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ABSTRACT

KNOWLEDGE MANAGEMENT IN NEW PRODUCT DEVELOPMENT (NPD)

**by
Luca Maria Mancinelli**

This thesis analyses features that, in New Product Development process (NPD), foster knowledge, and their contribution to the creation and application of knowledge with the aim of increasing both global performance and organizational effectiveness. Since knowledge is becoming more important to achieve competitive advantage, companies have already started to focus on their ability to generate new competencies and create new opportunities for producing new knowledge.

One of the issues compelling knowledge management understands what aspects of the organization's work system and organizational design affect its ability to acquire, create and apply knowledge. In fact, the way that workers are organized and managed determine the success of NPD organizations. In this work, topics such as Knowledge Management and New Product Development are addressed. Furthermore, the study focuses on several models and frameworks of knowledge management, extracted from the existing literature, provides analyses of such models, and, based on them, proposes an additional framework.

**KNOWLEDGE MANAGEMENT IN
NEW PRODUCT DEVELOPMENT (NPD)**

by

Luca Maria Mancinelli

**A Dissertation
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New Jersey Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Engineering Management**

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*Dedicated to my family and friends.
My life would be emptier without all of you.*

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LIST OF ABBREVIATIONS

KM: Knowledge Management

KMSs: Knowledge Management Systems

NPD: New Product Development

NP: New Product

High-tech: High Technology

IT: Information Technology

CoP: Communities of Practice

CE: Concurrent Engineering

SBCE: Set Based Concurrent Engineering

ROA: Return on Asset ratio

ROS: Return on Sales

ROI: Return on Investment

HR: Human Resources

R&D: Research and Development

TMT: Top Management Teams

APQC: American Productivity and Quality Centre

CHAPTER 1

INTRODUCTION

Organizations are immersed in an environment that changes fast, and their survival is connected to their ability to process data and information and to the creation of new knowledge. One of the main factors that contributes to this changing environment is globalization: lower trade barriers and changes in business practices force firms to react. In addition, a continuous technological innovation results in shorter product life cycles, and markets ask for better, innovative multipurpose products and services. Knowledge Management (KM) allows building competitive advantages by increasing firm's performance (in terms of time, cost and innovation) and by enhancing product improvements and differentiation. KM enables also the ability to use existing knowledge and incorporate it in new and innovative products.

This topic is complex and therefore includes a wide variety of aspects: this work shows the current state of the art and exposes the key features of this field, such as its benefits, factors and drivers. In addition, it provides examples of Knowledge Management methods exposed in literature and analyses them showing both their advantages and disadvantages. Building on the selected frameworks and models, this work proposes an additional framework that includes most of the salient aspects of the Knowledge Management discipline.

CHAPTER 2

PROBLEM STATEMENT, THESIS STRUCTURE AND METHODOLOGY

2.1 Problem of Knowledge Management in Companies

The focus of the work is to demonstrate that knowledge management plays a significant role in firm strategy and lead to a more efficient new product development in high-tech firms. More in detail, the work tries to answer to the following question:

- How is it possible to capitalize on the knowledge present within an organization, and therefore make it profitable to obtain competitive advantages?

Organizations have become more focused on knowledge management practices because they have understood that managing knowledge is fundamental to remain competitive in their markets. Knowledge management leads the efficiency, the effectiveness and the innovation of a firm. Knowledge in New Product Development (NPD) is related to problems faced in the design or production process.

The main value of a knowledge management strategy is due to the need of knowledge creation. Innovation is the key core for competitiveness; firms must anticipate surprises on the marketplace, be flexible and adaptive to the rapid changes of the market and overcome products' development problems. All these goals can be reached using a knowledge management strategy. Several studies have been developed to underline the importance of knowledge management strategy.

By analyzing the studies proposed in literature and the models developed, it can be understood what the main characteristics of Knowledge Management are, and why it is related to firm innovativeness. First, the globalization and the rapid changes in the market demand firm to overcome products' limits and problems. These needs could be achieved with an appropriate use of knowledge: firms should be supported by

applications of information technologies to store the knowledge achieved by experiences, but not only. The main value of the experience is also represented by the relationship among individuals: the experience should be shared to lead to the employees' specialization; for this reason, is also important to guarantee an easy access of workers to the knowledge.

The knowledge sharing among the individuals is also a key core of the knowledge and it is crucial to create a joint organization that is capable to adapt to the rapid changes of the market and achieve effectiveness. Knowledge management is a useful strategy for NPD because it leads to innovation. In High Technology (high-tech), companies, it is extremely important because they must face, more than others, the dynamic changes of the market. The demand of innovation is due to the short life cycle of the products: a high-tech organization needs to anticipate surprises on the marketplace, overcome the limitations of its own products and the ones of its competitors, and be focused on customers' needs. A key factor to overcome market's threats, therefore, is represented by a strategic use of the knowledge management.

2.2 Objectives of Study and Study Limits

As previously said, the main objective of the following work is to propose an effective response to the question formulated above. To do so, the work is based on literature review of academic reports focusing on knowledge, knowledge management, the NPD and the NPD process, and as a common context, the application in the high-tech field. The literature review also involved authors who proposed models and frameworks regarding knowledge management in the NPD process, and its applications. The study, then, analyses such frameworks and models extracted from the existing literature, and

ends up with a proposal for a knowledge management model based on the contributions of the authors considered in the study.

2.3 Methodology and Thesis Structure

The methodology applied to perform the study was a systematic research on the academic search engines made available by the University of Parma. The keywords to carry out the research were the following: *Knowledge, Knowledge Management, Knowledge management methods, Knowledge management history, frameworks, models, New Product Development, High technology field, firms.*

The work is structured as follows:

In this current chapter, problem statement, objective and methodology, thesis structure are exposed.

Chapter 3 introduces Knowledge, Knowledge Management and its related key factors, such as Knowledge Management process, enablers within firm, goals. Lastly, Knowledge Management is connected to New Product Development.

Chapter 4 summarizes New Product Development. The chapter gives a general comprehension of different NPD approaches, phases, risks connected to product development, and performance evaluation criteria.

Chapter 5 presents several models and frameworks of Knowledge management applied in the NPD process. Each model is focused on distinct aspects of this vast topic. The models are briefly exposed, and for each, a brief “benefits and limits” analysis is performed. The study ends with a conclusive section, in which there are, first, a summary table of the models that is followed by another one that instead highlights the different focus and objectives of the models presented in the thesis. Furthermore, based on the contribution of the models, a framework theorized by the author is presented.

CHAPTER 3

KNOWLEDGE AND KNOWLEDGE MANAGEMENT

3.1 Knowledge

This chapter describes what knowledge and knowledge management are, and the roles that both play in firms. However, to better understand what knowledge management is, a good starting point may be understanding what knowledge is.

Knowledge is neither data nor information, though, it is related with someone or something, which can include facts, information, descriptions, or skills acquired through experience or education. It can refer to the theoretical or practical understanding of a subject and it can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject). Knowledge and expertise is dispersed through the organization and is often closely held by individuals or work units (C.W. Choo, 1996). Furthermore, it is a combination of both data and information (when seen from an Information Technology point of view), and, a mix of, for example, knowhow, experience, values, ideas, intuitions, curiosity, motivation, attitude, ability to trust and to deal with complexity, to result in an asset which can be used to improve the capacity to act and support decision making.

Data, information and knowledge are strictly connected and related to each other, as we can see from the following figure:

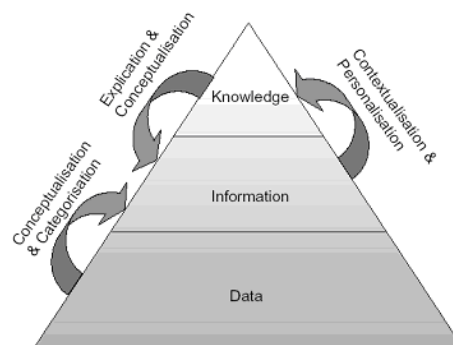


Figure 3.1 Knowledge Hierarchy Model
Source: A. Hoppe, et al. (2011). *Wisdom - the Blurry Top of Human Cognition in the DIKW-Model?*

Data, information and knowledge are not interchangeable concepts: understanding what those three words mean and how it is possible to get from one to another is essential (Davenport and Prusak, 1998).

Data: is a set of discrete objective facts about events. In an organizational context, is most usefully described as structured records of transactions. Data is facts or numbers, collected to be examined. It is the raw material of the creation of information and exists in any form, usable and not usable, and by itself, has little relevance or purpose and says nothing about its own importance. Data describes only partially any phenomenon and provides no judgement or interpretation and no sustainable basis of action. Organizations store data in technology systems, in a way to be less centralized and available on demand. Quantitatively, companies evaluate data management in terms of cost, speed and capacity; qualitatively, measurements are timeliness, relevance and clarity. Organizations need data and are dependent on it. Effective data management is essential to business' success.

Information: it is a message, in form of document or audible or visible communication. Information is meant to change the way a receiver of such message, perceives something, to have an impact on his judgement and behavior. (Davenport et al., 1998). To generate information, we should categorize and connect data. Therefore, information may be described as “data that makes a difference”. Information moves around organizations through hard and soft networks: a hard network includes: wires, mailboxes, e-mails, and delivery vans and so on; soft networks are generally less formal and visible. It is *ad hoc*. Information is an intrinsic component of nearly every activity in the organization (C.W. Choo; 1996). Quantitative measures of information management tend to include connectivity and transactions, while qualitative measures measure usefulness. Unlike data, information has both a meaning and a *shape*: data

becomes information when its creator adds some meaning and value, for example, by giving it a context or units of analysis, or by calculations or corrections.

Computers are helpful for adding value and meaning, transforming data into information, but rarely help with context. Therefore, it is concluded that having information technology available not necessarily improve the state of information.

To make a better use of information in an organization, it is necessary to build a database where data is *captured*, stored, and, subsequently, have the possibility to access to it.

Knowledge: Considering what has been stated above, it also includes beliefs, and experiences. It is broader, deeper, and richer than data and information. Knowledge is a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied mostly in the minds of individuals. In organizations, it is embedded not only in documents or repositories, but also in routines, processes, practices and norms. Knowledge is formally structured, but also intuitive, and it may be difficult to capture it in words and logical terms. Furthermore, it can be seen both as a stock and as a process. Knowledge assets, in organizations, are hard to pin down. Knowledge is built by applying some specific relations to a collection of information units. The Knowledge Hierarchy Model (Figure 3.1) aims at describing the structural or functional relationships between data, information and knowledge.

Knowledge, therefore, derives from information, and information derives from data. The transformation from one to another happens through comparison, connections, conversation and implications, all among individuals. These knowledge-creation activities take place daily, in any organization: members share their personal knowledge through apprenticeships, trainings, and articulate what they know through

dialogue and discourse, as well as channels that are more formal. It is possible to obtain knowledge from individuals or groups of workers and knowers, or also in organizational routines. Knowledge is also delivered through structured media such as books and documents (Davenport et al, 1998).

Knowledge in firms is evaluated by the decisions or actions to which it leads. Better knowledge can lead to measurable efficiencies in product development and production. It can be concluded that knowledge is what makes organization go. This last statement supports the idea that since knowledge resides in the minds of individuals, this personal knowledge needs to be converted into knowledge that can be shared and transformed into innovations. Literature review shows that there are different perspectives about what is Knowledge. Nielsen and Michailova (2007) review the three most recognized views on knowledge (Table 3.1). The perspective in which knowledge is considered defines the role and the implications in Knowledge Management Systems (KMSs).

Organizations have realized that knowledge is one of the most valuable resources to gain competitive advantage, but to achieve competitive advantage, knowledge requires some characteristics: accuracy, consistency, relevance and appropriate context. In other words, knowledge needs to be managed effectively and efficiently, just like its main components: data and information.

Table 3.1 Knowledge Views:

View	Definition	Role of KMS
Knowledge as an object	Knowledge, equated with information access, is viewed as a thing to be stored and manipulated (e.g., an object)	KMS focuses on gathering, storing and transferring knowledge (information)
Knowledge as a process	Knowledge is a process of simultaneously knowing and acting (e.g., applying expertise)	KMS focuses on links among sources of knowledge to create wider breadth and depth of knowledge flows
Knowledge as a capability	Knowledge is a capability with the potential for influencing future action (e.g., the capacity to use information; learning and experience result in an ability to interpret information and to ascertain what information is necessary in decision making)	KMS focuses on enhancing intellectual capital by supporting development of individual and organisational competencies

Source: Extracted from B.B. Nielsen & S. Michailova (2007).

3.2 Knowledge Management

In the previous section, we have seen the nature of knowledge and some of its features. However, there is a need of “*planning and ongoing management of activities and processes for leveraging knowledge to enhance competitiveness through better use and creation of individual and collective knowledge resources*” (CEN, 2004), this process is known as knowledge management. In order to systematize this field, researchers have given their approach to the definition of knowledge management:

- *KM is a process of systematically and actively identifying, activating, replicating and transferring knowledge* (Probst et al; 2003);
- *KM is a method to simplify and improve the process of creating, sharing, distributing, capturing and understanding knowledge in a company* (Karlsen & Gottschalk; 2004);
- *The processes of KM include knowledge identification, creation, acquisition, transfer, sharing and exploitation* (Abdul et al; 2008);
- *KM is a method of controlling processes of knowledge creation, its codification, ordering, storing, retrieval, processing, transfer and application* (Jemielniak & Kozminski; 2008);
- *KM scope is about the generation, communication, transformation and application of knowledge that is sufficient onto the reasoned action in situated contexts in which individuals and organizations find themselves* (Zhu; 2008);

Another group of knowledge management definitions and characteristics focuses on the whole knowledge possessed by individuals and organizations and the benefits of its application:

- *The challenge of KM is out to generate and leverage collective knowledge in the firm to create value that leads to competitive advantage* (Zhang; 2007);

- *KM is about harnessing the intellectual and social capital of individuals in order to improve organizational learning capabilities (Swan et al; 1999);*
- *KM is a systematic approach to managing and leveraging an organization's knowledge assets which may include knowledge of the organization's customers, products, market, processes, finances and personal services (Cope et al; 2006);*
- *KM refers to the developing body of methods, tools, techniques and values through which organizations can acquire, develop, measure, distribute and provide a return on their intellectual assets (van Donk & Riezebos; 2005);*
- *KM deals with the organizational optimization of knowledge with various technologies, tools, and processes to achieve set goals (Kamara et al; 2003).*

Summarizing, it is possible to conclude that knowledge management deals with knowledge and its creation processes in organizations, and the achievement of goals and competitive advantages deriving from the right exploitation of knowledge.

Knowledge Management deals with management of data, information, explicit and tacit knowledge. The main enablers of knowledge, in any organization, are employees, processes and technology.

3.2.1 Knowledge Management Historical Background

The term “knowledge management” has been around for many decades. The knowledge sharing has become ever more important to build on earlier experience, eliminate costly redundancies, and avoid making the same mistakes again. The primary technology used to transfer knowledge consisted of the people themselves, indeed, much of cultural legacy stems from the migration across continents (Dalkir, 2005).

There are many contributors on the evolution of knowledge management such as Peter Drucker, and Peter Senge. Drucker was the first to coin the term knowledge worker (Drucker, 1964). Senge (1990) focused on the "learning organization", a cultural dimension of knowledge management, in which organizations learn from past experiences stored in corporate memory systems. Barton-Leonard (1995) documented the case of Chapparral Steel as a knowledge management success story. Moreover, a cross-industry benchmarking study was led by APQC in 1996. It focused on the following KM needs: as a *business strategy, transfer of knowledge and best practices, customer-focused knowledge, personal responsibility for knowledge, intellectual asset management, innovation and knowledge creation*. (APQC, 1996). Others significant contributors to the evolution of KM were given by I. Nonaka, and H. Takeuchi. Nonaka identified the role of knowledge management and how the knowledge is created among the individuals. He also underlined that knowledge sharing among people and teams represents the starting point for the next surge in the knowledge screw. Another big contribute was given by T. Davenport, (1998) who pointed out the organizational need of storing the acquired and created knowledge. Studying a case of knowledge management, he showed that a successful knowledge management for an enterprise must contain skill resource knowledge bank and on-line inquiry system. Ler (1999) underlined that knowledge management involves collecting and transferring information to demanders. Hendrike (1999) proposed that knowledge must be present if knowledge exchanges between knowledge owner and knowledge demander persists. Liu et al. (2005) proposed that knowledge management has currently become the main manufacturing resource and the prerequisite for success in the production environment. Figure 3.2 gives an extract of the timeline of the main contributions to this discipline. With the advent of the information age, KM has come to mean the systematic

leveraging of knowledge assets. The computer technology that cooperated to superabundance of information started to become part of the solution. New communication technologies are now able to simulate rich, interactive knowledge encounters, virtually. Information technologies such as an intranet and the Internet enable to knit together the intellectual assets of an organization and organize this content through the lenses of common interest, common language, and conscious cooperation. In 1969, the launch of ARPANET allowed scientists and researchers to communicate more and to being able to exchange their large data sets. Next, a messaging system was added to this data file transfer network. In 1991 the network was transferred to the Internet. In these years, were developed concepts such as "knowledge acquisition," "knowledge engineering," "knowledge-based systems, and computer-based ontology. The design and development of knowledge-based systems have much to offer to knowledge management, which also aims at the capture, validation, and dissemination of valuable knowledge from experts. The knowledge management started to be considered as a useful strategy from 1989. During past years, the use of knowledge management has become ever more important and some European, Japanese, and American firms started to use in-house programs for knowledge management. Starting from the early 2000' KM began to be considered academically. Over 100 universities around the world offer courses in KM, and many business and library schools offer degree programs in KM (Petrides And Nodine, 2003). In table 3.2, are presented the main steps that characterize knowledge management's history. It is possible distinguishing two main historical cycles of the knowledge management literature: *first generation's cycle*, and *second generation's cycle*.

Table 3.2 Main Contributors in Knowledge Literature

Authors	Contribute
Drunkers, 1959	Definition of knowlege workers
Polanyi, 1966	Definition of tacit and explicit knowledge
Nonaka, 1994	Theory about knowledge creation and sharing
Davenport, 1996	Importance of achieving, sharing and storing knowledge
Hendrik, 1999	Knowledge existence is related to persistence of exchanges between knowledge owner and demander
Liu et al,2005	Knowledge management as a prerequisite for enterprise's success and effectiveness

Source: Prepared by the author, based on Literature Review.

The first cycle can be summarized as a vision of knowledge management as an instrumental component: it was theorized how knowledge should be created, acquired and stored. The second cycle, on the other hand, was characterized by contributes which mostly pointed out the importance to use KM as a strategy to achieve business success and sustainability.

