]. There are number of literatures identified top management support, e.g.,Felekoglu and Moultrie [6]and R&D, e.g.,Yeh et al. [7],as critical constituents for successful new product development.Genrally, top management support is defined as "degree of senior management support [provided] for new product initiative", e.g., Evanschitzky et al. [8]. The strong support and motivation from top management influences R&D activities in the companies for inventive product development by proper utilization of available resources. R&D practice encourages the team to apply new ideas with the help of experts' experience and innovativeness. This study investigates the role of top management support for motivating R&D activities in Indian scenario. This research adds a new chapter to the available literatures depicting the interrelationship of top management support and R&D activities for technological developments of the new products which is again accelerates NPD success of the firm.

Conceptually, the novelty of this study is the realization of the interrelationship of top management support and R&D activities for motivating the small and medium scale industriesto adop R&D activites for achieving competitive advantage for industrial sustainability. It also identifies the obstacles faced by the companies to implement thses practices in practical situation. Structural equation modeling (SEM) approach has been used to develop by using IBM SPSS AMOS 21.0 software packages to show the interrelationship of these constructs to measure NPD success which is again quantified by technological developments.

2. METHODOLOGY

Structural equation modelling (SEM) is an approach used here for developing the interrelationship among the factors, critical for the NPD and correlate them with organizational success. The comprehensive statistical approach is used for testing the hypotheses among latent and manifest variables and depicts their relationships as well, e.g.,Hoyle [9]. The representation of of the structural model, estimation of path values and finally the testing of the developed model is performed by using SEM analysis, e.g.,Rigdon [10]. In this study, the interrelationship model have been developed by using top management support as a success factor which enriches R&D practices of the firm which is another success factor and

VII. Roy, S., Modak, N., & Dan, P. K. (2017, December). *R&D and Market Analysis for Product Development Process in Achieving New Product Development Success*. Proceedings of 4th International Conference on Industrial Engineering (ICIE-2017), SardarVallabhbhai National Institute of Technology, Surat, India. ISBN: 978-93-86238-39-9.

R&D and Market Analysis for Product Development Process in Achieving New Product Development Success

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Abstract: *Globalization challenges the companies to exploit their creativity for sustaining in the strong competitive market environment. Innovation ensures industrial sustainability through proper utilization of the available resources. Continuous research and development (R&D) shapes the new ideas and develop innovative products by analyzing the market through identifying customers demand. This empirical study portrays the role of R&D and market analysis to enrich the product development process (PDP) for new product development (NPD) success. The primary data from 76 experts from Indian manufacturing industries have been collected for data analysis purpose. Structural equation modeling (SEM) approach has been used to develop the path model using IBM SPSS AMOS 21.0 software packages depicting the positive impact of R&D and market analysis on product development process (PDP) for successful new product development which is turn be quantified by quality measures such as meet quality guidelines, achieved product performance goal and achievement of design goal.*

Keywords: *Critical success factors, product development performance, structural equation modeling (SEM)*

1. INTRODUCTION

Customer satisfaction is the crucial aim of the company to achieve success in the volatile market environment. Globalization results in unpredictable customer desires according to the updated needs among the end-users. This leads towards application of innovative ideas for new product development (NPD) (Buyukozkan and Arsenyan, 2012). There are several constituents closely associated with success and survival of the company by controlling NPD activities. These factors are famously renowned as critical success factors (CSFs) (Ernst, 2002; Bhuiyan, 2011). Among various factors technology (Lau, 2011; Mendes and Ganga, 2013; Yeh, Pai and Liao, 2014), managerial support (Sun and Wing, 2005; Cooper and Kleinschmidt, 2007; Felekoglu and Moultrie, 2014), cross-functional teamwork (Ernst, Hoyer and Rübsaamen, 2010; Thamhain, 2011; Fazilah, Jaafar and Suraya, 2014) are the commonly discussed by previous researchers. Research and development (R&D) is another essential activities every firm for successfully develop new products with best qualities as per customers' requirements. Previous literatures (Cooper and Kleinschmidt, 2007; Ernst, Hoyer and Rübsaamen, 2010; Wang and Lestari, 2013; Yeh, Pai and Liao, 2014) identifies the need of R&D in large industries as well as in small and medium enterprises (SMEs) also. In practical scenario there are a lack of investment is R&D in SMEs which driving them in backward direction in the global competition (Sun and Wing, 2005). R&D requires a clear idea about the market condition and requirements of targeted customers. This leads towards the continuous market analysis. Researchers (Sadeghi, Azar and Rad, 2012; Medeiros, Ribeiro and Cortimiglia, 2013) signifies the role of identification of target market for developing successful new products. These NPD activities need a systematic product development process (PDP) which has been neglected in the SMEs due to the higher cost involved in association with the uncertainties of the market acceptance (March-Chorda, Gunasekaran and Lloria-Aramburo, 2002). Previous researches (Spivey, Munson and Wolcott, 1997; Lewis, 2001; Tzokasa, Hultink and Hart, 2004) have portrayed the need of PDP for achieving NPD success. Like success factors there are success measures which are used to quantify the NPD success. There are time based measures (Lynn, 2005; Sivasubramaniam, Liebowitz and Lackman, 2012), cost based measures (Cooper and Kleinschmidt, 2007), customer based measures (Huang, Soutar and Brown, 2004) for measuring the ultimate NPD success according to their requirements. Therefore, the clear identification of the factors impel product development success is essential to be recognized to optimal utilization of the available resources for PDP to increase the market demand for new products developed in firms. R&D and market analysis controls the PDP for developing new products as per customer demand. The main objective of this study is to realize the role of R&D and market analysis to control PDP which escalates NPD success again be quantified by quality based measures such as meet quality guidelines, achieved product performance and achievement of design goals. This empirical research

