
**What is the interrelationship between
team characteristics, knowledge
management and team performance?**

Master Thesis

**What is the interrelationship between team characteristics,
knowledge management and team performance?**

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September 2012

PREFACE

This was a very interesting master study, a turbulent route towards new insights, new methods and changed views. During my first contact with the PTO program Dr. Job Hoogendoorn mentioned the story of the eyewear manufacturer. He promised to teach us how we could see things through many different glasses and to develop our own glasses which we could use for the rest of our life, not only during our professional career but as humans. He was absolutely right.

I would like to thank Prof. dr. Justin Jansen for his guidance and critical reviews that lead to new thoughts (and to rewriting several chapters). I also would like to thank my co-reader Dr. Job Hoogendoorn for showing me that statistical analysis is only part of the story. And of course drs. Pepijn van Neerijnen and Dr. Michiel Tempelaar from the Department of Strategic Management and Entrepreneurship for useful tips and interesting discussions. Furthermore I want like to thank my colleagues from ASML for providing the valuable data and new insights that were needed for this study.

And finally, I am very grateful to my family, Mariëlle, Thomas and Ilse who constantly supported me when I used precious family time to work on this thesis or to study for yet another exam or assignment. Although sometimes difficult they allowed me to work on my hobby project and even let me use the families' game room as 'temporary' office.

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Summer 2012

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ABSTRACT

In today's organizations time-to-market is seen as a source of competitive advantage because it increases product profitability. A swift development of new products and technological enhancements is therefore crucial in order to be able to compete in the arena where market share and interest from the customer is at stake. New Product Development (NPD) teams that hold the key to the company's future profit therefore get a lot of attention from (senior) management.

When NPD teams are important for time-to-market it is also an almost obvious question to what the parameters are that influence their performance. The academic literature on these parameters encompasses many aspects like leadership styles, team attributes and also knowledge management (KM). This thesis contributes to the existing literature base by describing the interrelationship between team attributes, KM and team performance and also tries to identify the role of empowering leadership and support from management.

Data from 31 NPD teams from ASML, a high tech company, has been analyzed on the aforementioned relations and it was shown that the aspect of psychological safety plays a significant role in the creation and integration of new knowledge in a team, other attributes that are part of this study (diversity among team members, interdependency and job tenure) did not show a direct relationship with KM. The role of empowering leadership mainly affects the diversity in an NPD team in a way that it leads to more communication which results in higher levels of knowledge creation. It does not affect the relation that other team attributes have on KM. Evidence for the moderating effects of management support have also been found for the knowledge creation aspect of KM only. It has a positive effect on psychological safety, people feel safer when they experience management support but it negatively affects job tenure; support from management on team members who work in a team for a long period of time negatively influences the knowledge creation capabilities. Finally team performance, both NPD speed and team creativity were analyzed in relation to KM. It was found that knowledge integration has a positive influence on the creativity of a team. No empirical evidence has been found that KM leads to higher levels of NPD speed.

Keywords: New Product Development, Team Attributes, Team Performance, Empowering Leadership, Management Support, Organizational Learning, Knowledge Management, Knowledge Creation, Knowledge Integration.

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1. INTRODUCTION

Time to market, defined by Vesey (1992) as “the elapsed time between product definition and product availability”, is often seen as an important source of competitive advantage, especially for industries with a short product life cycle of only a few years. Several studies show that product profitability and advantage over competitors increases when time to market is shortened (Langerak et al. 2010, Schilling and Hill 1998, Datar et al. 1997, Oakley 1996). An increased pace in the development of new products and technological enhancement is therefore crucial in order to be able to compete in today’s dynamic markets (Chen et al. 2010, Kessler et al. 2000). Insufficient attention to New Product Development (NPD) could even lead to a reduction in sales volume (Cohen et al. 1996).

An example of missed sales opportunities is the case of the development of the Apple Macintosh in the early eighties. The development project was extremely ambitious with respect to the development of new hardware and new software. But due to the delay of several quarters in the development of this product the company lost a significant amount of money due to missed sales opportunities. The total value of the company also dropped to less than fifty percent of its value in ‘83 due to stock devaluation (Cohen et al. 1996).

Due to the importance to the company many teams in organizations enjoy the interest of management when performance is the point of attention. Especially when these teams develop new products which may bring tomorrow’s company profit. More specifically, the performance of these NPD teams plays a crucial role in meeting time to market requirements (Chen et al. 2010, Cohen et al. 1996).