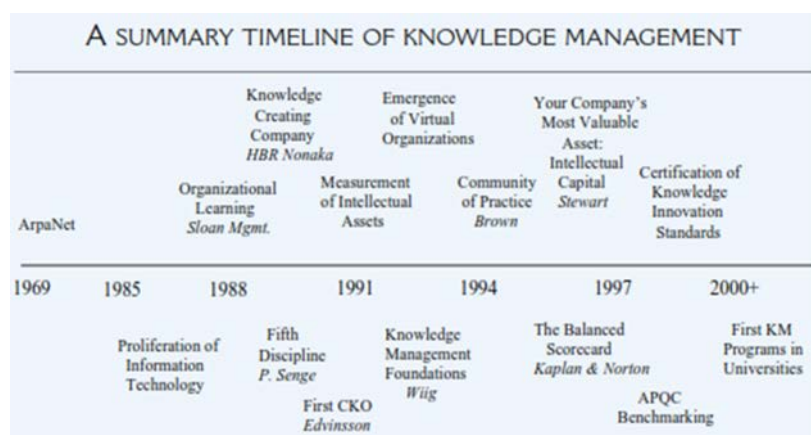


Figure 3.2 Timeline of Main contributions to Knowledge Management

Source: Dalkir, K., (2005). Knowledge Management in Theory and Practice.

The most widely diffused theory of knowledge creation is the one developed by Nonaka (1994). The knowledge conversion theory is a framework based on communication. Nonaka shows that the processes of interactions among individuals play a critical role in the process of knowledge creation. The study conducted shows that knowledge creation is achieved through a recognition of the synergic relationship between tacit and explicit knowledge in the organization, and through the design of social processes that create new knowledge by converting tacit knowledge into explicit knowledge. This theory is known also as the SECI Model.

Individuals can convert knowledge from tacit to explicit and vice versa. Furthermore, the theory illustrates the three main dimensions in which knowledge flows through the process of knowledge creation: *individual*, *group*, and *organization*. Starting from a single individual, each mode of knowledge creation involves more participants and a higher level of coordination between them.

Figure 3.3 helps to better understand SECI Model:

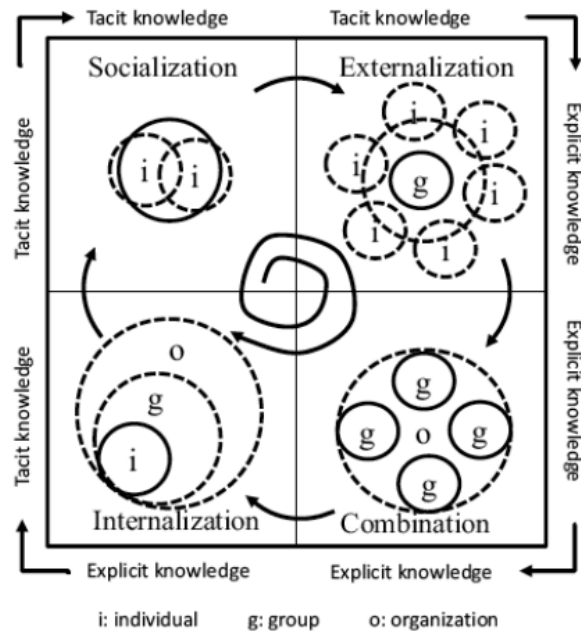


Figure 3.3 Nonaka’s Knowledge Creation Model
 Source: I. Nonaka and N. Konno (1998). The Concept of “Ba”: Building a Foundation for Knowledge Creation

Tacit or implicit knowledge is personal knowledge that is hard to formalize or communicate to others. It consists of subjective expertise, insights and intuitions that comes to a person from having carried out activities for a prolonged period. Tacit knowledge is a source of competitive advantage.

Explicit knowledge is formal knowledge that is easy to transmit between groups and individuals. It is frequently articulated in the form of mathematical formulas, rules, specifications and so on. Explicit knowledge needs to be nurtured and cultivated from tacit knowledge. These two categories are complementary, and organizations must convert personal tacit knowledge into explicit knowledge that can push innovation and New Product Development.

Nonaka defines different modes of interaction that contribute to knowledge conversion and creation process:

- *Socialization*: process of creating common tacit knowledge through shared experience. Members shares their knowledge and experiences. In this dimension, knowledge is acquired through observation, imitation and practice. (E.g. On the job training)
- *Combination*: process of creating explicit knowledge by explicit knowledge brought together from multiple sources. Individuals exchange and combine their explicit knowledge together, involving several communication mechanisms. Existing information in computerized databases are used to produce new knowledge.
- *Internalization*: process of conversion of explicit knowledge to tacit knowledge. Explicit knowledge is embodied, and external experiences are internalized through other modes of knowledge creation, in the form of shared mental

models or work practices. This method is facilitated if individuals can re-experience indirectly the experience of others.

- *Externalization*: process of conversion from tacit knowledge to explicit knowledge, using metaphors, analogies and models. This mode is frequently used in the concept creation phase of new product development (C.W. Choo, 1996).

The four modes of conversion feed off each other in a continuous spiral of organizational knowledge creation: the studies performed by Nonaka illustrates how individual knowledge can be converted into organizational knowledge. The knowledge flows from the individual to the organizational levels by applying the four modes of interaction through which the conversion from tacit to explicit knowledge occurs (Figure 3.4).

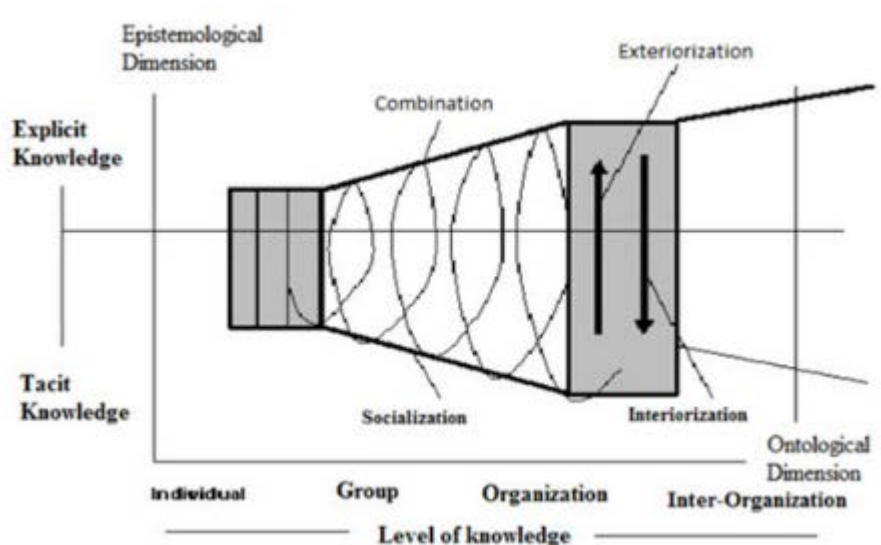


Figure 3.4 Knowledge Flow
Source: I. Nonaka, (1994). A Dynamic Theory of Organizational Knowledge Creation.

The interactions among individuals amplify and contribute to the creation of new knowledge and to its evolution from personal (individual) to collective (organizational). The knowledge creation in an organization, referring to Nonaka's theory, usually starts from individuals that develop some insight or intuition. This tacit know-how may be

shared by socialization, and, from an organization point of view, externalization of tacit knowledge is vital: combining separate bodies of expertise and reconfiguring them, give birth to new explicit knowledge that need to be internalized by the individuals, becoming new tacit knowledge. Organizational knowledge creation, though, takes place only when the four interaction dimensions are efficiently managed in order to create a continuous cycle able to shift constantly from one mode to another.

A key to innovation and to new product development is unlocking the personal, tacit or implicit knowledge of the organization's workers. In this perspective, however, since information may flow from external environment and it is progressively embodied into knowledge, that is therefore focused to enable organizational actions, it is important for members to choose what information is significant and should be attended to (C.W. Choo, 1996). Knowledge validation is necessary (through experiments or market analysis and so on) therefore, for an appropriate creation of effective new knowledge that can increase competitive advantage.

It is important to assess that an organization need to create an environment in which there are conditions for creation and formation of new knowledge.

Nonaka and Takeuchi (1995), found five enabling conditions for knowledge creation in organization: *Intention, autonomy, fluctuation and creative chaos, redundancy, requisite variety.*

Intention is defined as an organization aspiration to its goals. The most critical aspect is to clearly identify a vision about what kind of knowledge should be developed. At the organizational level, is fundamental that organization foster their employees' commitment to the proposed values.

Autonomy means that members should be allowed to act autonomously as far as circumstances permit. This leads to flexibility in acquiring, interpreting information, which leads to knowledge creation.

Fluctuation and creative chaos, which stimulates the interactions between the organization and the external environment. *Chaos* is created automatically by a crisis and by managers proposing challenging goals or ambiguous visions. It is important to note that creating chaos can be used only if individuals have the ability to reflect upon their actions.

Redundancy, which is the existence of information that goes beyond the immediate operational requirements of organizational members. There are several ways to build redundancies in an organization such as information overload, overlapping approach on activities, internal competition between groups and so on. Redundancy provides individuals a sense of their position in the organization.

Requisite variety indicates the existence of different information within company boundaries, by which members cannot interact on equal terms and this may be a source of obstacles in interpretations. It is important, in the organization, the creation of mechanisms of analysis of appropriate information that combines well with the amount of information present within it.

Such activities including knowledge obtaining, refining, storing and sharing can effectively increase the value of the knowledge asset in an organization. Competitive and resulting rewards can be obtained by taking advantage of knowledge management and intensive learning.

3.3 Knowledge Management Processes

Many authors, to identify which activities, stages and processes take part in the knowledge management, have studied the KM framework, also known as life cycle model. Alavi and Leidner (2001) defined that creation, storage, retrieval, transfer and application compose KM. Maier (2006) pointed out that the following KM activities involved in the KM process: identification, acquisition and creation; organization, publication, search and retrieval and, deletion and archiving; distribution and collaboration.

The European Guide to Good Practice in KM of CEN (2004) proposed a framework composed by the *identification, creation, storing, sharing* and *use of knowledge*. Summarizing the studies developed by several authors, the KM process is viewed as a continue close loop process in which there is never ending.

3.3.1 Knowledge Management's Main Enablers

- Information Technologies (IT):

IT facilitates the development of Knowledge Management activities and improves its capabilities and can be related to KM with several ways. The term includes computers, ancillary equipment, software and procedures. The IT are identified by all those mechanism that lead to the creation and maintenance of knowledge. Knowledge creation, sharing, storage, are improved by the use of such technologies, which facilitates communication, transmission and speed. IT is a useful instrument to prevent knowledge loss and to promote its creation connecting all the individuals among the organization.

- Communities of Practice (CoP):

A community of practice is a team informally bound together that shares expertise and with the goal of a joint enterprise in which knowledge is created and shared. Communities of practice can drive strategy, generate new lines of business, solve problems, promote the spread of best practices, develop people's skills, and help companies recruit and retain talent. It is possible to identify two different features of those communities: *practice sharing* for a knowledge creating and sharing and the *sense of belonging* to a team with a unique and distinctive value.

Communities of practice and IT are instruments that help, and support knowledge management widely used in firms.

3.4 Knowledge Management Goals

Firstly, knowledge management goals must be consistent to the core mission of the organization. With paying attention to the mission of organization, there are some goals defined that all organizations can benefit from them by employees learning, sharing, reusing, collaboration and innovation. The actual objective of knowledge management is not only to organize and share what is already known, but also to create the conditions to support the knowledge creation process. There is a two-side relationship between knowledge management systems and organizations. On one side, organization can bring success factors or barriers to knowledge creation; on the other side, the knowledge management system should be designed consistently with organization management to be effective and efficient. Knowledge management is strictly related to organizational management, but it is also deeply dependent on the knowledge creation process. Aware of this, the following are some of the goals of any knowledge management system in an organization:

1. Better and faster decision-making process: usage of knowledge and information at the proper time will increase the power of decisions. Furthermore, the re-use of knowledge in repositories allows decisions based on genuine experience, on larger samples and on practical lessons learned.
2. Reuse of ideas, documents and experiences: reuse of past knowledge acquired from organizational activities help to minimize rework, prevent problems, save time and accelerate progresses.
3. Avoidance of past mistakes and errors: Knowledge management allows sharing lessons learnt, both successful and ruinous. Knowledge is generated also by committing mistakes, so, sharing knowledge generated from wrong choices help to prevent committing them repeatedly.
4. Providing methods, tools, templates, techniques and examples: Methods, tools, templates, techniques and examples are the building blocks supporting repeatable processes and procedures. Using these consistently streamlines work, improves quality and ensures compatibility across the organization.
5. Accelerate the delivery to customer: Knowledge sharing, innovation and re use of data in proper way will increase the delivery of product and service to customers.
6. Enabling the organization to leverage its size: If an organization become able to properly use all the knowledge and experiences that employees, groups and processes generate, the global revenue and the benefits of the organization will both increase. This exploration under the economical side will cause to leverage the size of company in each sector of a market that has demand for it.

In addition, based on study of Knowledge management projects in several different organizations, Davenport et al. (1997) identify the following objectives of knowledge management:

- Capture knowledge;
- Improve knowledge access: to facilitate access to information and knowledge to obtain an effective problem solving and decision-making activities;
- Enhance knowledge environment to facilitate processes of knowledge creation, sharing and use;
- Manage knowledge as an asset to gain sustainable competitive advantages.

Bukowitz and Williams (2000) state that KM is the mean by which a company generates wealth from its knowledge, or its intellectual capital. Starting from this concept, the goal of this process is to transform most of all types of intellectual capital that can be managed in order to create, develop and extract value from it.

Considering particularly the field of New Product Development, the use of the KM leads to the building phase of a project. This process is developed in three phases:

- 1) *Assessing intellectual capital*: this capital needs to be evaluated and optimized.
- 2) *Feeding intellectual capital*: that involves the development and maintenance of knowledge. It implies to take into account the main imperatives: the investments' orientation, the allocation of resources necessary to the creation and the constant update of the intellectual capital. This capital will be even more precious if it is supported by a system set up to handle the knowledge flows between its various parts:

- Link, motivate: create links that are helpful for the development of intellectual capital by encouraging cooperation between the various units of the company,

by introducing new forms of partnership and by increasing loyalty among the employees.

- Praise, increase confidence, last: set up policies, procedures and cultural norms which enhance trust, by showing the links which exist between respect for values and wealth creation and by making the most of the full personality of each employee.

3) *Selecting knowledge*: examination of company knowledge capital from the point of view of opportunity costs (Abandoning intellectual capital or buying/acquiring knowledge).

3.5 Relation between Knowledge Management and NPD

The essence of new product development (NPD) is the creation and exploitation of new knowledge (Shani et al, 2003) and using it to solve organizational issues and put new products in the marketplace. At the same time, business sustainability is embedded in the firm's ability to manage its new product development processes. As previously said, in an organization, is crucial to transmit and to manage correctly flows of data and information. This amount of information creates a complex knowledge-rich context for NPD activities; therefore, the design of a NPD work is anchored to knowledge management. Since knowledge is both applied and generated in the course of work activities, the effectiveness of NPD teams depends on the richness of the knowledge available to be used by the employees.

In an organization, knowledge-intensive units, such as NPD teams, are characterized by their requirements to gather and convert information to knowledge. A challenge for NPD, therefore, is to design and create an organizational context for the work that makes it more likely that the employees will attend to different information,

attach new meanings and try new approaches to problem-solving (Mohrman et al; 2003).

A NPD strategy is an information processing procedure dependent on wider knowledge integration, to achieve its goals. This integration regards the combination of both external and internal knowledge, in the firm. A good integration will have a positive effect on NPD performance.

It is possible to conclude that the effectiveness of knowledge management methods plays a key role in NPD strategy, and firms with good knowledge management methods will have better performance. Clark and Wheelwright, (1992), concluded in their studies that companies would obtain better NPD performance if they could respond to any fluctuation in the outside environment faster than their competitors. Good strategy flexibility within the enterprise becomes then, a catalyst for generating a new product R&D concept.

CHAPTER 4

NEW PRODUCT DEVELOPMENT

4.1 New Product Development

As previously defined, the New Product Development represents the result of new knowledge generation. In this work, NPD is viewed as a process of knowledge creation through the syndication of diverse streams of knowledge. This process has emerged as one of the most important function in organizations. In many industries, competitive advantage steams from being the “first to market” and survival often depends on the speed at which new products can be developed. The New Product Development strategy is dependent on wider Knowledge integration to achieve its goals (Clark and Wheelwright, 1993; Liu et al, 2005).

Globalization and other rapid changes in the marketplace bring companies to generate new knowledge to remain competitive. The introduction of new knowledge represents the key word for performances and competitiveness. To better understand what the term New Product Development refers to, it is necessary to start with several definitions extracted from the existing literature:

- *A new product development is an integral part of a healthy, growing economy and it contributes by generating revenue and profits to a corporation that otherwise would not have been generated. (Annacchino, 2006)*
- *New Product Development (NPD): Process of developing a new product or service for the market. This type of development is considered as the preliminary step in product or service development and involves a number of steps that must be completed before the product can be introduced in the market. (businessdictionary.com)*

- *New Product Development is a term that encompasses all aspects of the process from generation to customer service support. At one extreme, it covers basic research whilst at the other it can be as simple as repositioning an existing product in a new market. (Barclay, 2002)*

Different classifications have been created to explain which features define a new product. There are several types of new products: some are new to the market, some are new to the firm, and some are new to both. Moreover, some are minor modifications of existing products while some are completely innovative. Booz, Allen & Hamilton (1982) work offers a landmark definition of new product in which its newness is related either to the company or to the market dimension.

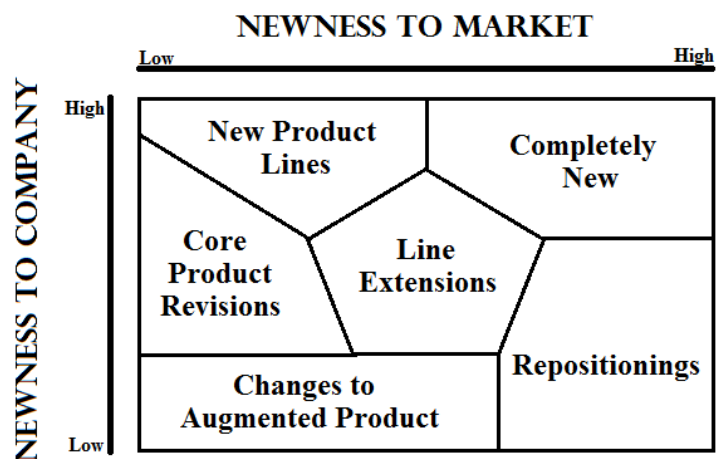


Figure 4.1 Product's Newness Dimensions

Source: Adapted from: http://www.synthium.net/resources/internet-marketing/marketing-guide/new_product_development.html

From Figure 4.1: The simplified matrix shows:

Low newness to both market and company are strategies such as improvements, revisions of existing products, or cost reduction.

Medium newness refers to addition to existing lines and products repositioning. (These are typically conceived as medium innovativeness).

High newness is exemplified by new to the world products, which also hold elevated levels of newness to the company.