VIII. Roy, S., Modak, N., & Dan, P. K. (2016, December). *Product Development Process as a Success Factor for Developing Quality Products with Reduced Cost in Indian Manufacturing Industries*. Proceedings of 6th International & 27th All India Manufacturing Technology, Design and Research Conference (AIMTDR-2016), College of Engineering, Pune, India. ISBN: 978-93-86256-27-0.

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Product Development Process as a Success Factor for Developing Quality Products with Reduced Cost in Indian Manufacturing Industries

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ABSTRACT

Manufacturing industries face a huge challenge in present volatile global market environment. Due to globalization the companies need to concentrate on new product development (NPD) for the sake of sustainability in the competition and at the same time for economic growth of the nation. There are number of factors influencing NPD performance, positively or negatively, are known as critical success factors (CSF) which in turn control the companies' success and survival. Previous literatures enlightened various factors related to management, technology, quality and customers and also their effects on NPD performance. This study concerns about one of the factor which is product development process (PDP) is critical to success. Various manifests of PDP have been identified from previous literatures to measure the PDP. Likewise, various aspects of success measures have also been recognized from previous literatures which are used to express the product development success of any firm. According to previous researchers, there are six types of success measures category such as time, cost, quality, customer, technological improvements and additional features. Though, two most important categories of them such as quality and cost have been considered here as success measures for this study because producing quality products with reduced cost is the main aim of companies for customer satisfaction. For this empirical research, a questionnaire concerning both importance and implementation perspective of manifests of PDP, has been developed. Data have been collected from NPD personnel and managers of 58 engineering manufacturing industries in India, involved in product design and development activities. Reliability of these survey data have been checked by Cronbach's Alpha reliability testing using IBM SPSS software. Structural equation modeling (SEM) approach have been used to develop a framework for analyzing the effect of latent construct which is PDP on product development success which is expressed here by quality and cost related constructs. The hypothesis testing performed by using SEM approach proves that manifests used to express PDP are positively related to PDP and also positively influence NPD success as well. In case of implementation of manifests of PDP, numbers of obstacles faced by companies to implement these manifests have also been identified through a detailed survey for betterment of NPD performance in future days.

1. Introduction

Successful development of new product is one of the most critical and challenging task for the management [1]. Globalization leads the firms towards an international competition where they have to adopt new strategies for success and survival [2]. To achieve competitive advantage, management should focus to develop new products as per customer requirements within the budget [3], [4]. Researchers over the past decades have witnessed that NPD process is based on series of development stages [1] which have been influenced by various factors famously known as critical success factors [5] as these factors play crucial role in firm's success [6]. Previous researches prove that technology [7]-[9], R&D [7], [10], [11], market analysis [12], [13], top management support [14]-[16], these are the commonly used factors discussed frequently by the researchers in previous studies. The essentiality of PDP as a factor and its manifests to develop products at minimum cost and introduce them to the market as early as possible has been discussed by many researchers [17], [18]. Same as success factors there are numerous measures for product development success as indexed by previous researchers [19]-[21] which are equally important for SEM framework development. As per the design and development experts' opinion of various manufacturing firms of India, these success measures have been clustered in separate groups such as measures related to quality, cost, time, customer, technology and additional features. The success measures related to quality and cost has been considered here as firms' aim are to develop quality products with reduced cost which can help to achieve success and wide customer acceptance.