This raises the question on what aspects influence the performance of a team and how team performance can be described. Is it just the speed of development or are there different characterizations of team performance? In new product development projects there are two aspects that play an important role. First there is a need for creativity as new products need to be developed that are different or an improved version of an existing product. These creative and inventive activities are generally encouraged in pro-active technology oriented firms (Zhou et al. 2005) and to a lesser degree in other companies (Sethi et al. 2001). And, secondly, these inventions and creations need to be ready for market introduction swiftly as client needs urge companies to deliver quickly and competitors are also pursuing their market share on improved and new products (Mohammed and Nadkarni 2011). In order to be able to

fulfill the time to market requirements the speed at which the development teams deliver the new products is related to a balance between team creativity and time efficiency (speed). Kratzer (2008) suggest this to be related to alignment between formal and informal communication structures but these results are only based on a very small number of projects and more studies in different industries are needed to support these findings further.

Besides the definition of team performance one could also question whether they are able to use new and existing knowledge. Knowledge on the latest (technological) developments in- and outside the project or company may affect the ability of a team to outperform others. The NPD teams go through a process of problem solving and creation before the final product is ready for production or perhaps even before prototyping. Important aspects of this process of knowledge creation and embedding are the exchange and combination of information by the team members (Schulze and Hoegl 2006, Hoegl and Schulze 2005, Smith et al. 2005). Hoegl and Schulze (2005) add different knowledge creation modes to this by describing several forms of knowledge sharing. Another aspect is the embedding of the newly created knowledge in the organization (or among the team members). This is described by Crossan et al. (1999) as a continuous process of interpreting, integration and institutionalizing of knowledge among individuals, groups and the organization.

The literature on the performance of NPD teams shows that the speed at which new products are developed is related to various attributes of the teams and the team members. For example, the educational level of the team members or the amount of years they work for the company contributes to an increased performance level (McDonough III 1993, Ancona and Caldwell 1992). Also functional diversity contributes to a better performance because a larger amount of competencies enables the team to consider a problem from more different perspectives (Sethi et al. 2001, Egan 2005, Campion et al. 1996, Magjuka and Baldwin 1991). Campion (1996) also showed that interdependence between team members increases performance due to increased motivation and shared responsibility for team accomplishments. And although the research on these characteristics is ongoing for over twenty years the more recent literature suggests that more studies on team characteristics are needed (Mohammed and Nadkarni 2011, Kratzer et al. 2008, McDonough III 1993, Egan 2005). This study attempts to contribute to the understanding of the role of team characteristics on the performance of teams by selecting several attributes and measuring their impact on both the creativity of teams and the speed at which products are being developed.

The effect of differences in behavior of leaders on the performance of teams has been investigated extensively. Several forms of leadership are mentioned in the organizational literature. For example the open and closed action strategies (Gebert et al. 2010) which shows great resemblance with the active leadership styles as transactional leadership or empowering leadership. Empowering leadership, giving more responsibilities and autonomy to team members (Conger and Kanungo 1988), has a positive effect on the intrinsic motivation of teams and team members and also on the performance of these teams (Conger and Kanungo 1988, Thomas and Velthouse 1990, Kirkman and Rosen 1999, Kirkman and Rosen 2000, Kirkman et al. 2004, Srivastava et al. 2006, Somech 2006, Zhang and Bartol 2010). Transactional leadership on the other hand is related to leaders who set goals for the workers and provide extrinsic motivation (Avolio and Bass 1999, Den Hartog et al. 1997, Bycio et al. 1995) and may have a positive effect on the integration of knowledge into the organization (Gebert et al. 2010). Furthermore, the effect of empowering leadership behavior on team performance has been demonstrated by several scholars (Gebert et al. 2010, Keller 2006, Bonner et al. 2002, Lowe et al. 1996) but the context of these studies varies. Studying these effects in the context of team performance in NPD projects on aspects as speed and creativity needs to be explored further (Bonner et al. 2002, Cardinal et al. 2011). This study aims at that aspect; it attempts to shine some light on the influence of empowering leadership and support from management on the performance of NPD teams.

When looking at teams many different characteristics can be identified, for example basic demographic aspects of team members like gender or age. But also the time they have spent in the company or within the team, the frequency of communication or the degree of interdependency between the members of a team are often used in studies. Many of these aspects are related to the performance of teams (Sethi et al. 2001, McDonough III 1993, Campion et al. 1996, Van Knippenberg and Schippers 2007). The following attributes have been identified as being relevant by several scholars and are therefore selected for this study: Functional diversity, interdependence, tenure and psychological safety.