Based on figure 4.1, six different classes of new products are identified (Stanski, 2009):

- 1) *New to the word products*: innovative and revolutionary for both the market and the company. These are first of their kind and create generally new markets. They generate high revenues to the enterprise and have a multiplication effect because they create new requirements for parts and subassemblies that need to be and supplied by vendors.
- 2) *Products completely new for the company but not for the market*: this category of product allows a company to enter in new markets not previously joined. Adding new categories of products, however, may endanger the positioning of the existing products. These new lines generate incremental revenues for the manufacturer, which exploits the familiarity of its market.
- 3) *Repositioned products*: repositioning is a methodology based on firm's knowledge and technologies that can be exploited to produce equivalent products for other market segment. It represents a strategy useful to increase or maintain market share. It can be considered more a marketing activity than a developing one.
- 4) *Existing product lines enlargement*: new models are added to the existing line in order to widen the offered variety, to satisfy new market segments. Moreover, lines extensions allow the enlargement of the influence of the company's brand. These products generate incremental revenues by leveraging the existing product familiarity rather than the company one.
- 5) *Products improvement and revisions*: it is an important activity deriving from customers' advices and feedbacks. It involves the introduction of innovative technologies in order to improve the offered products performances and reliability

to maintain the company competitive level. Since time passes, products become obsolete and customer's expectations increase, so companies must add greater values to their products. Generally, it represents a defensive strategy.

6) *Costs reductions*: it's a strategy aimed at retargeting of existing products to new market segments. This category encloses the least "new" of the new product categories. These NPD lines are intended at the supplanting of existing offerings to provide similar advantages at lower costs to the business.

Summarizing, these categories define the New Product (NP) in two main different dimensions: the introduction of a product completely new and the improvement of existing products. However, what does it really mean the introduction of a new product on the marketplace?

4.2 NPD Process

In literature, NPD process is described as a series of activities, which starts with the generation of a set of preliminary different product concepts that, consequently, is progressively reduced along the process. These activities are accompanied by a gradual increase of the level of their definition, which brings to the realization of the product in a repeatable and reliable way (Ulrich and Eppinger,2012). In the upcoming pages, different approaches are presented:

4.2.1 Sequential Approach

It is an approach where a product development is sequential: the next phase starts only when the previous one is finished, and it has produced the necessary information. In other words, the output of the previous phase is the main input of the following phase. In addition, every phase's end is a checkpoint to control the project risk. This approach

does not support integration and collaboration, does not create conditions for Time to Market reduction and process flexibility. Each function deals with a specific task, so knowledge is very specialized and segmented. The typical process flow is reported below:

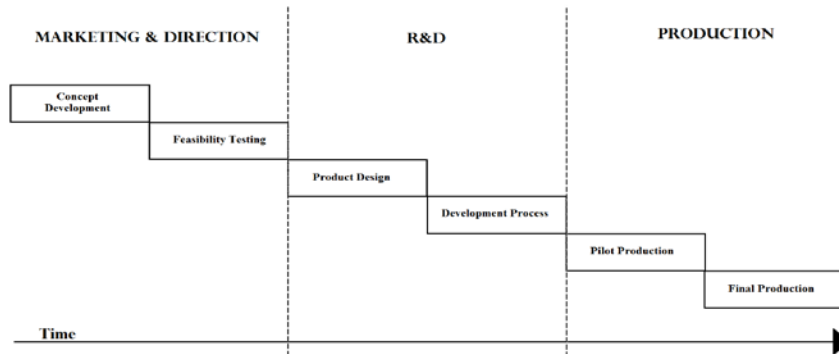


Figure 4.2 Sequential Approach
Source: Author's elaboration

4.2.2 Concurrent Engineering

This approach is based on the overlapping development phases' concept, which means that the following phase starts before the preceding one is ended. It starts as soon as it gets the minimum information necessary. As the two phases are overlapping, an intense information exchange is needed, so that as additional information is created in both the phases, the other can adapt quickly.

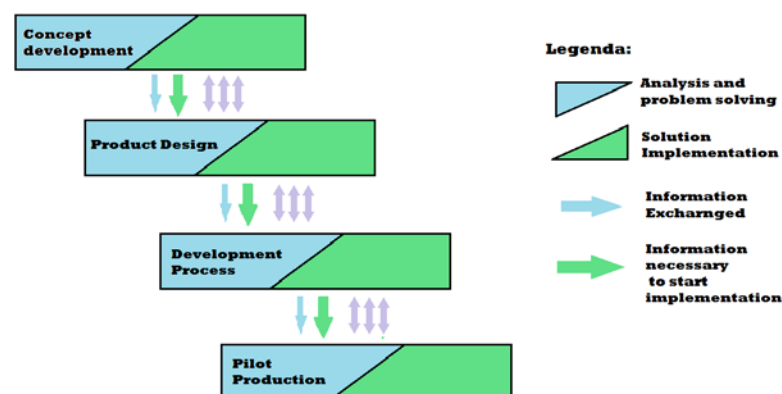


Figure 4.3 Concurrent Engineering Approach
Source: Author's elaboration

Decisions are based on information gained by upstream and downstream activities together, and this requires organization since communication is meant to be bi-directional. To highlight the reasons why Concurrent Engineering (CE) has been adopted and where it fails, the table below summarizes CE pros and cons.

Table 4.1 Advantages and Disadvantages of Concurrent Engineering

Advantages	Disadvantages
Less review needed	Initial concept is fundamental
Less risk of modifying objectives needs	Decisions are made with uncertainty of the preceding phase output
Focus on customer value from the very beginning	Good information sharing system is needed
Automatic approval from all the functions	Process output is highly dependent on resources
Development cost reduction	
Failure risk reduction	

Source: Author's elaboration

To better perform, Concurrent engineering approach relies on *cross-functional teams*: *Cross-functional teams* are those teams in which members drawn from a variety of disciplines (such as engineering, marketing, manufacturing), transform ideas, concepts and products specifications into saleable products. The speed of the product development process, in term of time to market, can be obtained by involving relevant functions and participants from the beginning of the project and anticipating manufacturability issues. Cross-functional teams lead to the sharing of information and decisions made in the design and production process. Cross-functional teams also take into consideration customers' needs. The involvement of cross-functional teams in NPD process is due to the need of minimalizing miscommunication and encouraging an informal sharing. They also are useful to understand the strength and weakness of the process and they increase the likelihood of the new product success.

4.2.3 Set Based Concurrent Engineering approach

Set- Based Concurrent Engineering (SBCE) is developed in direct contrast with the sequential development. This approach proposes a parallel development of different solutions and a progressive narrowing of the design space. The figure below explains what a design space is and how the narrowing of the possible solution is obtained.

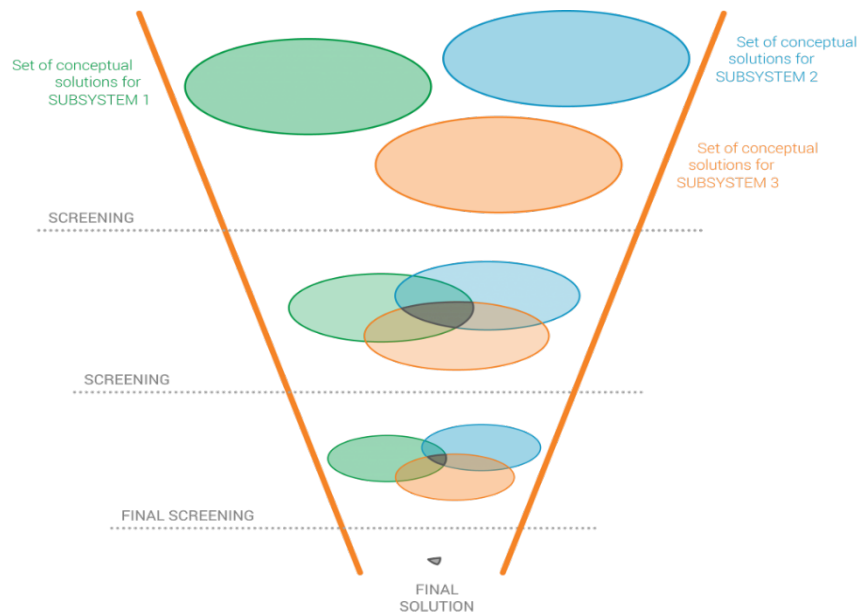


Figure 4.4 Set Based Concurrent Engineering Approach

Source: Lean Analytics Association. <http://lean-analytics.org/set-based-concurrent-engineering-sbce-why-should-you-be-interested/>

The process is based on three principles: *map the design space*, *integrate by intersection* and *establish feasibility before commitment*. Three steps, to better understand what they mean, can describe each one.

Map the design space is the development and characterization of the sets of alternatives used in the convergence process. It comprehends the definition of feasible regions, exploration of trade-offs by designing multiple alternatives and communicate sets of possibilities. In the first step, each function defines a feasible region from its perspective. Then, trade-offs are explored by designing, prototyping and simulating alternative systems or subsystems. Finally, these feasible sets are communicated to the

other functions, so that they can better understand everyone's design space and trade-offs.

Integrate by intersection means that as various functional groups begin to understand the considerations from their own perspective and others, design teams integrate subsystems by identifying solutions workable for all. This phase starts by looking for intersection of feasible sets, which means finding the overlapping design areas, where feasible complete solutions can be found. Then, minimum constraints are imposed, leaving flexibility to explore new adjustments to improve integration.

The last step is seeking conceptual robustness, which means to select those solutions that are functional regardless of physical variations (e.g.: manufacturing variations).

Finally, *establish feasibility before commitment* makes participants seek to understand all the possibilities and interactions before committing to a particular design so, first, narrow sets gradually while increasing details, then stay within sets once committed and control by managing uncertainty at process gates (Durward et al,1999). This means to define many gates in which uncertainty is leveled by reducing the number of sets and deepening the knowledge about the product and the context.

However, this innovative approach would need a very long description to be perfectly understood.

4.2.4 Stage-Gate Approach

The Decision-stage models are characterized by the presence of stages (where the activities are performed), followed by gates (review points with specific input, exit criteria and a go/kill/hold/recycle decision as output) (Cooper, 1990).

The Stage Gate System is multi-functional and consists of parallel activities, carried out by people from different functional areas (Cooper and Kleinschmidt, 1993). Cooper's

Stage-gate systems recognize that product innovation is a process and, like other processes, can be managed. Therefore, he proposed a generic model for managing new products development, improving performance.

Stage-gate systems simply apply process management methodologies to this innovation process. Between each stage, there is a quality checkpoint or gate, which contains both a set of deliverables and a set of quality criteria that the product must meet before moving to next workstation. Stage-gate systems use similar methods, dividing the innovation process into a predetermined set of stages, themselves composed of a group of prescribed, related and often parallel activities (Cooper, 1990). Usually stage gate systems involve from four to seven stages and gates, depending on the company or division. A typical system is shown in Figure 4.5:

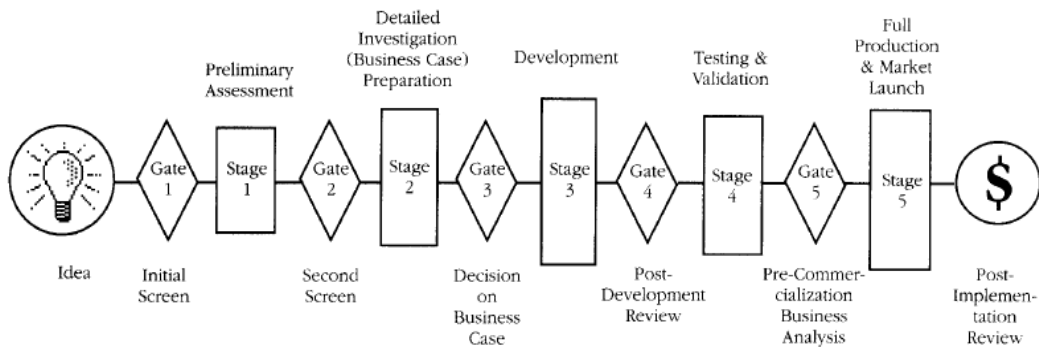


Figure 4.5 Stage-Gate Approach

Source: Cooper (1990) Stage-Gate System: A new Tool for Managing New Products

Each stage is usually more expensive than the preceding one. Concurrently, risk is managed with the increase of global knowledge level. The entrance to each stage is a gate; these gates control the process, as quality checkpoints in a production plant control the production process. In the same way, each gate is characterized by a set of deliverables or inputs, a set of exit criteria, and an output.

- The inputs are the deliverables that the project leader must bring to the gate,
- The criteria are the features upon which the project will be judged,

- The outputs are the decisions taken at the gate, usually in the form of go/kill/hold/recycle, and the approval of an action plan for the next stage
- (Cooper, 1990).

Each project leader is required to provide the specified deliverables, meet the stated criteria at a given gate, and drive the whole project, stage-to-stage, gate to gate.

Cooper's process model is composed as follows:

- *Idea*: a new product idea.
- *Gate 1 - Initial screen*: is the first decision to commit resources to the project; if the verdict is GO the project goes to the next stage and is officially born. In this gate, 'must meet' and 'should meet' criteria include strategic alignment, project feasibility, differential advantage, adherence with the firm's core business and resources, and market attractiveness. Non-financial criteria are measured.
- *Stage 1 - Preliminary Assessment*: is an inexpensive phase aiming at determining project's technical and market merits.
- *Gate 2 - Second Screen*: Additional 'should meet' criteria are added, regarding sales force and customer reaction, generated from stage 1. A simple financial calculation is assessed (i.e. payback period). If the result is GO the project continue to the heavier stage 2.
- *Stage 2 - Definition*: it is the final stage prior to product development in which the project has to be clearly defined. In this phase the attractiveness of the product must be assessed, market researches are performed, customers' needs are identified and translated into technically and economically feasible solutions. Moreover, a detailed financial analysis (discounted cash flow approach and sensitive analysis) is conducted as an input to gate three.

- *Gate 3 - Decision on Business Case:* it is the project last point, in which it can be killed before entering to the development stage. The results of financial analysis are now very important; a GO response in this gate determines a heavy spending. Decisions on product key features, specifications and attributes are taken; a delineation of the product benefits is delivered, and preliminary operations and marketing plans are evaluated.
- *Stage 3 - Development:* involves the development of the product and of detailed test, marketing and operations plans. An updated financial analysis is prepared.
- *Gate 4 - Post-Development Review:* it is a checking phase of the continued attractiveness of the product and of the quality of development work. In this gate, economic questions are reviewed based on additional and more detailed data.
- *Stage 4 - Validation:* is a phase that tests the entire variability of the project considering product, production process, customer acceptance and economic aspects.
- *Gate 5 - Pre-Commercialization Decision:* this gate is the predecessor of commercialization stage, and the decisive point at which the project can still be killed. In this gate, the focus is on the quality of the activities performed during stage 4. Financial projections are fundamental here. Then operations and marketing plans are ready for implementation in the last stage.
- *Stage 5 - Commercialization:* is the last stage, during which operations and marketing launch plans are executed.
- *Post-Implementation Review:* At some point, the new product process must be ended, and the product becomes a 'regular' one. The stage-gate model ends with

a deep review of the entire process, during which strengths and weaknesses of the project are highlighted. Then a learning process is implemented.

Not all stages are mandatory (Cooper, 1990).

Ulrich and Eppinger (2012) elaborated a new stage-gate process model composed of six phases (Figure 3.6). Each one comprises a series of activities and feedback processes. Their key idea is the conception of product development process as ‘the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product (Ulrich and Eppinger, 2012).

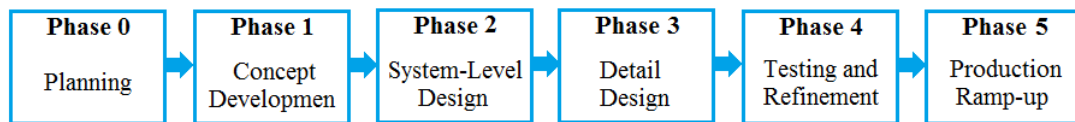


Figure 4.6 Stage-Gate Approach proposed by Ulrich & Eppinger

Source: Author’s elaboration based on Ulrich & Eppinger (2012).

Cooper (2008) itself in gave a further evolution of Stage-Gate model.

Named the “Spiral Development” (Cooper, 2008), and seen in Figure 4.7.

This way to operate tries to surmount the typical problems characterizing the traditional linear process models: project teams need accurate information right at the time, but it takes months to design and develop a product that agrees all the specifications. Meanwhile, customers and markets’ expectations can shift, especially in case of very innovative products. The idea of spiral development wants to obtain and provide prototypes to customers, right from the beginning of the process, and to immediately get feedback, useful then to generate the successive, more accurate version of the product. Spiral development also bridges the gap between the need for sharp, early and fact-based product definition before development begins and the need to be flexible, agile and to adjust the product’s design to additional information and fluid market conditions as product development proceeds. The method thus allows developers to

continue to incorporate valuable customer feedback into the design even after the product definition is supposedly locked-in.

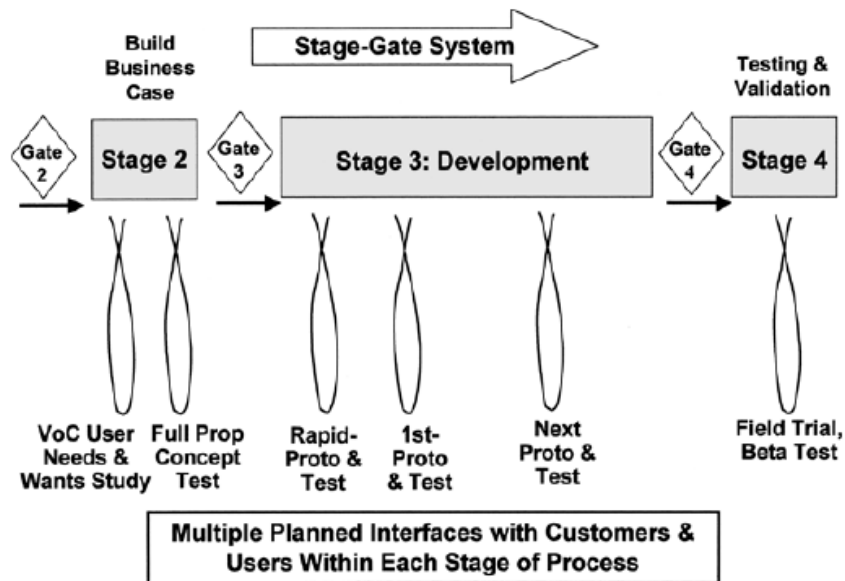


Figure 4.7 Cooper’s Spiral Development
 Source: Cooper, (2008) Maximizing Productivity in Product Innovation.

This methodology can be seen as a set of “build-and-test, then seek feedback and-revise” iterations with the user or customer. Teams remove unnecessary work and come quicker to a final product by building a series of these iterative steps, or loops. Cooper suggested that the number of necessary spirals depends on the type of product to develop. Below is given a brief description of the different spirals the model is composed of:

- The first loop must be the voice-of-customer study assumed in Stage 2: project team members visit clients to better understand their unmet and implicit needs, troubles and benefits required in the new product. At this point, the project team probably has very little to illustrate the customer: the purpose of this visit is to listen and watch, not to show and tell.
- The second spiral marked “full proposition concept test”: project team give a representation of the proposed product. Because of the type of product and

business, this representation can be a computer-generated virtual prototype, a hand-made model or mock-up, an extremely basic prototype, or even a few computer screens for new software. The focus of this spiral is to provide to customers a sufficient feel for what the product will be and perform. Interests, tastes, preferences and purchase intents are hence recognized even before the project become a formal development project. Feedback is required, and the needed product revisions are made.