The objective of this study is to develop a framework using SEM approach considering the PDP as a success factor and quality and cost as success measures based on the empirical data collected from Indian manufacturing industries.

IX. Roy, S., Modak, N., & Dan, P. K. (2015, November). *Developing a Framework for Factors Effecting the New Product Development Success: In Indian Companies*. Proceedings of 57th National Convention of Indian Institution of Industrial Engineering& 3rd International Conference on Industrial Engineering (ICIE-2015), SardarVallabhbhai National Institute of Technology, Surat, India. ISBN: 978-93-84935-56-6.

Developing a Framework for Factors Effecting the New Product Development Success: In Indian Companies

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***Abstract**: The key purpose of this study is to recognize the factors influencing the new product development performance of Indian manufacturing companies to sustain in the competitive market. The importances of the identified factors as well as their degree of implementation have been considered here. The Structural Equation Modeling (SEM) approach has been used to build a causal relationship among fivelatent constructs by using LISREL 9.2 software package along with SPSS. Here four latent constructs i.e. top management support, product quality, information technology (IT) management and project management act as success factors which influence the product development performance (PDP). Break-even time, attain return on investment and profitability is considered as success measure of new product development performance. The final result shows that though all the factors have positive impact on product development performance, but product quality plays the key role to attain better product development performance in Indian engineering companies.*

***Keywords**: Critical success factors, product development performance, structural equation modeling (SEM).*

1. INTRODUCTION

The rapid growth of the global market and the ever changing market environment enforces firms and organizations to invest in the new product development (NPD) in order to sustain in the competitive market environment (Buyukozkan and Arsenyan, 2012). Several factors which are affecting the firm's improvement is known as the critical success factors and from the previous literatures (Ernst, 2002; Bhuiyan, 2011) it has been proven that, these various factors are important for the success and survival of organizations. According to previous literatures new product performancecan be affected by various factors.Technology is one of the most important factor which is critical to success and is been considered by various researchers (Lau, 2011; Mendes and Ganga, 2013; Yeh, Pai and Liao, 2014). Like technology other factors such asresearch and development (R&D) (Benedetto, 1999; Cooper and Kleinschmidt, 2007; Ernst, Hoyer and Rübsaamen, 2010; Fian, Kline and Duhovnik, 2011; Wang and Lestari, 2013; Yeh, Pai and Liao, 2014), cross-functional team collaboration (Holland, Gaston and Gomes, 2000; Sun and Wing, 2005; Cooper and Kleinschmidt, 2007; Holland et al., 2007; Ernst, Hoyer and Rübsaamen, 2010; Thamhain, 2011; Fazilah, Jaafar and Suraya, 2014) are also very popular factors which are critical to NPD success. Benedetto (1999) has introduced a factor called product launch which defines the proper time to launch a new product in the market which again influence by sales force, R&D, Skills of market research and promotion. On the other hand, the paper by (Fazilah, Haafar and Suraya, 2014)focuses influence of top management support in NPD performance of Malaysian automotive companies. There are various literatures (Lynn, Reilly and Akgün, 2000; Chorda, Gunasekaran and Aramburo, 2002; Ernst, 2002; Sun and Wing, 2005; Lynn et al., 2005; Cooper and Kleinschmidt, 2007; Wei, LiXiong and HuiTing, 2009; Sedighadeli and Kachouie, 2013; Felekoglu and Moultrie, 2014) where top management support and commitment plays a vital role for NPD success. According to the research finding by (Yeh, Pai and Liao, 2014) the quality standards of products and complete quality management system are the two dimensions with highest impacts in the customer-oriented business environment. Ahmad (2014) clarifies that behind the economic success of any manufacturing firm quality is the main factor with again influences the sustainable product development. According to the author quality has a relation with organizational performance. In the article by (Iamratanakul et al., 2007) the market share of any product depends upon the quality of product that is the flexibility, robustness of it which can fulfill customer requirements. Cooper and Kleinschmidt, 2007 highlights the high quality product development process which can provide quality products as per consumers' needs. To add more value-added edges to their products Sun and Wing, 2005 suggests the Hong Kong toy industries to implement the quality standards which can differentiate their products from their close competitors.According to Anantana, Enkawa and Suzuki, 2009 information technology (IT) is one factor which can