Currently an ongoing research project at ERIM (Erasmus Research Institute of Management) investigates how companies can compete on knowledge, with a focus on

innovational excellence¹. This project focuses on the challenges of combining and coordinating different sources of knowledge and expertise in the new product development process. The methods that are used to guide this process have an influence on the total developments costs and the lead time of developing a new product. An aspect of consideration is the way leaders guide the NPD teams towards increased performance. This thesis contributes to that research topic as it aims at investigating the aspects of team characteristics in relation to knowledge management (both creation and integration of knowledge) and the moderating effects that an empowering leadership style and managerial support may have on this relation. Furthermore, the relationship between knowledge management and team performance will be reviewed for NPD teams in an environment where time-to-market is essential.

1.1 RESEARCH QUESTIONS

As presented in the previous paragraphs, both creativity and speed are important aspects of team performance. These need to be balanced in order to deliver new product in a short amount of time (Kratzer et al. 2008). The relation between team characteristics and team performance has been studied by many scholars but aspects of team performance in the context of New Product Development are of a different nature. Also the role of leadership behavior and the performance of teams has been the central point of interest of research projects.

The objective of this research project is to study the relationship between team characteristics and knowledge management, the role of knowledge management processes on team performance and to what extent the behavior of the leader and support from management influences the relation between the team attributes and knowledge management. Based on the literature study which is performed for this thesis it is believed that this relation, in the context of NPD teams, is not been part of a previous study.

¹ Research proposal by Prof. Dr. J. Jansen, Dr. M. Tempelaar and Drs. P. van Neerijen, “Striving for Innovation Excellence: Competing on Knowledge”, October 29, 2011.

The above mentioned subjects result in the following research question:

What is the interrelationship between team characteristics, knowledge management and team performance? And how does empowering leadership and management support moderate the effectiveness of team characteristics?

In order to be able to answer this question four sub-questions have been formulated. First: “What is the relationship between team attributes and knowledge management?”, Secondly, “What is the influence of empowering leadership on the relation between team attributes and knowledge management?”, What is the influence of management support on the relation between team characteristics and knowledge management?”, “and finally, “what is the relationship between knowledge management and team performance?”. Following a traditional IPO (Input, Process, Output) model (Hackman and Morris 1975), the relation between the input parameters (Team Attributes), the role of knowledge management processes, the outcome (Team Performance) and the moderating variables (leadership behavior and management support) is depicted in Figure 1, the conceptual model.

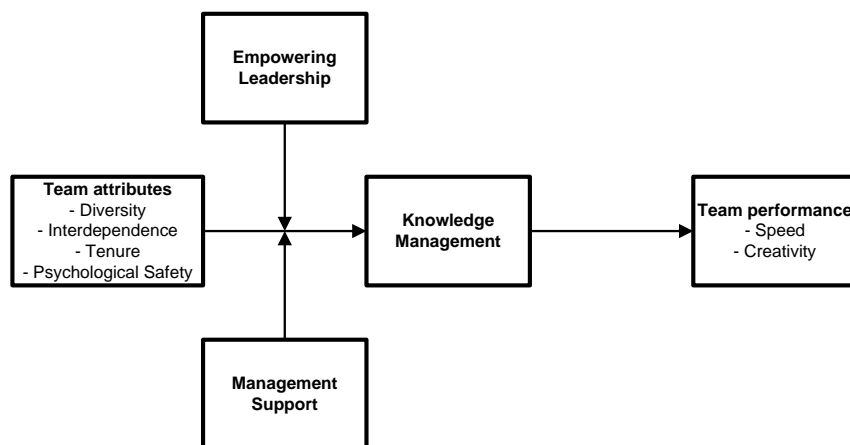


Figure 1: Conceptual model.

This thesis adds the following aspects to the existing knowledge base. In the context of new product development in a technology oriented enterprise, NPD-team characteristics that influence the knowledge management constructs, knowledge creation and integration, will be identified. And secondly, the influence of empowering leadership behavior and the support provided by management on knowledge management in NPD-teams will be charted. The managerial implications are to be found in optimal composition of NPD teams, related to the

aforementioned attributes, and the way leadership behavior contributes to knowledge management within these teams. Also the context in which team and leader operate may influence the optimal composition or effects of leadership behavior on performance. This information can be used to form and develop NPD teams or to improve the performance of these teams.