- Moving into the Development Stage, the project team creates the next and more complete version of the product, possibly a rough model or a prototype. Designers test it with customers, and again they search for feedback, and then used to rapidly revise and build the first-working prototype; and after that, the process flows to Spiral #3, #4 and so on. In this way, each following adaptation will be closer to the final product, and at the same time, more similar to the customer's ideal. These loops look exactly like spirals, hence the name "spiral development."

4.3 NPD Phases

In the previous pages, different NPD approaches have been presented, but, although they are substantially different, they share the same objectives systematically: in the following paragraphs, a deeper look at the several stages that compose NPD development is given, not considering the existing different approaches. The New Product Development process is a high knowledge creating process. Every problem found in the attempt to fit the product concept and satisfy the customer requirements bring to the achievements of new knowledge, which can be capitalized and reused, in order to make the NPD processes more efficient.

Firstly, it is necessary to perform a research of market opportunities; this kind of analysis requires the identification of the possible source of innovative ideas and how those can be implemented. Once a set of alternatives is identified, they have to be conveniently examined in order to exclude poor, unsuitable or unattractive ideas from the following phases. It is also necessary to evaluate the selected alternatives because of market opportunities and customers' needs. When a single alternative is positively evaluated, the actual development process begins.

The real development process starts from a more detailed definition of the product's concept and with an identification of a designed plan, which make its realization possible. When this phase, which include both the systemic design (product architecture and consequent organizational and managerial choices) and the detailed design (geometries, specifications, materials) is completed, it is necessary to examine the new product in the contest of its normal use. The NPD process ends with a validation phase, during which pilot productions are carried out to test and fine-tune the manufacturing process, and market tests are performed to assess the customers' reaction (Cooper, 1990). All the processes involved in the NPD creation represent a set of multidisciplinary activities, which involve different business areas, throughout the design process.

4.3.1 Planning and Ideas Generation

This phase is also defined as Phase zero since it precedes the project approval and the actual beginning of the product development. It starts from the company strategy and includes the technological development and market objectives assessment. The core object of the planning phase is a "portfolio of opportunities", which is a set of potential development projects that the company might decide to carry on. The objective of this

phase is to select the most promising projects to be developed (Ulrich and Eppinger, (2012). The company has to consider several aspects that can affect the decisional process: new products should be aligned with the company strategies on the market with respect to competitors, and it should consider the technological innovations and their performances. This phase leads to several opportunities of developing new products, to satisfy the company' necessity of building a balanced development portfolio and aim to the exploitation of pre-existent product platforms. In addition, a firm should consider also an estimation of appropriate human and financial resources required to carry on the selected projects. There are risks connected to the approval of a higher number of projects to the available resources: a drop-in productivity, a dilation of the projects' completion time, late launch on the market or reduction of profits.

The company must choose the most relevant projects to develop and the ones to exclude from the planning. Then, an estimation of time and sequence of implementation are required. To define the product plan, projects approved in the planning process have to be arranged in a time sequence. The planning phase ends with the mission statement of the project: a document that specifies target market, the product objectives, the main assumptions and bonds, and the stakeholders directly affected by the success or failure of a new product. With respect of sources of ideas, either customers' needs or technologic innovation, two different innovation processes can arise, respectively *market pull* (a market opportunity pulls the development process), and *technology push*, where a new available technology pushes the new products development.

Tidd and Bodley (2002), state that the best development strategy to choose is based on product novelty degree. In case of incremental innovation or extension of the product line the most effective approach should be market pull; on the other hand, when the innovation is radical and responds to needs the customers are still not aware of, the

best approach should be the technology push. In both cases, it is necessary to collect information from customers (Tidd and Bodley, 2002) through interviews, focus groups, on-site observation (Ulrich and Eppinger, 2012). It is understandable how the development process it is related to the knowledge of the customer's needs and the technological improvements required by the market. A correct management of this knowledge fundamentally leads to the identification of specific needs that may emerge and subsequently have to be satisfied, giving to the company a chance of anticipate market trends. In other words, once information is gathered, it is translated in terms of knowledge of customers' needs.

4.3.2 Conceptual Design

This step refers to the concept development for the ideas selected in the previous phase. In literature there are several definitions of *product concept*, below are reported the most comprehensive ones:

- *A concept is the description of shape, functionalities and features of a product, and it is often accompanied from a set of specifications, an analysis of competitive products and a preliminary economic evaluation to justify the project (Ulrich and Eppinger, 2012).*
- *The concept is an idea of new product, which defines who will use the product, its key features, and the consumption pattern (Kotler and Keller, 2007).*

In this phase, it is important that the project team generate a relevant number of different concepts to make sure that the most valid alternatives have been taken into consideration. In order to develop a successful product, it is essential that the concept is well defined; as a poor formulation could compromise the subsequent development

phases, leading to consequences difficult to reverse. A risk connected in this phase is that superficial analysis of the possible concepts could lead to the advancements of project of products with lower performances or inferior concepts compared to the competitor ones. A good practice to limit these risks is ensured using a structured method for the concepts generation and benchmarking activities. Information obtained from competitors helps to better define the product positioning (Ulrich and Eppinger, 2012).

Starting from the customer's needs identification, alternative product concepts are generated and evaluated to select the promising ones for further development.

The selection process of the concept is composed of a phase of "concept screening" and a phase of "concept scoring":

- The *concept screening* is a qualitative process aimed at quickly improving and reducing the number of concepts.
- The *concept scoring* is a more detailed quantitative analysis of these few basic ideas, and its purpose is to determine which is the solution with the highest probability of triggering a successful product.

4.3.3 Pre-Design and Detailed Design

This phase comprehends the definition of the product's architecture, the scheme through which the product functionalities are allocated to single physical parts and its partition in subsystem and components.

The tasks involved are:

- Definition of the product's functional requirements: a set of independent requirements that completely characterize the functional needs of the product or service.

- Definition of product constraints: bounds on acceptable solutions. They can be either input or system ones: Input constraints are imposed as part of the design specifications and system constraints are imposed by the system in which the design solution must function. Subsequently these elements are associated to the product and its parts through a:
- Mapping process: it helps to define the design parameters that are key physical variables in the physical domain that characterize the product design that leads to the satisfaction of the functional requirements.

The last task is the definition of the process variables: key variables that characterize the process that can generate the specified design parameters.

This phase also includes the evaluation of some organizational and managerial needs for concept realization, which considers additional human, financial, technological and logistic resources necessary to the successive development phases. Lastly, a financial feasibility analysis is needed. The detailed design comprehends the complete definition of the geometry, materials and tolerances of each component, and the identification of the standardized parts that can be purchased by suppliers. In addition, the production plan for internal production of the remaining parts is defined. The outputs of these phases are:

- For the Pre-design stage: a draft detailed project, a document that summarize the entire project and that includes also the organizational planning of its development.
- For the Detailed Planning: technical documentation including drafts and files describing every aspect of the product and the relative production and assembly processes.

4.3.4 Testing and Prototyping

In the earlier NPD phases, the product has existed only in descriptive terms, or in a graphic dimension. During this phase, the company assesses the feasibility of what has been designed, under a technical point of view. Therefore, prototypes are built and evaluated. A responsibility of the development team is the achievement of one or more physical versions of the product, that help to understand if what that has been designed can effectively meet the requirements and the key attributes that the product must have, with respect of the budget available.

During *alpha* testing, initial prototypes are realized through different processes, with respect to those that will be used during the manufacturing phase. These prototypes are tested to determine if the product includes the desired functionalities and respects the customer requirements. The following prototypes, called *beta* prototypes, are pre-series products, evaluated both from the company and from the customers in their context of use; their aim is the assessment of performances and reliability in order to identify possible changes for final product improvement as well as the verification of the reactions of prospects towards it.

4.3.5 Pilot Production and Product Introduction

Every new product introduced in a plant must undergo the ramp-up, during which the product is realized through the actual manufacturing process; this production is called Pilot Production, since it aims to staff training and to solve any possible problem related to future production. The duration of this phase is variable, since during this period, with the increasing of the process' level of understanding, there is a gradual increase of the production level, thanks to adjustments of the productive solution and change in tools and equipment. Moreover, scraps, wastes and downtime are reduced, inspection

and quality check methodologies are developed, both maintenance and reprocessing time decrease. (Terwiesch and Bohn, 2001).

The transition to large-scale manufacturing phase is usually gradual; the productive volume increases, passing from the pilot production to the regime use, through the ramp-up phase. However, not every ramp-up finish in a successful way: it can happen that the productive plant cannot reach a level of yield able to reach the break-even point (Terwiesch and Bohn, 2001). The production of new products of course implies risks: for a company it's crucial determine whether the introduction of a new product can improve its competitiveness in the market.

4.4 New Products' Risks

Nowadays, the introduction of new products in technology-driven markets can be a risky operation (Yelkur and Herbig, 1996): Antil (1988) states that the failure rate in product launches can be very variable. However, this risk tends to relevantly increase when firms deal with very innovative technologies, where uncertainty is higher and global knowledge level is low. There are two main typologies of risks that need to be taken into consideration during the development process:

- 1) *Technological risk*: before the launch of a new product, the firm must verify if the innovation level and technical capabilities required are possessed and sustainable.
- 2) *Commercial risk*: the company must be able to assess the market responsiveness; the failure of a new product launch is often because the company launched with an inadequate time to market (Hbr.org).

Despite these risks, every enterprise cannot stop innovating; without introducing new product, in fact, a reduction of market share and a loss in terms of competitive advantage is inevitable (Yelkur and Herbig,1996).

4.5 NPD Performance Evaluation Criteria

Performance is defined in terms of *effectiveness* and *efficiency*. With respect of NPD process:

- *NPD effectiveness* is the extent to which the new product is successful by some external criteria.
- *NPD efficiency* measures the extent to which the NPD project adheres to budgets and schedules.

For this thesis are identified and proposed a series of other parameters (rather than those described above), which can be classified in two main categories: *financial* and *non-financial* ones and in four subcategories of the NPD performance: *time, costs, level of innovation* and *quality*.

4.5.1 Financial Dimension

New product performance has traditionally been defined in terms of financial results; under this point of view, the main costs related to the project are taken into consideration. This dimension evaluates the project's success in terms of revenues for the firm and considers project's total cost and respect of budgeted costs, among others such as Return on Asset ratio (ROA), Return on Sales (ROS), and Return on Investment, (ROI), development cost and market share's goals. An effective way to enrich the financial performance's evaluation may be also the consideration of other financial indexes such as the following:

- Overall profitability, defined as the degree to which the product's profits exceeded the firm's minimal acceptable profitability.
- Payback period in years: the number of years required to regain the initial outlay in the project;

- Sales growth: percentage growth in total sales.

NPD financial performance can be also assessed as the level of sales success achieved by the new product with respect to other new product launches, competing product launches, and sales objectives for the launch.

4.5.2 Non-Financial Dimension

In the current competitive context, NPD efforts cannot be assessed solely based on financial results; non-financial measures become equally relevant to make a richer assessment of an NPD project success.

Time dimension acquires the major position among these performances.

Within *time* metrics are included the following:

- *Time to market*, which indicates the time taken by the NPD teams to bring the product into the market. Reducing the time to market means arriving on the market before the competitors; being the first mover leads to many advantages such as: temporary monopoly on the market (in terms of volumes and sales margins), gaining a competitive and unassailable position, extending the product lifecycle, benefits after the product launch phase in term of image and market share. On the other hand, a first mover strategy implies the risk linked to take decisions based on partial or uncertain information.
- *Total development time*: that includes the time operatively needed to generate the concept, choose among the alternatives the best one. It also considers the time necessary to the fulfillment of a detailed design and every activity composing the NPD process, as well as the coordinating time among the team members and among different teams or functions

- *Compliance to scheduled time* that is represented by the firm's capacity to respect the time line. Chiesa and Masella (1996) refer to the term adherence to schedule in order to measure how projects are carried out adherently to plans; the relative metrics should reflect whether, at a certain milestone, time to completion is as planned. The two authors underline how this performance can influence the enterprise revenues.

Quality: the term quality can have different meanings: specification quality, compliance quality, perceived quality and responsiveness to customers or other stakeholders' needs. Quality performance includes several dimensions, among others, the most important ones are customers' satisfaction, product features quality, product's safety and reliability. Customer satisfaction, however, represents a subjective evaluation because it is related to the quality perceived by the customer. Different scales can be used to evaluate the extent to which a firm achieved its goals for customer acceptance and satisfaction: such as the product's design performances, which involves aspects like product resistance, manufacturability, testability and unique features that differentiate it from the competitors' ones. Products within their portfolios are more likely to complement rather than to cannibalize one another, and they are more likely to be built around core capabilities that create cost efficiencies in product development.

Innovativeness: in this work, innovativeness is seen as the potential discontinuity that a product might generate in the marketing and/or technological process. Coherently with this view, innovation is fundamental to the maintenance of firms' competitive position and profitability. The financial value of new products seems to be a function of the level of their innovativeness. It ends up fundamental, however, incorporating this measurement in the NPD evaluation, since radical developments demonstrate to have more prominent incentive than incremental advancements, new product ideas have more noteworthy incentive than line expansions and technological breakthroughs are

more productive than incremental upgrades, but, on the other hand, risks connected to innovation are higher.

4.5.4 Team and Knowledge Performances

In addition to performance metrics mentioned above, some authors introduce two other classes of measures: team performances and knowledge performances. These two dimensions can be included in non-financial performances, but literature is not as mature as what concerns more traditional performances such as time to market or customer satisfaction. Different team performance models have been suggested in literature. Sivasubramaniam, Liebowitz, and Lackman (2012), for example, dedicate their work to define and measure NPD team performances. These models utilize a systems perspective to identify a set of inputs, which set the team conditions, affecting how teams interact and work: this view of team performance suggests that team inputs and processes have a strong impact on NPD outcomes. From a business performance perspective, Ahn, Lee and Lee (2006) focus also on NPD knowledge performances, identifying different metrics: applicability of the technical platform developed, technical knowledge created, new market opportunities based on the knowledge created and marketing knowledge created.

There is no methodology, a canonical or universal approach for evaluating NPD performance. An important aspect to mention in evaluating the performance of the NPD is that different approaches are distinguished also based on the evaluation procedure. In particular, according to the moment in which the performance is measured: either ex-ante, during the process (with the possibility of termination at any time) or after the completion of an R & D project, to measure its final value (Szakonyi, 1994). There are also approaches based on benchmarking, which look at the practices used compared

with those of competitors or other firms. These can be applied to the whole function or to a single activity within NPD process. This kind of methodology is generally associated to qualitative and subjective evaluations. The project evaluation is a continuous process. What changes over time is the quality of the information on which the evaluation is made, which improves with the passage of time and the uncertainty reduction.

CHAPTER 5:

MODELS

5.1 Models

The following are conceptual frameworks, extracted from the existing literature, that are helpful to better understand how knowledge management processes and methodologies can be implemented to achieve better global organizational performance. Knowledge management is a field in constant development and there exist a vast number of distinctive knowledge management models and frameworks, each of which is different in focus, objectives, characteristics and approaches. In the following pages, a few are presented. Although the models are one substantially different from the other, in a generic knowledge management model, critical success factors are represented by:

- K.M. metrics that are used to measure and stimulate strong relationships between K.M. activities and competitiveness,
- Knowledge templates to achieve management of core knowledge,
- Various information groups activities for the ideas generations,
- IT systems and rules to satisfy individual development.

The models are sorted in chronological order, from the oldest to the most recent. In addition, surveys' questions, equations and hypothesis are not provided, and calculations are not shown. Some articles presented case studies in which the frameworks have been tested. Those are not included in this thesis.

5.1.1 Model 1

The model is extracted from article “*From Embedded Knowledge to Embodied Knowledge: New Product Development as Knowledge Management*”, written by R. Madhavan and R. Grover, in 1996.

As previously said, two dimensions of knowledge are tacit and explicit. Tacit knowledge is conceived of as embedded knowledge. Based on the conceptualization of NPD as a process of transfer of knowledge possessed by the NPD team, into new products that incorporate such knowledge, the article shows how the knowledge is transformed from embedded to embodied one, and how knowledge management can help NPD process management. The paper develops propositions on how to manage and optimize the creation of knowledge in a NPD process.

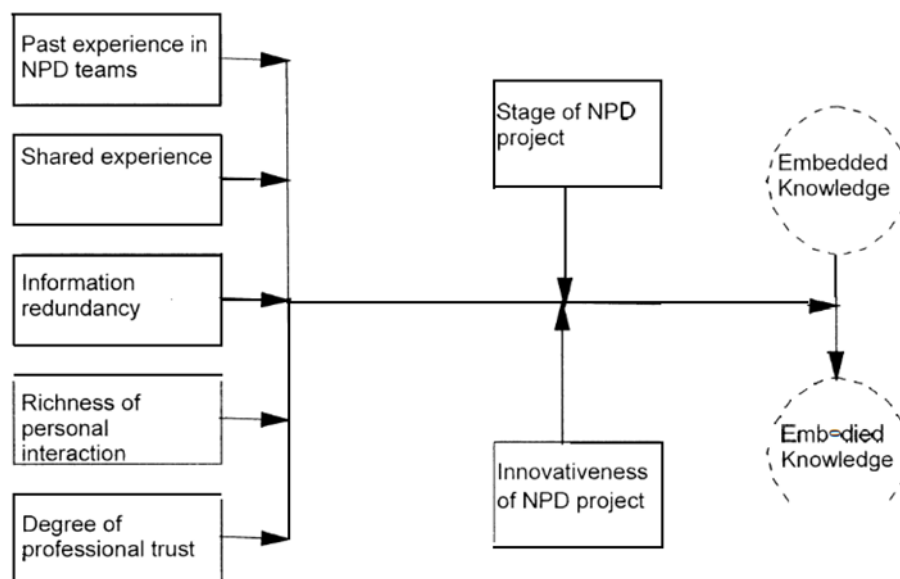


Figure 5.1 Transformation from Embedded to Embodied Knowledge
Source: R.Madhavan et al, (1996). From Embedded Knowledge to Embodied Knowledge: New Product Development as Knowledge Management

The identification of the NPD process variables that lead to the efficiency of the conversion from embedded to the embodied knowledge is given by the identification of the following dimensions:

Past Experience in NPD teams: is positively related to the efficiency with which embedded knowledge is converted to the embodied one. Team members that have previously worked together are more effective than a group that has not worked as a team before, because they developed their own knowledge from the combination of individual collections of tacit knowledge. Thus, the efficiency is more provided by the experience in the same team than the experience with other individuals.

Shared Experience: brought in the team-by-team members. It represents a crucial factor that leads to the conversion from embedded to the embodied knowledge. The maximum efficiency is achieved by a medium level of shared experience.

Information redundancy: the information redundancy leads to efficiency when its level is medium. Even if the redundancy improves the likelihood of acquiring and transforming knowledge, high level of information redundancy brings the loose of efficiency.