1.2 METHODOLOGY

For this study a quantitative case study has been chosen as empirical method. This allows for a statistically based analysis of influencing parameters, team characteristics, and showing the level of influence of each factor. To support this (positivistic) approach, hypotheses, based on the aforementioned research questions, are tested.

In order to collect primary data surveys have been collected from the members and the team leaders of 31 NPD teams from a high-tech corporation (ASML Netherlands), this represents a good variety of different teams and allows for a statistically relevant analysis of the hypotheses. These people have been selected on their participation in NPD teams, so supporting groups like Human Resources or IT services have not been selected nor have they been surveyed. As rule of thumb five respondents per team are required. This prevents that the data is defined by only one member and represents a single vision. This, however, is also related to team size, large teams require more respondents in order to be representative for the entire team while fewer respondents are sufficient for smaller teams.

The level of analysis are teams which means that many NPD teams need to respond to the surveys. These results will be analyzed on team level to indicate the team performance, leadership and team characteristics. The teams of choice are NPD teams in various stages of product development. These lightweight (Schilling 2008) teams are headed by a team-leader and have specific areas of expertise like electronics, mechanics, software or optics. They are so-called mono disciplinary teams.

Data analysis of the data retrieved from questionnaires is performed by using multiple regression analysis to find the correlations between team performance and the team characteristics (Sarin and McDermott 2003). In order to define the internal consistency of the responses on the surveys the Cronbach's alpha (α) was calculated. With a score of Cronbach's α of .7 or better the internal consistency has been considered good (Field 2009, Bryman and Bell 2011).

The data was collected from New Product Development teams at ASML Netherlands, a high-tech corporation that produces lithography equipment for micro chip manufacturers. Time-to-market and team performance is crucial for continuous company performance.

1.3 OUTLINE

In chapter two the status of the literature on these topics is described, along with the variables and the respective constructs. The hypotheses for this study are presented here as well. Chapter three describes the methodology and the obtained data. In chapter four the descriptive statistics and the regression analysis for testing the hypotheses of the data is presented and finally, in chapter five, the results are discussed and conclusions are drawn. Also a reflection on this study regarding limitations and suggestions for future work is shown here.

2. LITERATURE REVIEW AND HYPOTHESES

As mentioned in the introduction, the relation between knowledge management within NPD teams can be related to the characteristics of these teams. To understand which team characteristics play a significant role it is important to review the literature on previous research on this subject. It is also required to define which characteristics shall be taken into account and what their influence on knowledge management is. Additionally, the influencing or moderating role of empowering leadership and management support on this relation will be reviewed. Finally, the effect of knowledge management on team performance will be addressed.

In this chapter also hypotheses for the aforementioned relations will be presented and an update of the conceptual model will be shown, describing the hypothesized relations and the accompanying hypothesis.

2.1 NPD TEAMS IN ORGANIZATIONS

When we consider today's innovating organizations it can be seen that they often rely on teams to develop new products (Ancona and Caldwell 1992, Hoegl et al. 2004, Brown and Eisenhardt 1995). This is interesting because one could wonder why they do not rely on individuals for this kind of work. The answer seems to be quite straightforward. In order to be able to cope with complex products they are often split into different (functional) modules (Ulrich and Eppinger 2000) where each module fulfills a different function of a product and requires specialized in-depth knowledge, for example in the fields of electronics, software of mechanics. When a complete product has to be developed these people will work together and form teams of specialists with different competencies. It is very unlikely that all competencies are available in one person or that he or she has enough time to work on all aspects within a reasonable amount of time.

When large or several NPD projects are simultaneously in progress the specialists themselves may also form teams. They share knowledge on the same discipline and work together to provide this know-how to different projects. Within the team they distribute new information and ensure that state of the art knowledge is present with all team members.

So, concluding, teams play an important role in innovation; they provide the essential knowledge and combine this knowledge and create new and innovative products or services.

2.2 WHAT ARE TEAMS?

In the previous paragraph the role of teams was discussed. But what are teams? Is there a definition available from the literature? Some authors do not make a clear distinction between groups and teams, they are often considered similar and the terms are used as synonyms (Barczak and Wilemon 1989). And while some researchers refer to interdependency among a group of people as work groups (Wageman 1995, Guzzo and Dickson 1996), this terminology is often replaced by the term team. More recent literature however posits clear differences between the terms group and team. Bell (2007) defines a team as a group of at least two people who interact interdependently to achieve a common objective. The interdependency between the individuals is considered a key-element for teams (Guzzo and Dickson 1996, Hiller et al. 2011, Kozlowski and Ilgen 2006, Katzenbach and Smith 2005, Salas et al. 1992), without this aspect a team does not exist and one could only speak of a loosely formed group. A team is more than a group because their members develop a sense of shared commitment and synergy. They need other team members in order to be able to function properly.