Richness of personal interaction: that is based on communication among the individuals. This collaboration allows the facilitation of problem solving, task coordination, and information sharing and conflict resolution. This dimension is determinant in effective knowledge utilization and leads to the creation of new knowledge. Personal interactions are positively related to the efficiency with which embedded knowledge is converted to the embodied knowledge. This interaction needs to be frequent, direct and it has been demonstrated that informal networks are more significant than formal ones.

Degree of the personal trust: two sub dimensions compose it:

- *Team orientation:* that means that team members look to their goals as “team players”,

- *Estimated competence* of other members: a high level of perceived competence brings to a higher degree of professionalism.

These two factors determine the level of trust among the organization members. However, the team orientation is more related to knowledge transformation efficiency than competence.

Two more contributes are underlined: Stage of NPD and Innovativeness of the product:

Stage of NPD: The efficiency with which embedded knowledge is converted to embodied knowledge is moderated by the stage of the NPD process. Teams perform better than individuals do, in tasks, when the problem is unstructured, a situation that is expected to occur in the early stages of the NPD process. Accordingly, higher degrees of conversion efficiency occur in the initial stages.

Innovativeness of the products: The more the product has a high innovative content, the more efficient the conversion of knowledge from embedded to embodied will be.

Summarizing, this model explains which variables influence the transformation of the embedded knowledge to the embodied knowledge basing on the Nonaka knowledge theory.

Benefits and Limits

The proposed model provides an explanation of those variables that affect the knowledge' transformation and thus the development of a new product. Although it identifies several variables that team member should took into consideration, it does not provide a way of its implementation and it is not consistent because its validation is only referred to theoretical constructs and not to its application into a firm's strategy.

5.1.2 Model 2

The model is extracted from publication titled “Knowledge Management: An organizational capabilities Perspective”, proposed by A. H. Gold, A. Malhotra and A.H. Segars, in 2001.

It represents a way to gain organizational effectiveness focusing on knowledge infrastructure and knowledge process capability. The research examines the issue of effective knowledge management from the perspective of organizational capabilities. A key to understanding the success and failure of knowledge management efforts within organizations is the identification and assessment of the factors that are necessary for the implementation of these management efforts. The model wants to identify the preconditions necessary for knowledge management.

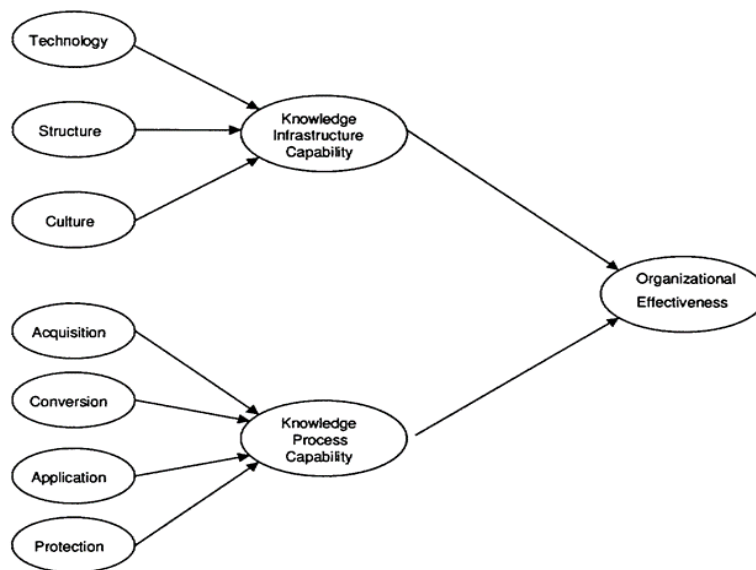


Figure 5.2 Knowledge Management Capabilities and Organizational Effectiveness
Source: A.H. Gold et al, (2001). Knowledge Management: An Organizational Capabilities Perspective

This perspective suggests that a knowledge process’ architecture is composed of acquisition, conversion, application and protection activities: along with a knowledge infrastructure consisting of technology, structure and culture. These two dimensions are essential preconditions for effective knowledge management.

Infrastructure capabilities:

Technology: The first factor that influences the structural dimension is technology. The knowledge management includes technological parts such as *business intelligence, collaboration and distributed learning, knowledge discovery, application, and opportunity generation:*

- *Business intelligence technology* leads to generation of knowledge regarding firm's competition and to the expansion of its economic environment.
- *Collaboration and distributed learning:* they are crucial elements for the knowledge sharing within the organization.
- *Knowledge discovery technology:* brings to the acquisition of new external and internal knowledge,
- *Knowledge application technology:* leads to the use of existent technology.
- *Opportunity generation:* allows the company to track the knowledge about its customers, employees and partner.

Structure: The second factor is the organizational structure. It is the key core for the leveraging technological architecture. It is essential that the organizational structure is built for flexibility to encourage collaboration and knowledge sharing. The importance of this dimension is represented by the need to create an incentive system where employees can share their own knowledge and collaborate.

Culture: Organizational culture is determinant in the firm's ability to manage its knowledge. The organizational environment should incentive, both formally and informally, the interaction among the employees.

Process Capabilities:

Process capabilities point out the importance of managing the knowledge externally.

The following sub dimensions compose this dimension:

- *Acquisition processes*: those are processes oriented toward knowledge achieving. The ability to acquire knowledge is partly based on the organization's absorptive capacity. However, the key factor for the knowledge acquisition is represented by benchmarking activities and collaboration. Benchmarking' role is the identification of outstanding practices and it allows assessing the current state of a particular process identifying gaps and problem. Collaboration takes place at two levels within the organization: between individuals and among the organization and its business partners.
- *Conversion processes*: these processes are oriented to the useful application and use of the existing knowledge. The knowledge conversion is determined by several processes such as firm's ability to organize, integrate, combine, structure, coordinate, or distribute knowledge. The combination and integration of the existing knowledge leads to the redundancy's reduction and to the efficiency improvement by reducing the excess volume.
- *Application processes*: they are oriented toward the actual use of knowledge. The organizations should focus on the efficient storage of the knowledge to guarantee a quick and simply access to it. The key core for the competitiveness is represented by the creation and location of the knowledge and its sharing.
- *Protection processes*: processes oriented to protect knowledge from an illegal and inappropriate use. The need of protecting knowledge should be taken into consideration and not to be abandoned and marginalized. To obtain the asset's protection several steps can be taken, such as incentive alignment, employee conduct rules or job designs.

The results of this work provide a basis for understanding the competitive predisposition of a firm as it enters a program of knowledge management.

Benefits and Limits

Infrastructure and Process capability, combined, lead to obtaining of firm's effectiveness. The organization effectiveness is represented by several aspects: ability to innovate and to anticipate surprises on the market place, improvement of efforts' coordination, the rapidity of the new product's commercialization and the responsiveness to the market changes.

Summarizing, this model provides a way to assess knowledge management from a perspective of an organizational capability. The knowledge infrastructure, composed by technology, structure and culture, it is a precondition for an effective knowledge management. This model provides a way to evaluate firm's predisposition to knowledge management efforts: to compete effectively, firms must leverage their existing knowledge and create new knowledge that favorably position them in their chosen markets. This model sought to identify the key contributions of knowledge management capabilities: improved ability to innovate, improved ability to coordinate efforts, rapid commercialization of new products, and ability to anticipate surprises, responsiveness to market changes, and reduced redundancy of information and knowledge.

The limitations carried out by this model are that it is only defined a priori, based on theoretical constructs, thus a validation to prove model's effectiveness is needed. In addition, there are not any about how the sub dimensions are related one another and it does not give any consistent measure of how the organization effectiveness can be measured.

5.1.3 Model 3

The model is extracted from article “Knowledge Management and New Product Development: a study of two companies”, written by A.B. Shani, J.A. Sena and T.Olin, in 2003.

The study is focused on knowledge creation and its exploitation, and it explores the relationships among organizational context, NPD process and knowledge management. Organization design and knowledge management architectures are identified as moderating factors in the success of NPD activities.

The authors adopt a design-based view to provide an alternative way to view the process by which knowledge is created, transferred and utilized, and incorporate it following the sociotechnical system theory. The design-based new product units are intended as entities based on a collective learning cycles. Sociotechnical system theory looks to organizations as a composition of:

- *Social subsystem*: that involved the knowledge of the workers,
- *Technical subsystem*: that is composed by the knowledge base, the corporate database, computer and network infrastructures and office automation products designed to support the knowledge of the workers,
- *Environmental subsystems*: it is a frame for human and technical subsystem, which interfaces with various external constituencies.

Knowledge is both viewed as an integrating practice of coordination of human and automated activities and as a social phenomenon within the collective learning cycles.

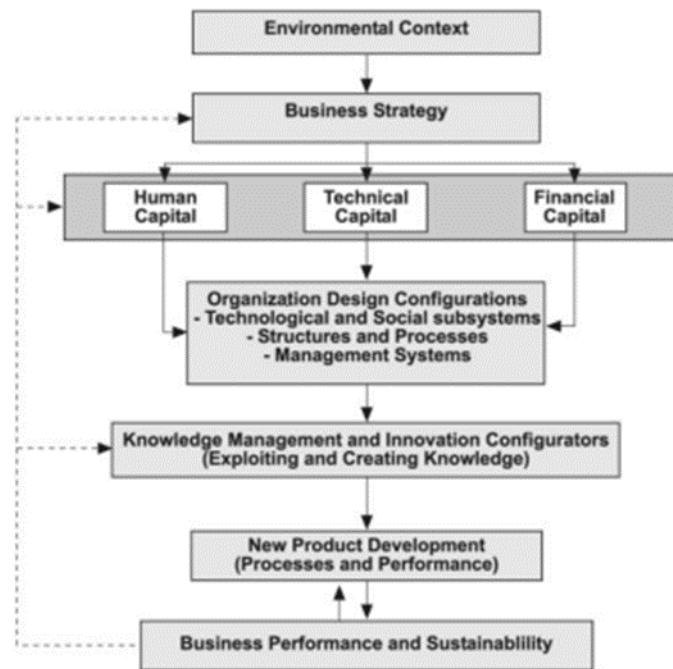


Figure 5.3 Design Based framework

Source: A.B. Shani et al, (2003). Knowledge Management and New Product Development: A Study of Two Companies

Several clusters compose the model's framework:

- *Environmental and business context*: it is represented by the elements and forces in the marketplace in which firms compete,
- *Business Strategy*: that drives to the investments in human, technical and financial resources and it set the stage for the firm's design configuration,
- *Design configuration*: it is composed by both social and technical subsystems. In this area the project team and auxiliary units are influences and are influenced by NPD knowledge management processes,
- *Knowledge management and Innovation Configuration*: that determine how the firm can acquire and create knowledge,
- *New Product Development Processes and Performances*: its outcomes influence the business performance and sustainability. This cycle also

influences the long-term performance of the business and regeneration of resources.

Business strategy combined with both organization design configuration and forms of knowledge capitalization influence the firm's ability of managing knowledge and be led to innovation. In addition, knowledge management combined with the innovation configuration determine how firms can capitalize and locate new knowledge and provide the context in which NPD efforts are designed, developed and completed. Finally, NPD work design, process and outcomes influence the firm's performance and sustainability.

Benefits and Limits

This model points out how business sustainability is led from the firm's ability to manage its NPD processes. The framework proposed investigates the complex relationship between organizational context, NPD and knowledge management. The positive contribute given by this model is that it integrates strategic thinking, sociotechnical system design thinking, knowledge management NPD theories and emerging body of knowledge around learning system. Thus, the framework is interdisciplinary, clear and built upon theoretical basis. However, there are not actual tests that prove the validity of this model, besides the two case studies provided in their article.

5.1.4 Model 4

The model is extracted from article “An empirical model of the organization knowledge system in NPD firms”, written by S.A. Mohrman, D. Finegold, A.M. Mohrman Jr.; in 2003.

The study proposes a model of a knowledge system in the NPD firm. The purpose is to define the aspects that contribute to firm’s ability to generate advantages based on knowledge capabilities. The focus is on knowledge works behaviors: organizational features that foster knowledge and how these behaviors help to create and applicate new knowledge for organizational effectiveness. Therefore, the objective is the improvement of organizational effectiveness by the development of a quantitative model of the NPD organization viewed as a knowledge system that results in new knowledge and its effective application.

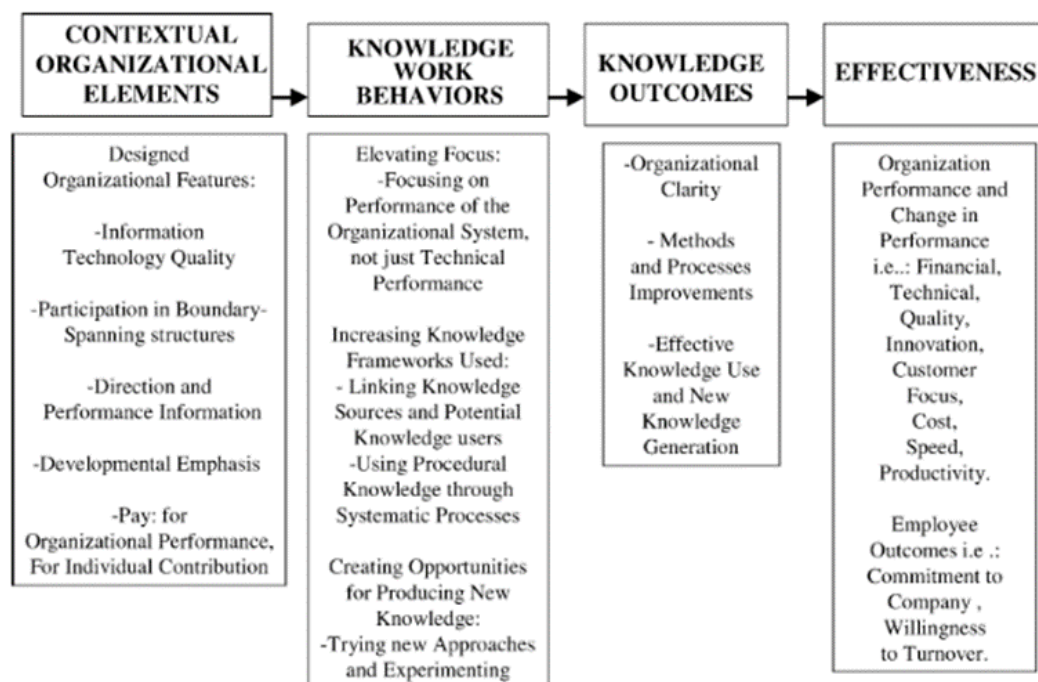


Figure 5.4 Conceptual model of NPD organization knowledge system

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

The knowledge system is composed of four high levels constructs:

- Contextual organizational elements: these are features designed into the organization, which houses the NPD work. These shape the knowledge works behaviors of the organization:
 - 1) *IT quality*: useful for storage and distribution of explicit knowledge
 - 2) *Participation in boundary spanning structures*: it exposes employees to knowledge from different disciplines and functions during addressing complex, technical challenges.
 - 3) *Direction and performance information*: goals, metrics, plans are intended to create shared understanding about standards and targets.
 - 4) *Developmental emphasis*: Human resources practices are contextual elements that influence employee behavior.
 - 5) *Pay*: Aligning rewards with knowledge strategies and goals can motivate employees to develop skills and knowledge.

- Knowledge works behaviors: these are various ways which knowledge workers can broaden their spectrum of knowledge accessed. The model categorizes four works behaviors (*focus on system performance, use of systematic processes, knowledge linking, try new approaches*), by three ways they can broaden knowledge in NPD:
 - 1) *Elevating focus*: focusing on system performance, attending to more aspects of the situation from a systemic perspective.
 - 2) *Increasing the knowledge framework used*: implementation of improved knowledge sharing systems and utilization of systematic processes.
 - 3) *Creating opportunities for producing new knowledge*: by adoption of new approaches, experimentation, and learning from past lessons.

- Knowledge outcomes: socially constructed outcomes of sense making activities mentioned earlier. Outcome lead to higher levels of effectiveness.

- 1) *Organizational clarity*: clarity with which NPD participants understand their organization (in terms of strategies, priorities, logics and so on). It results from knowledge works behaviors.
 - 2) *Methods and processes improvements*: by discovering new intellectual capital, methodologies, algorithms, work processes are redesigned to incorporate new knowledge.
 - 3) *Effective knowledge generation and use*: they are social constructs that result from sense making activities of NPD work.
- Effectiveness: Two dimensions are considered: organizational performance outcomes and employee outcomes.

Organizational performance outcomes: divided into:

- 1) *Overall performance*: it is a composite of company's effectiveness on multiple dimensions,
- 2) *Change in performance*.

Employee outcomes: composed of two dimensions:

- 1) *Commitment to company*: Level of an individual's identification with and attachment to the organization.
- 2) *Willingness to turnover*: Turnover may reduce the intellectual capital of the firm and detract from efforts to develop and grow its competencies.

The model has been tested on high tech firms by surveys. Its overarching logic assesses that knowledge management capabilities lead to higher levels of organization effectiveness. From a sample of 1200 engineers, a structural equation model of this knowledge system for NPD. The results of their study is provided in the following pages.

Results:

1. **Construct:** *Organizational design:*

- Directions and performance information have a pervasive impact on three of the knowledge behaviors: *focusing on system performance, using systematic approaches, trying new approaches*. Directions and performance information has the strongest path in the model: the presence of directions and performance information broaden primarily workers' tasks and methodologies of problem-solving, but, it only indirectly drives the linking of knowledge across the organization, its effective generation and use, and indirectly improves methodologies and processes.
- IT quality contributes to three knowledge work behaviors: *using systematic approaches, knowledge linking, trying new approaches*. In addition, it relates weakly with both *effective knowledge generation and use* and *to commitment to company*. Information Technology is just an enabler of the work of knowledge system, it is a tool aimed at supporting activities.
- Participation in boundary structures relates weakly with two knowledge outcomes: *methods, processes improvements, and organizational clarity*. It relates also with *focusing on system performance*. Working in groups not necessarily links knowledge across the organization.
- Developmental emphasis is significant with all knowledge work behaviors. Moreover, it relates with two knowledge outcomes: *organizational clarity* and *effective knowledge generation and use*; and positively connected to *commitment to company*. Its substantial number of connections in the model underline its importance: developing employees expand their capacities for individual and

collective sense making by exposing them to new formal and tacit knowledge, gained from experiences.

- Pay for organizational performance relates positively with *knowledge linking* and with *try new approaches*. Pay for individual contribution weakly relates with *try new approaches* and with *use of systematic processes*. Both of them positively impact *commitment to company*, and negatively impact *willingness to turnover*. Rewards, in relation to the results, however, are weak incentives, since they are considered as compensation variables. They imply a need for the organization, to create a motivational environment that support exchange and interactions among employees.

Figures 5.5 and 5.6 show the impacts of the first construct on Knowledge work behaviors and Knowledge outcomes.

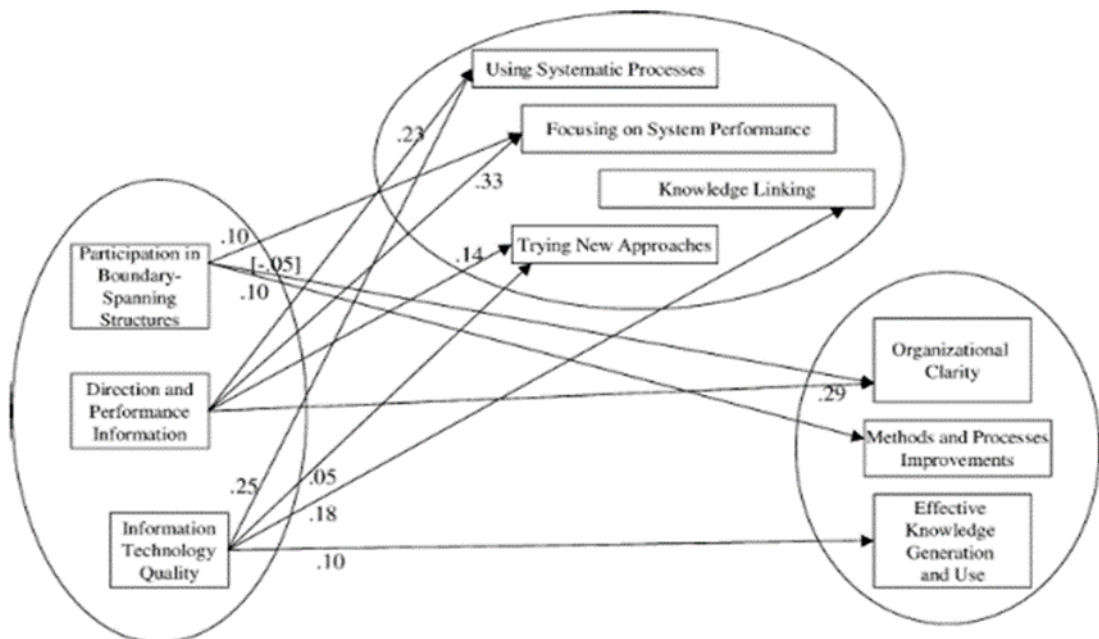


Figure 5.5 Direct non-HR Organizational Contextual Elements Influences.

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

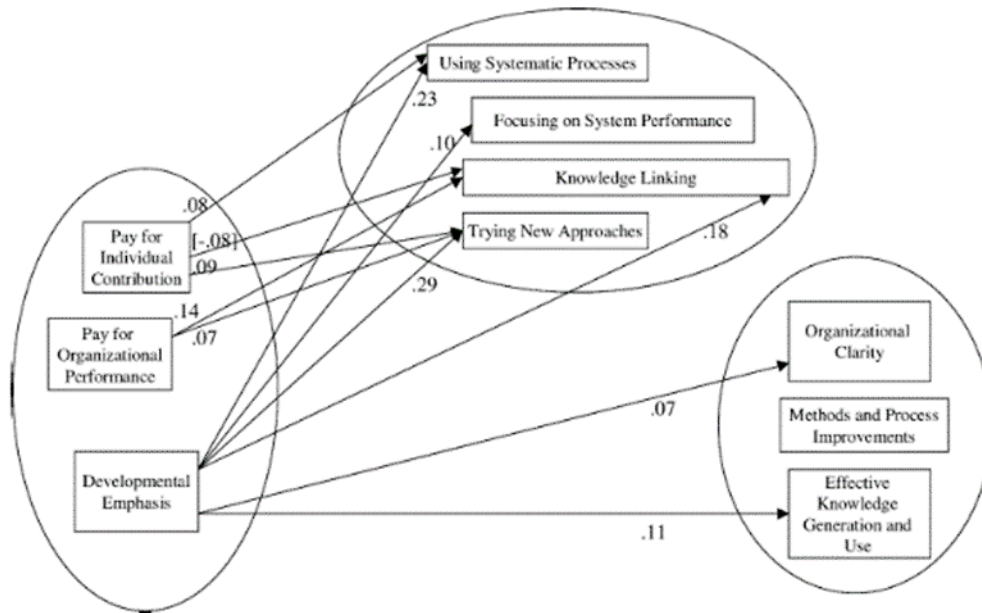


Figure 5.6 Direct HR Practices Influences

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

2. Construct: Knowledge work behaviors:

- Trying new approaches is related positively with *organizational clarity*, *methods and processes improvements* and *effective knowledge generation and use*. In addition, it relates positively also with *Commitment to company*, and negatively with *willingness to turnover*. Due to these connections, it comes deductible that learning through experience and experimentation is essential for knowledge outcomes.
- Focusing on system performance have relations with *methods and processes improvements*, *organizational clarity* and *overall performance*. The breadth of focus and procedural knowledge that systematically drives NPD activities are enablers of capacity to absorb knowledge frameworks and of application of knowledge in new approaches.
- Using systematic processes is weakly connected to *methods and processes improvements*, but it has strong connection to *organizational clarity*. This

implies that procedural knowledge has a central role: if systematic approaches are implemented, organizational clarity is enhanced, then, knowledge is linked, and new approaches are tried.

- Knowledge linking has effect on *effective knowledge generation and use*.

Both focus on system performance and use of systematic processes enhance *knowledge linking*. These impactful variables have more of a subsequent impact than the *knowledge linking* itself, so, knowledge management programs should focus more on making knowledge available. In addition, both variables are knowledge work behaviors that lead to superior performance independently of their knowledge outcomes, because they are consistent with organizational values and priorities even if no innovation or organizational clarity are involved.

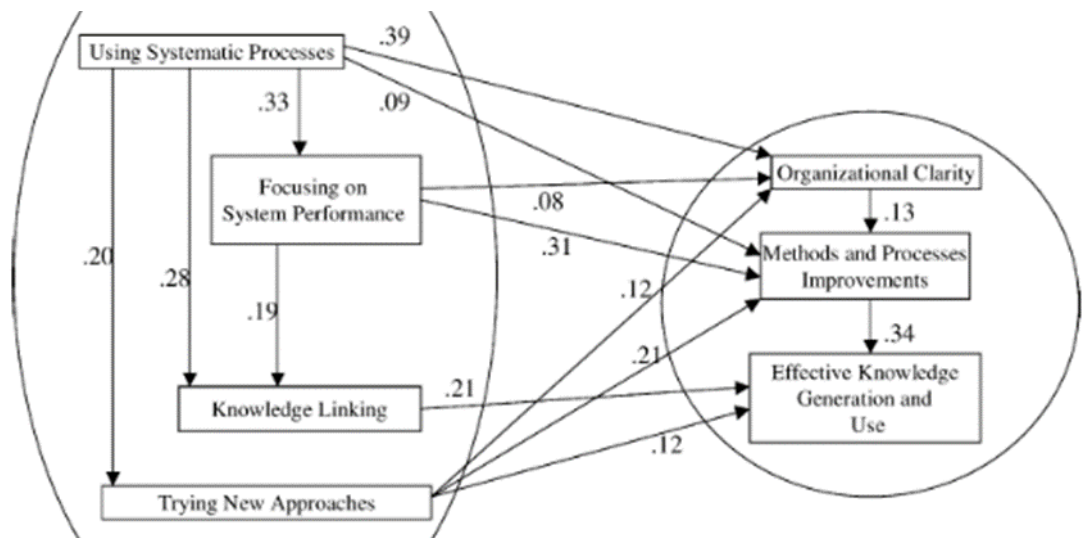


Figure 5.7 Knowledge Work Behaviors and Knowledge Outcomes

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

3. Construct: *Knowledge outcomes*:

- Organizational clarity positively affects both overall performance and change in performance.

- Methods and processes improvements positively affects change in performance.
- Effective knowledge generation and use impacts change in performance and overall performance. Organizational clarity is connected with methods and processes improvements, which directly explains effective knowledge generation and use.

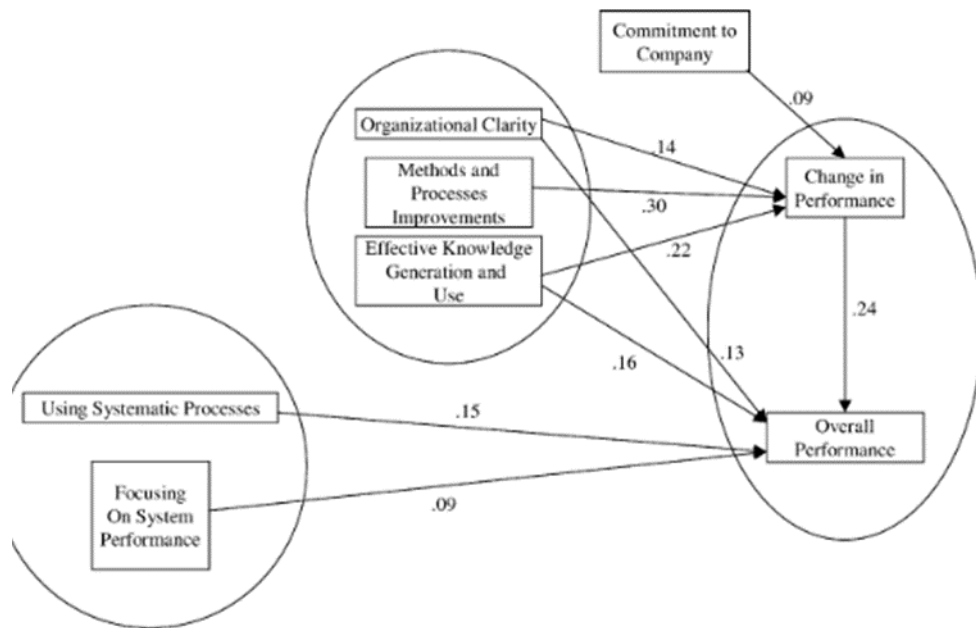


Figure 5.8 Direct Impacts on Organizational Performance.

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

4. Construct: *Effectiveness Variables:*

- Commitment to company has a negative relation with willingness to turnover and a positive relation with overall performance.
- Since developmental emphasis, trying new approaches, organizational clarity, methods and processes improvements are predictors of commitment to company, then, learning and self-development possibilities are more effective tools than compensation and rewards for NPD workers. The same Human Resources (HR) strategies that help build knowledge are the most important ones that help knowledge to be retained.

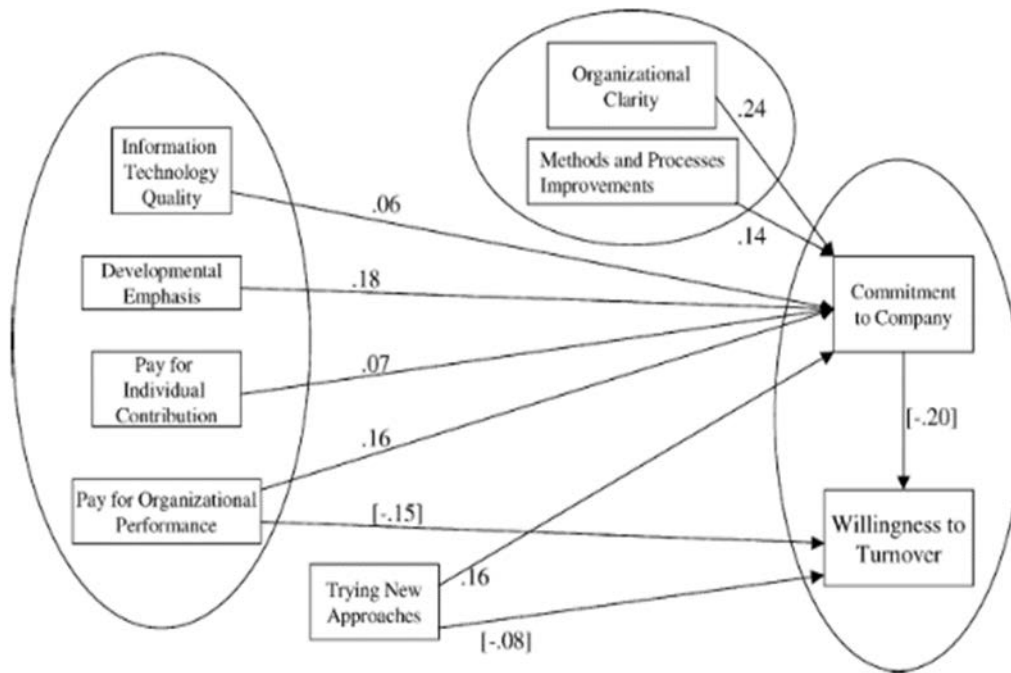


Figure 5.9 Direct Determinants of Employee Outcomes

Source: S.A. Mohrman et al, (2003). An Empirical Model of the Organization Knowledge System in the New Product Development Firms.

Benefits and Limits

The model provides quantitative evidence that knowledge and knowing capabilities translates in NPD firm's effectiveness. Including a systematic approach in the organization, is helpful to understand how various elements of the knowledge system fit together to yield knowledge and business outcomes. The model underlines *how participating in boundary structures* and knowledge linking methods are necessary but not sufficient activities to NPD knowledge management. Knowledge work behaviors are significant contributors to knowledge outcomes: management can influence work behaviors through the design of the following contextual organizational elements:

- IT infrastructure,
- Boundary structures,
- Rewards for employees;

However, these are less relevant contributions compared to design elements such as self- development possibilities and directions and performance information. Providing employees with strategic information help them to better understand why their work is important, and how it fits in the bigger picture, therefore, enhancing commitment to company and to organizational requirements. Organizations would benefit if managers had better assess that work experiences are, with respect of the results, the primary source of development of human capital and the source of attachment to the firm.

The model however, has been tested only on mature companies engaged in large system development. These, all have long development cycles, can count on deep technical expertise and face huge challenges integrating the work of large teams. In addition, all are populated with mature workforce. Another limit to the study is represented by the exclusion of connections with external forces and knowledge or stakeholder (customers, suppliers, business partners and so on). The scholars, moreover, do not have objective measures of effectiveness and knowledge outcomes that are independent of the employee's sense of the system, since, all the responses come from the same instrument.

5.1.5 Model 5

The model is extracted from article “Knowledge Management as enabling R&D innovation in high tech industry: the case of SAIT”, written by W. Suh, J.H. Derick Sohn and J.Y. Kwak, in 2004. The model proposes a knowledge management utilization for Research and Development (R&D) organizations to enable successfully its innovation process. In addition, this model has been successfully implemented in a firm. As presented in Figure 5.10, three areas constitute the model: *Organizational characteristics*, *Knowledge Management focuses*, *Knowledge Management components*.

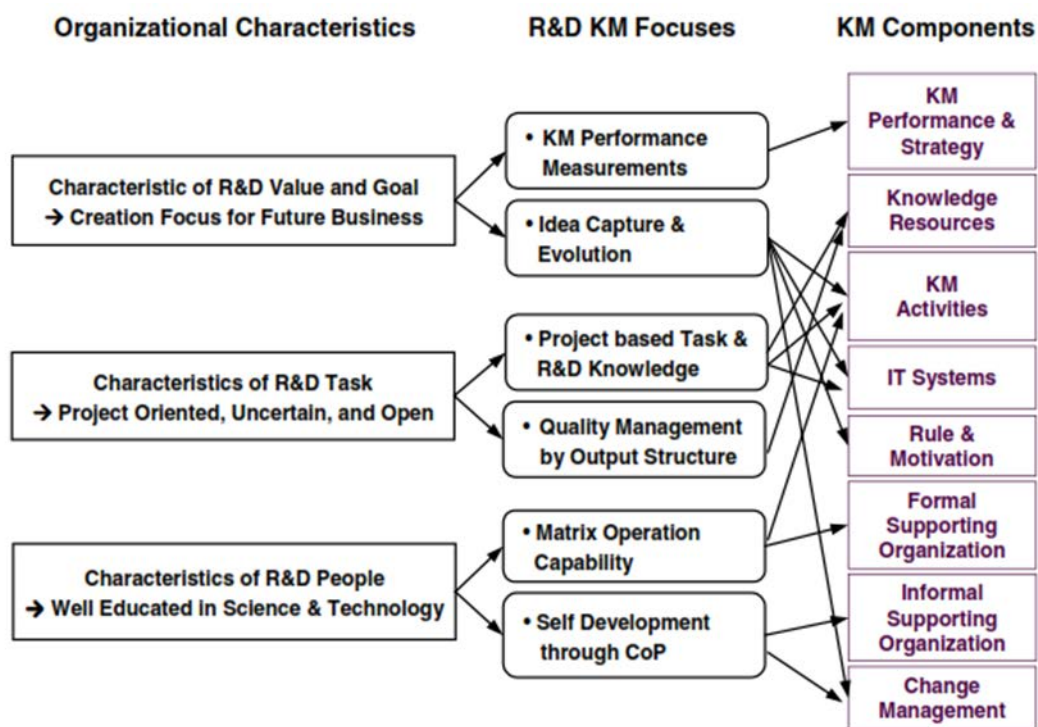


Figure 5.10 R&D Knowledge Management Model

Source: W. Suh et al, (2004). Knowledge Management as enabling R&D Innovation in High-Tech Industry: The Case of SAIT.

The framework is constituted by three main organizational characteristics:

- R&D value and goals for the creation of future business: this aspect is focused on the measure of the KM performances and *the capture and the evolution of*

knowledge. The KM performance measures play a critical role in directing activities to achieve creativity and organizational objectives and strategy. Capture and evolution of knowledge are linked to others important aspects of KM: its *activities, IT systems, rule and motivation and change management*. KM activities enclose all those activities that are needed to the acquisition, storage and use of knowledge and its conversion and sharing. IT systems are identified as one of the critical successful factor of KM, while the change management sub-dimension is related to the motivation and coercion that are needed to stimulate KM activities among organizational members.

- *Characteristics of R&D Tasks*: these tasks typically are performed on a project-base They require elevated levels of creativity and are associated with high levels of uncertainty. Since uncertainty typically is associated with R&D projects, often necessitates changes in anticipated processes and methodologies and stimulate informal communication, KM systems must remain flexible and autonomous. The project-based tasks and R&D knowledge are also related to IT systems and KM activities while, on the other hand, quality management is related only to the knowledge resources. R&D KM should also address quality management issues over output and throughput definition and requirement. The system must guarantee autonomy over tasks, but also establish rigid definitions and requirements over every output and throughput.
- *Characteristics of R&D people*: this aspect underlines the importance of having people well educated in science and technology. Matrix operational system is suitable for supporting knowledge not only for project application, but also for basic theory development. The capability of the matrix operation is connected to the *formal supporting organization* that should encourage the sharing of the

knowledge. In addition, another solution may be an informal supporting organization focused on the knowledge transmission and sharing such as CoPs.

Benefits and Limits

Summarizing, the implemented model represents a way to achieve R&D innovation. The positive contribute brought by this model is represented by the connection between organizational characteristics and KM components. It also points out how stimulating strong relationship between KM activities and organization's competitiveness increases the firm's values and leads to the achievement of its objectives. In addition, the template reflects both internal and external needs and requirements, which may increase R&D contribution possibilities to business performance. This model also introduces a motivational structure to address researchers' inspiration for self-development. Although this model represents a framework in which each dimension is related to the other, it has been tested only into one company, thus its validity needs to be proven by more tests and further studies.