Also different types of team can be identified, for example operational teams which are concerned with maintaining the position in existing businesses by focusing on improvements of current products and innovating teams that focus on the creation of new products for the company (Barczak and Wilemon 1989). As time-to-market is an important motive for this study the term 'team' refers to an innovative team with shared commitment and with interdependency on the topic of their expertise. They are all, so called, mono-disciplinary teams.

2.3 TEAM ATTRIBUTES

In the literature on teams and team performance many different team attributes have been described. In order to be able to select a subset of relevant parameters an overview is presented in Table 1, this shows the constructs that have been used by several authors in their studies. Demographic diversity is mentioned by many authors and seems to be an obvious choice as differences in age, gender etc. are easily recognized but Van Knippenberg and Schippers (2007) showed that this typology does not explain differences in team performance and is therefore not selected for this study. Diversity, as in educational background or the ability to approach problems in different ways, is a relevant parameter and mentioned in a vast amount of scientific papers and therefore used in this study. Also interdependence is

described many times and frequently indicated as crucial for teams. A third parameter, the psychological safety of the teams is selected because it provides information on the levels of trust and the willingness to help colleagues with their work. This team climate may affect the performance positively. Finally, tenure has been selected as a being related to communication and social integration (Ancona and Caldwell 1992).

Table 1: Overview of constructs used in scholarly publications.

	Diversity	Interdependence	Job Design	psychological safety	Process	Tenure ²
Anconda and Caldwell (1992)	x					x
Campion at al. (1996, 1993)	x	x	x		x	
Egan (2005)	x					
Ghoshal and Bartlett (1994)				x		
Gladstein (1984)	x					x
Gully (2002)		x				
Guzzo (1996)	x	x				
Kozlowski (2006, 2003)		x				
Kuenzi (2009)				x		
Magjuka and Baldwin (1991)			x			
Marks et al. (2001)		x				
McDonough (1993)	x ³					x
Schippers (2003)	x					x
Sethi (2001)	x			x		
Van Knippenberg and Schippers (2007)	x					

Diversity in teams is described by Egan (2005) as a collection of individuals who are able to approach problems or tasks from a variety of perspectives. It typically refers to the differences between individuals on any attribute than one can observe. In practice these differences are related to gender, age and ethnicity but also the personality of the individuals like attitude and values (Van Knippenberg and Schippers 2007). A third category of diversity aspects describes related differences like educational background and level of education. The

² Tenure can be divided into two sub categories, job tenure and organizational tenure (Gladstein 1984). In this overview these have been combined.

³ McDonough (1993) uses educational levels; this is part of diversity (Van Knippenberg and Schippers 2007).

educational level may have an impact on how fast team members can deal with technical problems (McDonough III 1993, Ancona and Caldwell 1992). Higher educated group members may tackle problems faster and therefore influence team performance in a positive way (Van Knippenberg and Schippers 2007). Van Knippenberg (2007) argues that the level of education is part of team diversity instead of being a separate construct to describe teams. It was found that demographic diversity (age, gender, ethnicity) was not related to the performance of the team and also job related differences does not impact the team performance (Van Knippenberg and Schippers 2007). Basically, Van Knippenberg (2007) concludes his meta-analysis of the 1997-2005 literature that diversity does not explain differences in the performance of teams. This is also the result of the work of other scholars, not mentioned by Van Knippenberg (Sethi et al. 2001, Campion et al. 1996, Sethi et al. 2002) thereby strengthening this statement. It is generally accepted that the chance of producing innovative ideas improves when the diversity increases and problems can be approached from different angles (Sethi et al. 2001). For this study this would imply that more diverse teams perform better on the aspect of creativity.