5.1.6 Model 6

The model is extracted from article “Technology Innovation and Knowledge Management in the High-tech industry”, written by I-Y. Lu, C-H. Wang and C-J. Mao; in 2007. The model focuses its attention on four categories of knowledge that are important in the relationship with management: *tacit, explicit, individual and collective knowledge*.

- *Tacit knowledge*: is difficult to formalise and communicate. This characteristic is related to two sub dimension: technical and cognitive. Mental models, beliefs, perceptions; compose the cognitive dimension while the technical is composed by skills, crafts, expertise.
- *Explicit knowledge*: is formal, systematic and it can be diffused easily. The explicit knowledge management involves knowledge storage, dissemination, retrieval and protection

The key core of knowledge management is the need to find a way to share and externalize knowledge. Socialisation processes lead the sharing of knowledge: employees can learn tacit knowledge from colleagues by observing, imitating and practicing. Thus, the knowledge could be shared also by mentor system and- on-the job training. However, the main need for using knowledge successfully is represented by the necessity to convert tacit into explicit knowledge. From the tacit/explicit prospection, the two main organization strategies are represented by the knowledge codification, storage and reuse and the personalisation strategy, which promotes the dialogue among individuals. The establishment of employers’ networks helps in the knowledge transfer.

The other two main dimensions are the following:

- *Individual*: who possess technical skills, experience, talent and intuitions. There are three skills that are embodied in employees: public and scientific knowledge, industry and specific knowledge and firm specific knowledge. The individual knowledge is a knowledge-storing medium. Thus, it is important transforming knowledge into documents and collective knowledge. The establishment of a culture of sharing leads to the facility in knowledge transfer.
- *Collective knowledge*: that can store shared experience. The collective knowledge answers to the need of creating a common employee language and the necessity of a mechanism for the experience sharing.

Summarizing, Knowledge Management can be viewed into two perspectives:

- *Process view*: that is composed by generation, codification, transferring and realization. Knowledge is a value chain. Therefore, this dimension is related to five activities: acquisition, innovation, protection, integration, dissemination.
- *Building blocks view*: is composed by six activities: identification, acquisition, development, sharing, vitalization, retention. The systematic framework is based on four process that are not liner sequence: creation, storage, retrieval, transfer and application.

Based on works of previous scholars as well as previous research, this study designs an integrated framework. The framework of knowledge management identified, as shown in figure 5.11, is composed by three parts:

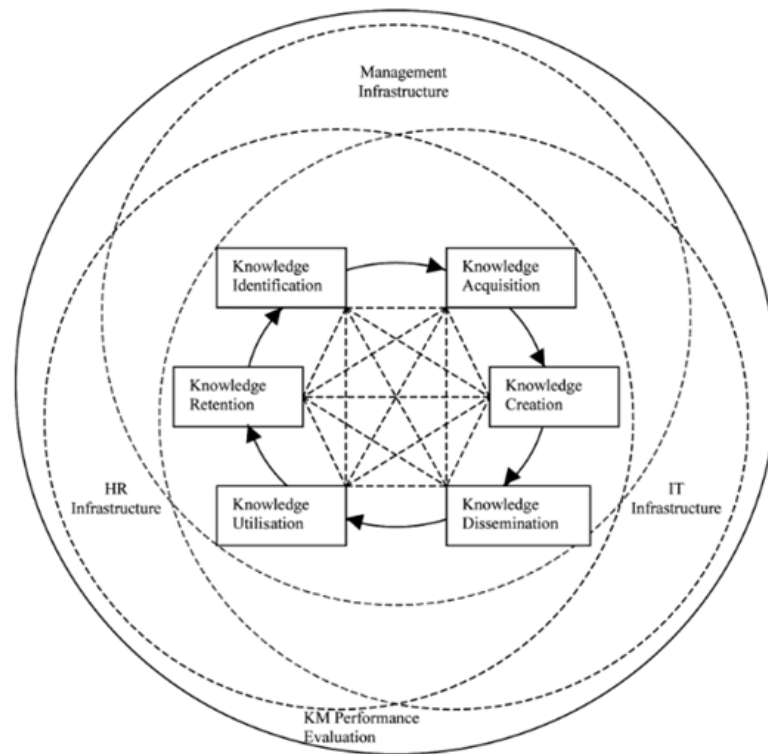


Figure 5.11 Knowledge Management Framework inspired by Lee and Yang (2000) and Probst et al, (2000).

Source: I-Y. Lu et al, (2007). Technology Innovation and Knowledge Management in the High-Tech Industry

- *The core process*: that is composed by identification, acquisition, creation, dissemination, utilization and retention. The acquisition should identify knowledge whit audits, benchmarking, knowledge maps, knowledge assets and using informal networks. The creation is based on Nonaka’s model. Knowledge creation also occurs through associating employees’ uniqueness with a set of activities such as, shared problem solving, implementation and integration of new technical processes and tools. The experimentation and the prototyping or the import of knowledge from outside to the firm are useful activities that lead to knowledge creation. Knowledge dissemination can be obtained using knowledge centres and by reports, site visits, tours, personnel rotation and training courses. In addition, the communities of practice help in the knowledge dissemination. Knowledge utilization represented the avoidance of measured or

abused knowledge. The organization should establish a culture where knowledge is stimulated among employees. For this scope, a use of friendly IT system is required to easily retrieve knowledge stored in the company. The commercialization, reutilization of intellectual capital is an important component for knowledge management. Finally, knowledge retention underlies the importance of knowledge preservation is related to the ability of exploiting external knowledge is a function of prior related knowledge. Organization's memory can be represented by internet databases, procedures, business processes.

- Management infrastructure: that encloses the need of top management supports: a top manager is a catalyst that sets organization intentions, clears barriers and prepares the grounds for a self-organized team guided by middle members. The strategy should be consistent with general strategy. Another scope of top managers is the learning promotion for knowledge transfer.
- Human resources: the organization must focus on the need of incorporating employees' expertise in firms' routine using learning procedures. It's also useful introduce mechanism for the distribution of interests arising from the utilization of the expertise. Organization also needs to recruiting outstanding knowledge workers, providing education, training, building organizational learning and setting reward systems.
- IT infrastructure: that assumes a supportive role to facilitate all those activities that are related to the core process: this comprehends intranet, group ware communication, data mining and database.

The performances evaluation is based on the Knowledge Management Assessment Tools (K.M.A.T.), developed by the American Productivity and Quality Centre (APQC) that analyses the effectiveness of knowledge management process, leadership, culture, technology, measurement.

Benefits and Limits

In conclusion, this model provides an integrated framework of knowledge management of all its phases. It also gives a way to identify knowledge management effectiveness. Despite his positive contributes, the main point is that this model should be tested for its validation, since it is based only theoretical ground. In addition, no external factor or influence in the knowledge management process is provided.

5.1.7 Model 7

The model is extracted from article “Impact of Knowledge type and strategic orientation on New Product creativity and advantage in High technology firms”, written by N. Kim, S. Im, and S.F. Slater, in 2013. The study focuses on two dimensions of knowledge type (knowledge tacitness and complexity) and two forms of strategic orientation (technological and market orientation) which influence the positional advantages, as determinants of NPD outcomes.

The model is based on the resource-based view and wants to explain how these variables influence new product creativity, and how new product creativity provides advantages in terms of customer satisfaction and product differentiation, which are dimensions that could lead to superior new product performance.

From a resource-based view of the firm, resources can be classified into three categories: *physical capital resources*, *human capital resources* and *organizational capital resources*. Organizational capital includes, among others, dynamic capabilities that enable managers to adapt, integrate and deploy physical and human capital to achieve firm’s objectives. The study suggests that knowledge assets, aligned with appropriate strategic orientations, comprise a dynamic capability. Drawing on the resource-based view, the study explicates how these knowledge and strategic variables influence new product creativity, which comprised the novel and meaningful characteristics of new products that are generated in the NPD and launch stages. Then, these two dimensions of new product creativity differentially provide product advantage in terms of customer satisfaction and product differentiation, which lead to superior new product performance. Knowledge and strategic orientation are asserted to be two of the most important antecedents to new product creativity.

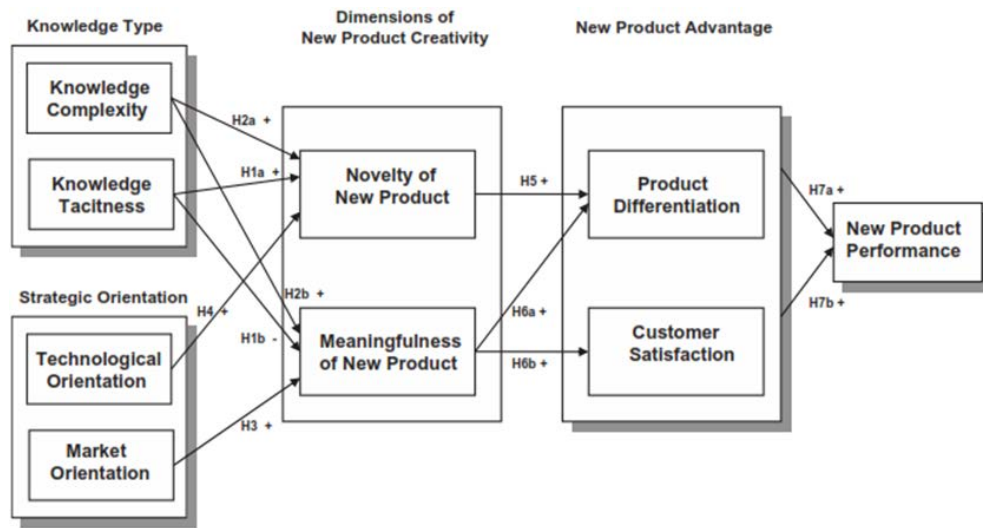


Figure 5.12 The conceptual Framework of Kim et al, (20013)

Source: N. Kim et al. (2013). Impact of Knowledge Type and Strategic Orientation of New Product Creativity and Advantage in High-Technology Firms.

Examination of the tacitness and complexity dimensions can explain the value of knowledge transfer and integration. Knowledge in NPD is nurtured through the search for tacit as well as complex knowledge that is accumulated in the various levels of organizational memory. Following these assumptions, the fate of a new product depends to some extents, on how well these dimensions of knowledge are incorporated and implemented in the NPD process.

Strategic orientation is critical to the management of NPD knowledge since it helps the firm determine the focus for knowledge creation, and how knowledge is shared and integrated to become a resource from which to develop and launch new products. A firm's comprehensive strategic orientation and technological orientation will have the greatest influence on new product creativity in high-tech markets. Technology orientation enhances novelty dimension of the new product, and market orientation, its meaningful counterpart.

Relations among variables:

Knowledge tacitness and new product creativity: Due to its unique, inimitable properties, tacit knowledge is a resource that can stimulate creative solutions to market opportunities and problems. Tacit knowledge allow deviation from existing patterns of actions and to explore new possibilities. However, tacit knowledge is context-specific, difficult to formalize, and can possibly be transmitted to workers of the same unit. Reliance on tacit knowledge can have a negative impact on new product meaningfulness, since it prevents team members with different backgrounds from communicating and sharing pertinent information with each other.

Knowledge complexity and new product creativity: The complex knowledge for NPD, rooted in technological and market information will enhance NP novelty because of its great potential for generating new and diverse ideas. The heterogeneous knowledge reflects a large pool of innovative ideas, and thereby, provide the firm with more opportunities to create unique solutions. Moreover, the ability to create and combine diverse information will increase new product meaningfulness.

Market orientation and new product creativity: A market orientation leads to positional advantage providing information on how to produce an offering consistent with the preferences of the target market. Product's meaningfulness increases because a market- oriented strategy engages the firm to develop a product tailored on the needs of customers and following market trends. New products developed therefore, are more useful and meaningful to customers.

Technological orientation and new product creativity: Technological orientation includes behaviors such as investments in R&D, use of the latest, state-of-the-art, sophisticated technologies in NPD, and proactive scanning, acquisition and integration of recent technologies inside and outside the industry. A firm with a strong

technical orientation is likely to develop and incorporate unique ideas based on superior technologies in the NPD process.

New product creativity and new product advantage: New product advantage is one of the most important determinants of superior new product performance. It is defined as perceived superiority over competing products, with respect to the product differentiation and customer satisfaction dimensions. Product differentiation represents the degree of distinctiveness of a new product relative to competing products in terms of product image and strategic positioning. Customer satisfaction is the degree to which a new product satisfactorily fulfills needs and expectations. New product creativity generates advantages by enhancing the novel qualities of the product: advanced technologies help to solve unusual market requirements more effectively than competing products. Firms that emphasizes meaningful new product solutions achieves competitive advantage by offering distinctive product attributes that can provide customer benefits.

New product advantage and new product performance: Both new product advantage dimensions: differentiation and customer satisfaction, increase new product performance in terms of sales, market share, ROI and profit, relative to competing products. Differentiation provides a distinctive positioning based on innovative technologies, whereas customer satisfaction creates superior customer-based profitability.

In addition to these variables: two more control variables were inserted in the model to account for external influences on new product creativity: *technology growth rate* and *market growth rate*.

Three more control variables: *resource deployment capabilities*, *firm innovativeness* and *R&D expenditure*, are considered as influential in New Product Performance:

- *Resource deployment*: degree to which a business unit can acquire and exploit human, financial and physical resources.
- *Firm innovativeness*: reflects the extent to which a firm is seeking or readily adopting innovative ideas.
- *R&D expenditure*: degree to which a firm emphasizes and invest in R&D activities.

Results:

Knowledge tacitness has no significant impact on new product novelty. Knowledge complexity enhances both novelty and meaningfulness of the product. Market and technological orientation enhance respectively the meaningfulness and novelty dimensions of the product. New product meaningfulness contributes positively to product differentiation and customer's satisfaction, while novelty enhances differentiation only.

Benefits and Limits

The study clarifies how the firms' different knowledge properties and strategic orientation both play a role as a source of new product creativity, and how creativity enhances new product advantage. The framework is analyzed at the product level, to appropriately reflect the performance of a specific new product that includes its market and financial outcomes. In addition, the possible benefit interactions between intangible resources (knowledge properties) and strategic orientations, under the novelty and meaningfulness dimension, are explored. The right combination of knowledge property and the organizational cultural orientations (knowledge tacitness-technological

orientation combination, knowledge complexity-market orientation combination) enhances novelty and meaningfulness.

The model, however, does not consider the other existing types of knowledge and of knowledge contents that can benefit new product creativity and new product development. Moreover, neither competitive factors nor market position of firm, are included in the framework, variables that can undermine its results and consistency.

5.1.8 Model 8

The model is extracted from article “Top Management attention to Innovation: The role of search selection and intensity in New Product Introduction”, written by Q.Li, P.G. Maggitti, K.G. Smith, P.E. Tesluk and R. Katila in 2013. The study focuses on Top Management Teams (TMT), and how they should look for information that could allow the development of new products. The authors develop and test an attention-based theory of search by top management teams and the consequent influence on firm innovativeness.

A key logic of the theory is that new product introduction is a function of the search and identification of new knowledge and information. In this perspective, Top Management Teams have a critical role in the search process. Search is defined as the controlled and proactive process of examining and evaluating new knowledge and information. This model identifies two main dimensions of the search activities: *search selection* and *search intensity*. These factors, combined, lead to firm innovation. Search is needed to achieve the introduction of new product in the marketplace at a faster rate.

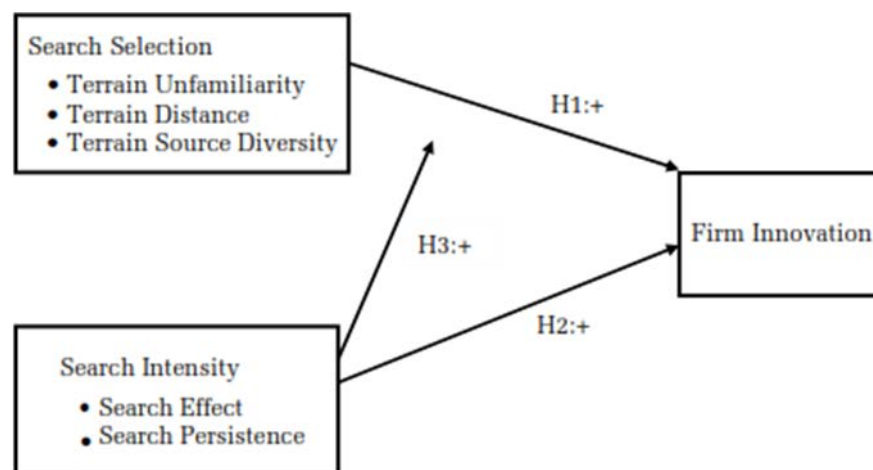


Figure 5.13 The conceptual Model of Li et al, (2013)

Source: Q. Li et al, (2013). Top Management Attention to Innovation: The Role of Search Selection and Intensity in the New Product Introductions.

Search Selection:

This dimension describes where TMTs look for information and new knowledge. Three sub dimensions that identify the type of terrain compose search selection: *unfamiliarity*, *distance* and *source diversity*. The main hypothesis of the search selection dimension is that it influences the number of new products introduced by a firm. The key core of the search selection is that distant and wide search leads to more productive and challenging.

- *Terrain unfamiliarity*: it contains the unfamiliar information.
- *Terrain distance*: it refers to the importance of focusing the search of novel outside the organization to acquire new notions for the developing of a new product.
- *Terrain source diversity*: it refers to the various sources used by TMT to acquire information.

Search Intensity:

This dimension has a fundamental influence on firm outcomes and it is characterized by two different sub dimensions: *search effort* and *search persistence*.

- *Search effort*: it is defined as the extent of investment in search activities relative to other tasks,
- *Search persistence*: it is the intensity of search with respect of the search duration. It is defined as the extent to which a TMT keep collecting information despite the number of alternative found.

TMT, in which there are high level of search effort and persistence, have better ability to notice, interpret and use the knowledge that is the main block of the development of new product. With other words, effortful and persistence searches increase the likelihood of possess valuable knowledge and to consider more

alternatives. Variation in TMT search influences the novelty of ideas and information that top executives select and interpret.

Summarizing, this model provides an explanation of how TMT should acquire knowledge focusing their attention on distant, unfamiliar and different sources and with an effortful and persistent search. This attention-based model represents an explanation of how TMT achieves innovation. The number of new products introduced for each firm in one-year measures innovation.

Results:

Results from the mathematical calculations used to verify the consistency of the hypothesis confirm that unfamiliar, distant and diverse search selection lead to more new product introductions. In addition, search persistence can result in new product introduction, yet, search effort decreases the number of product introduction.

Benefits and limits

This model was tested on 61 high-tech companies; thus, this makes the model more consistent than those that are only a priori. The main limitation given by this model is that it looks to the two main dimensions separately and it does not consider how each dimension influences the other one and, even though it is focused on the search of information, it does not investigate any way to decrease the redundancy of information, to make the search more effective. As well known and reported by other models, redundancy is an issue that should be resolved to focus the attention to which notions that lead to the development of a new product.

CHAPTER 6

CONCLUSION

The models are followed by a table, which displays the salient aspects of the models and differentiates them from the logics on which they are based:

Table 6.1 Salient Aspects of the Selected Frameworks

Authors	Main focus	Identified Dimensions	Benefits	Limits
Madhavan et al., 1996	Basing on the Nonaka's knowledge theory, this model looks to the NPD as a conversion form embedded to embodied knowledge.	Experience in NPD Teams, Shared Experience, Information Redundancy, Richness of Personal Interaction, Degree of Personal Trust.	Provides an explanation of those variables that affect the knowledge's conversion and leads to the development of a new product.	It's only based on a theoretical construct without a validation in the field, it also doesn't indicate how this model should be implemented.
Gold et al., 2001	Demonstration of how the organization's effectiveness is gained by the managing of knowledge.	Knowledge Infrastructure Capability, Knowledge Process Capability.	Provides an evaluation of firm's predisposition to competitiveness, identifies KM Structure as a precondition of effective knowledge management.	There are not any indication about how the organization's effectiveness can be measured, it does not consider the relationship among the sub dimensions, and it has not been tested in a company.
Abraham et al., 2003	The model focuses its attention on knowledge creation and exploitation basing on the sociotechnical system theory and looking to the NPD as based on learning cycles.	Environmental and business context, business strategy, organization design configuration, KM and innovation configuration, business performance and sustainability.	It investigates an interdisciplinary context by a clear framework built upon theoretical basis.	A test in the field is needed in order to prove its validation. Even if it points out which relationship there are in the learning cycle, it does not indicate how its implementation should be applied and it does not give any indication of how the firm should be organized to be led to higher effectiveness.

Table 6.1 (Continued)

Authors	Main focus	Identified Dimensions	Benefits	Limits
Morhman et al. 2003	The study proposes a model of a knowledge system in the NPD firm, considering all the organization's aspects that contribute to the firm's ability to generate advantages based on knowledge capabilities.	Model is composed of four higher constructs and 17 variables.	The model provides quantitative evidence that knowledge and knowing capabilities translated in NPD firm's effectiveness. The model investigates how various elements of the knowledge system fit together to achieve new knowledge and business outcomes.	The model has been tested only on large high tech firms, with mature workforce, engaged in large system development processes with long development cycles. No external factors have been included.
Suh, 2003	This model proposes a knowledge management utilization for Research and Development (R&D) organizations to enable successfully its innovation process.	R&D values and goals for the creation of future business; project oriented, uncertain and open and characteristics of R&D workers.	It investigates how R&D can achieve innovation, points out how the firm's effectiveness is related to the stimulation of strong relationship between KM activities and organization competitiveness.	It has only been tested into one company, more field tests are needed for validation.
Lu et al., 2007	The study presents a comprehensive and integrated discussion of the various facets of technology innovation and knowledge management for High-tech firms.	The model integrates two perspectives of knowledge management existing in literature. The framework is composed of K.M core processes, K.M infrastructure, K.M performance evaluation.	The model provides an integrated framework of Knowledge Management that includes all its phases and organizational dimensions and influences.	The integrated framework is based upon theoretical grounds, further studies should be performed for validation; no external and contingency factor has been included in the model.

Table 6.1 (Continued)

Authors	Main focus	Identified Dimensions	Benefits	Limits
Kim et al.,2013	Investigation of the relations among two knowledge types and two strategic orientations for new product performance improvements	The frameworlk has a resource-based view, the dimensions considered are Knowledge complexity and tacitness, coupled with technical orientation and market orientation strategies.	The framework clarifies how firms knowledge properties and strategic orientations both play a role as a source of new product creativity, and how creativity enhances new product advantage.	It doesn't consider other existing types of knowledge and of knowledge contents that can benefit new product creativity and NPD. Neither competitive factors nor market position of the firm are included, variables that can undermine its consistency.
Li et al., 2013	This attention-based model provides a explanation of how Top Management Teams (TMT) should acquire knowledge for the development of a new product.	Search Selection, Serch intensity	Innovation is consistently measured by the number of new products' introduction for year, this model was tested in 61-high tech companies, it identifies a way to improve knowledge acquisition.	This model doesn't provide a way of reducing information redundancy.

Source: Author's elaboration

Another table follows the one above, which resumes only the main objectives set by the different authors selected.

Table 6.2 Main Objectives of the Selected Frameworks

Authors	Title	Objective
Madhavan et al., 1996	From Embedded to Embodied knowledge: New Product Development as a Knowledge Management.	The effective management of NPD processes.
Gold et al., 2001	Knowledge Management: an Organisational Capabilities Perspective	Understanding the competitive predisposition of a firm as it enters a program of knowledge management
Abraham et al., 2003	Knowledge Management and New Product Development	The exploration of the complex relationship between organizational context, NPD and knowledge management
Morhman et al. 2003	An empirical model of the organisation knowledge system in new product development firms	The examination of the organizational antecedents of knowledge work behaviors and their impact on knowledge outcomes and organizational effectiveness.
Suh, 2003	Knowledge management as enabling R&D innovation in high-tech industry	Knowledge management model for R&D organizations and its application for the R&D innovation.
Lu et al., 2007	Technology innovation and knowledge management in the high-tech industry	Analysis of the various facets of technology innovation and knowledge management for high-tech firms.
Kim et al., 2013	Impact of knowledge type and strategic orientation on new product creativity and advantage in high-technology firms	Demonstrate the knowledge complexity and knowledge tacitly provide product advantages in terms of customers satisfaction and product differentiation, which lead to superior new product performances
Li et al., 2103	Top management attention to innovation: the role of search selection and intensity in new product introductions	The development of an attention-based theory of search by top management teams and the influence on firm innovativeness

Source: Author's elaboration

The models included have been selected based on their contribution towards the topics discussed in this work. Since Knowledge Management and New Product development are very vast topics, the *ad hoc* chosen models have helped to theorize a framework that wants to include the main dimensions that effectively affect new product outcomes. Based on their contribution, the framework here proposed, has as main objective to answer the question that represents the crucial point of the thesis.

The model follows the approach given by the contribution of Shani et al, (2003) which considers both sociotechnical system thinking and new product development from a knowledge perspective.

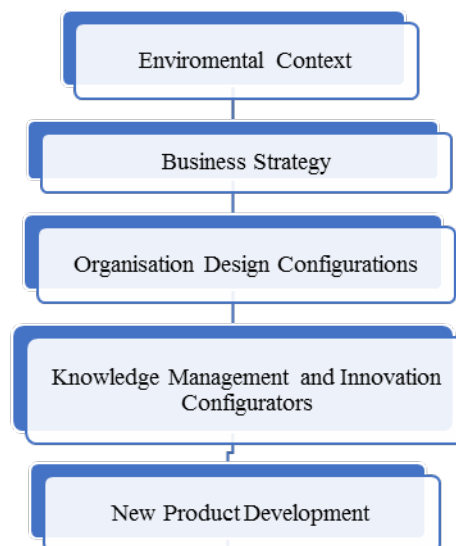


Figure 6.1 Conceptual Framework developed in Thesis
Source: Author's elaboration

The first cluster is the **Environmental Context**: it comprises elements and forces from the environment in which the firm competes: *level of competition, market uncertainty, company position in the reference markets, main competitors and their strategies, customer requirements, technological requirements to be able to compete in the market*. This cluster has been chosen as the first component of the framework because the environment in which the company competes cannot be ignored. Forces and agents mentioned above are among the main elements to consider in order

developing an effective strategy aimed at improving corporate performance. Any change in the balance of the market and of these elements represent a factor able to influence the strategy and needs a prompt reaction from the company.

Under a knowledge perspective, having data and information regarding the market, consumers and competitors is essential for the correct elaboration of a business strategy aimed at combating the events that affect the company in a direct and indirect way. To gather proper information compelling these areas, the “Li et al” (2013) model can be effective. Their work focused on search intensity and search selection may give useful input to direct the search for information and may “increase the capability of teams to comprehend and make sense of their situation and environment, which may be especially important in the deployment of new products” (Li et al, 2013).

The second cluster is **Business strategy**, since the external environment drives it also. Business strategy, on the other hand, is set upon both the vision of the company and its strategic goals. Following the structure of the framework of Shani et al (2003), strategy influences business capital investments directed towards *Human* and *Technical*.

Investments towards *Human capital*: Human Resources are the main carriers of knowledge in an organization, so organization need to focus on the retention of employees, include their expertise into routines via learning procedures, and introduce mechanisms for the distribution of knowledge. Moreover, efforts should be aimed at creating and encouraging a knowledge-sharing culture that facilitate knowledge dissemination (Lu et al, 2007).

Resources should be directed towards encouraging *individual contribution* and *fostering knowledge sharing*.

- Regarding the *individual contribution*, following the study performed by Mohrman et al (2003), financial resources should be targeting human resources practices, since they directly affect knowledge outcomes. “Developing employees, through formal developmental experiences, mentoring and job experiences, expands their capacity for individual and collective sense making by exposing them to new explicit knowledge and to tacit knowledge gained from experience”.
- Regarding *knowledge sharing activities*, investments should be aimed at encouraging interactions among workers, both formal and informal. Based on the contribution given by Madhavan et al (1996), organizing workers in multi-disciplinary teams encourage knowledge dissemination and combination. Other sharing activities are exposed and considered in the design configurations section of the framework.

Investments towards *Technical capital*: emphasis should be put on IT technologies and improvements of IT quality, since it has been stated previously that IT represents one of the main knowledge management enablers. Several authors, considered in the work of Suh et al (2004), all agreed upon IT systems being a critical success factor of Knowledge Management. “Knowledge management literature has focused on IT tools and their potential to support collaboration among workers with a different knowledge base. IT helps to enable knowledge access and sharing, to disseminate generic and codified knowledge” (Mohrman et al, 2003). Based upon Lu et al (2007), IT has a supportive role in the knowledge management process and can

facilitate all activities related to core Knowledge Management process: knowledge identification, acquisition, creation, dissemination, utilization and retention. Therefore, investments in IT are more efficient if they are aimed to create an infrastructure able to support knowledge management activities (Intranets, groupware, communication software, videoconference systems, data mining software, and creation and implementation of company databases).

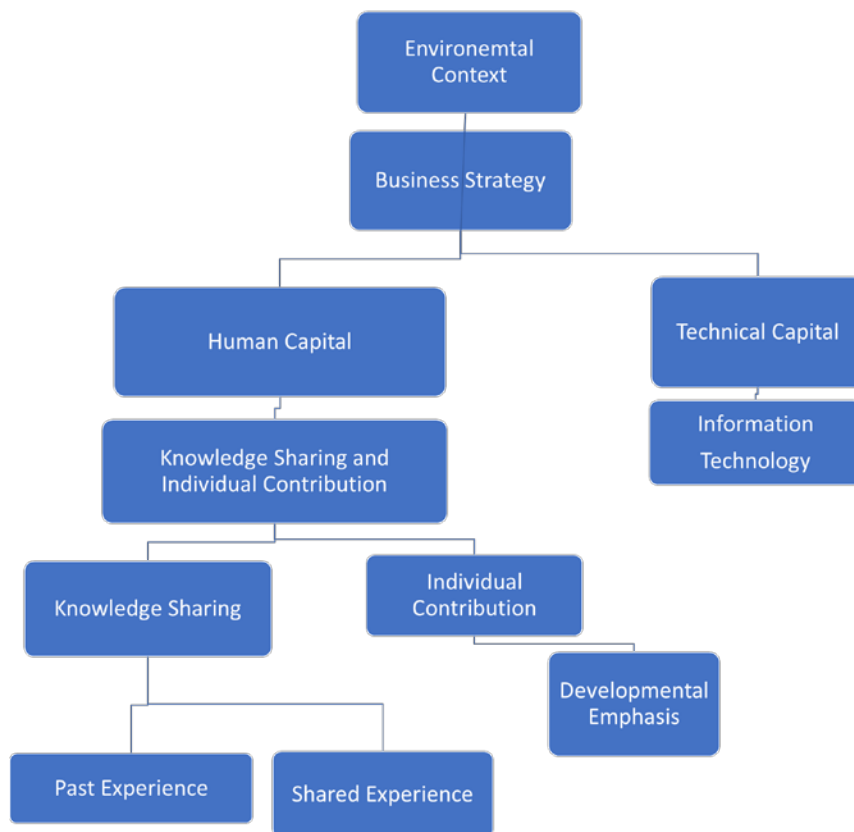


Figure 6.2 Cluster 1 and Cluster 2 of the Framework developed in Thesis
Source: Author's elaboration

The third cluster is **Organization Design Configurations**: this cluster considers first, the organizational structure, and then their orientation. Organization structure should be built focusing on achievement, distribution and sharing of knowledge. The main structures are represented by: *R&D teams organization, spanning structures and communities of practices*.

The importance of *R&D teams*, as pointed out by Suh et al (2004), is represented by their ultimate value: *creativity*. The R&D functional area use knowledge achieved from experimentation and experience, integrating it to create new knowledge. R&D teams should focus on effective knowledge flow in project-based task, for this reason knowledge resources must be designed basing on upon projects.

Collaborative teams may include the cross-functional teams and product councils and lead to the expansion of innovative sense making.

Communities of Practice lead to the development of an impressive rate in terms of volume of created knowledge.

Considering the contribute of Gold et al. (2001), several orientations to manage knowledge can be identified: *acquisition-oriented processes*, *conversion-oriented* and *application-based processes*.

- The *acquisition processes* are focused on the knowledge achievement. The creation of knowledge can be obtained creating new knowledge from the existing knowledge, through the collaboration among individual and business partners, or acquiring entirely new knowledge. In this process should be included several activities: such as the use of feedbacks from previous projects, the knowledge of competitors, benchmarking performances and the identification of best practices.
- The *conversion-oriented processes* allow the use of the existing knowledge. These are processes of conversion from tacit to explicit knowledge. This dimension may include the absorption of knowledge from business partners into the organization, the integration of different sources and types of knowledge and the transfer of the organizational knowledge among the individual.

- In the *application-based processes* are included the storage, retrieval, application, contribution and sharing of the knowledge. Effective storage and retrieval mechanism are fundamental for an easy access to firm knowledge. The application processes include the applying of knowledge learnt from mistakes, from the experiences and the use of knowledge to solve problems, to adjust strategic directions and to change competitive conditions.

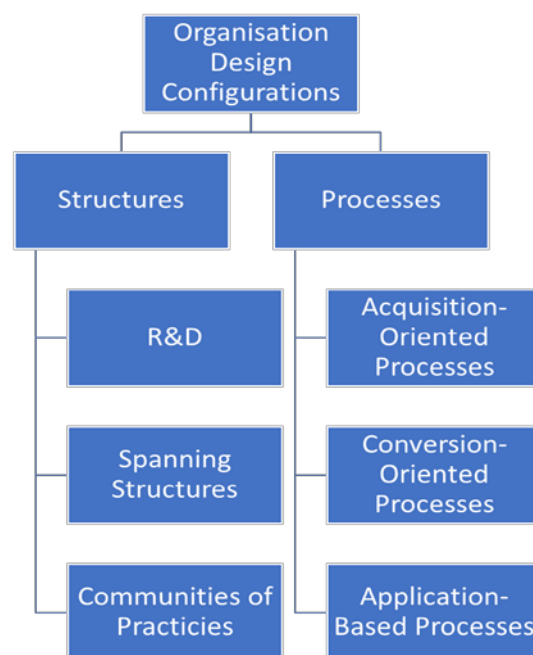


Figure 6.3 Cluster 3 of the Framework developed in Thesis
Source: Author's elaboration

The fourth cluster is **Knowledge Management and Innovation Configurators**: Knowledge management and innovation configurators determine how the firm can effectively capitalize and create new knowledge, providing the context wherein NPD efforts are designed, developed and completed (Shani et al, 2003). NPD activities can be performed relying on one of the processes exposed in the third chapter of this thesis, or by a methodology designed *ad hoc*. Essential to reach an effective product outcome is conglabate the process with the knowledge management activities.

This cluster encloses the main knowledge management activities (identification, acquisition, creation, dissemination, utilization and retention) which are core to the model of Lu et al, (2007); and knowledge works behaviors, (use of systematic processes, knowledge linking, and trying new approaches), mechanisms that are elements belonging to the framework proposed by Mohrman et al (2003). The knowledge management activities are in a continuous interaction and are supported by mechanisms such as the ones stated above: *knowledge linking* is helpful to extend the knowledge available to product developers in the NPD process, which can be applied to solve developing problems that may arise.

Use of systematic processes: the form in which NPD activities are performed is a generic source of knowledge that can be embodied in practices and used as a systematic procedural platform that guide decision-making and work.

Trying new approaches, by experimentation but not also, is intentionally carried out to find a better approach. The outcome is experimental learning and innovation.

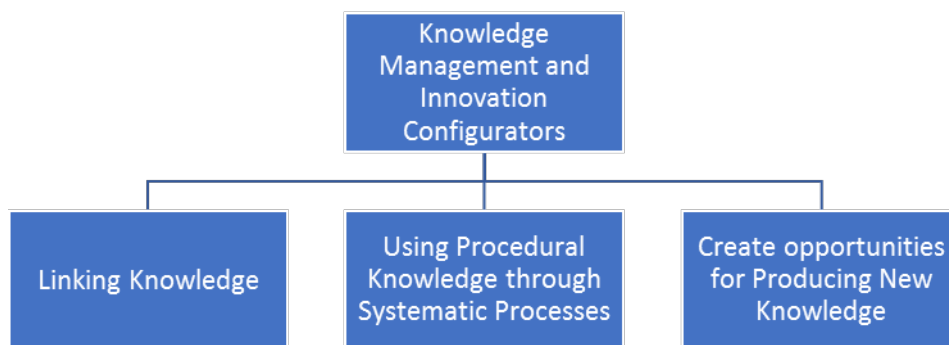


Figure 6.4 Cluster 4 of the Framework developed in Thesis
Source: Author's elaboration

This framework wants to answer to the key question of this thesis:

- How is it possible to capitalize on the knowledge present within an organization, and therefore make it profitable to obtain competitive advantages?

To obtain competitive advantages, a key factor is the market launch of an innovative product. Innovation derives from new knowledge creation and its exploitation, incorporating it into new business practices and new products. In order to achieve such goal, the current framework considers NPD as an output obtained from the interaction of several factors, both main and contingent, able to influence it.

The first factor is the environmental context in which the firm competes, since it drives partially the firm strategy. The company strategy itself sets company objectives, both in the short and long term. Strategy drives also investments towards human and technical capital, essential dimensions of the organization design configuration.

The organizational configuration considers the structure that can be adopted to perform NPD activities but not also, and the orientation through which the organizational units can approach the knowledge generated through the various company activities. The last dimension is Knowledge Management and Innovation configurators that considers mechanisms by which knowledge is created, developed, shared, exploited and embodied in new products or new practices. As a common output of this framework, a new product development routine can enhance long-term business performance.

The main limitation to this framework is that it needs to be field-tested to ascertain its validity. As a matter of facts, this conceptualization requires further studies, useful to define in more detail both the elements that compose it and a correct practical application.

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