Interdependence is considered a key-element of a team. The individual members are seen as a part of a larger social system like an organization. There is interdependency among the members (Campion et al. 1996, Guzzo and Dickson 1996, Coppoolse 1997, Guzzo and Shea 1992). Marks et al. (2001) describe interdependence as “interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing task work to achieve collective goals”. Interdependence is what teams separate from groups (Guzzo and Dickson 1996, Kozlowski and Ilgen 2006), without interdependency there would not be a team (Salas et al. 1992). According to Campion (1996) and Gully (2002) interdependence increases motivation by increasing a sense of shared responsibility for group accomplishments and consists of three different aspects; task, goal and outcome. Task interdependence is related to the degree of task-driven interaction between team members. Goal interdependence refers to the interconnections among team members implied by the individual or team goals that guides their performance. And finally, outcome refers to the feedback and rewards on individual or team level. In two studies Campion et al. (1996, 1993) found interdependency to be positively related to the performance of teams and is seen as an important predictor for the effectiveness of team. This was also recognized by Gully (2002) who states that increased interdependence results in stronger team-efficacy. Future research on the extent of interdependence is recently proposed by Cole et al. (2011) as this may result

in more interaction between the members of the team. Following the results of Gully et al. (2002) and Campion et al. (1996, 1993) teams which show a greater extent of interdependency among team members could show better team performance but also interact and communicate more which in its turn could affect the knowledge creation and integration capabilities of a team.

Tenure is the duration which an individual member or team leader is part of an NPD team. This aspect of group composition refers to the combination of job tenure and organizational tenure as the group-mean of each variable (Gladstein 1984). Ancona⁴ and Caldwell (1992) describe the homogeneity of tenure as being likely to influence the performance and the way NPD teams operate because social integration within a group and the frequency of communication is related to the amount of time members have spent together, how well they know each other. When looking at external communications (i.e. communication outside the team) it is shown that diversity in tenure does not have a significant effect (Ancona and Caldwell 1992). So the previously mentioned interdependency and also tenure are related to communication frequencies in a team and could therefore also influence the knowledge creation and integration capabilities of this team.

The *psychological safety* in a team or organization could be described as work ethic that influences the behavior and action of the members of a team (Ghoshal and Bartlett 1994). In some older studies psychological safety is referred to as organizational climate or culture so these terms can be interpreted as synonyms of the same aspects of an organization or a team. Ghoshal and Bartlett (1994) show that there is more than just economic activity, there is also personal behavior and motivation that influence individual and collective action. psychological safety consists of four dimensions; first there is the aspect of *discipline* which ensures that members voluntarily strive to meet implicit and explicit expectations. This also includes an open feedback environment and the possibility for sanctions. *Stretch* induces members to voluntarily strive for a higher ambition level instead of a lower level of objectives and includes the development of shared ambition and identity but also the possibility to give personal meaning to the individual team contribution. *Support* is about giving support to others and allows freedom of initiatives at lower levels while senior levels provide direction and setting priorities. Finally, *trust*, gives the team members the confidence that one can rely

⁴ Note that Deborah L. Gladstein and Deborah Ancona refer to the same author. She currently works as professor of organization studies for the MIT Leadership Center in Cambridge MA.

on agreements made among each other and that decisions are fair. (Ghoshal and Bartlett 1994, Gibson and Birkinshaw 2004). Recent literature conceptualizes these aspects as work climate which touches almost all aspects of organizational life that may affect team performance (Sethi et al. 2001, Kuenzi and Schminke 2009). As these aspects of the relation and interaction between team members could influence the performance of teams it is of interest for this study. Besides the previously described attributes like interdependence (how dependent are team members of each other) their sense psychological safety may result in increased performance.

2.4 KNOWLEDGE MANAGEMENT

A relevant process by which the team attributes relate to the team performance is knowledge management, more specific: the creation and integration of knowledge. The *creation of knowledge* refers to the degree to which new and possibly useful ideas are communicated to others (Gebert et al. 2010) and is an interplay between tacit knowledge, defined as personal know how, and explicit knowledge, defined as codified facts and information (Smith et al. 2005), that leads to the generation of new knowledge (Schulze and Hoegl 2006). From these forms of knowledge four combinations of the exchange of information can be made. Informal interaction between team members, or beyond the team boundaries, by spending time together or attending the same meetings leads to the exchange of tacit knowledge. Schulze and Hoegl (2006) classify this as socialization. Secondly the concept of externalization is described, this is about the formalization of tacit knowledge into explicit knowledge by means of formal methods of knowledge transfer like training or the exchange of lessons learned. Combination of knowledge by means of collecting, sorting and merging of previously unrelated but existing explicit knowledge shall also lead to new knowledge. And, finally, internalization is the process of absorbing explicit knowledge into the organization and converting it to individual tacit knowledge (Schulze and Hoegl 2006, Hoegl and Schulze 2005). In previous paragraphs it was shown that communication is related to team attributes as tenure and interdependency. When interdependency increases the frequency of communication also increases. This also applies to an increased tenure which results in increased social integration and communication. Schulze and Hoegl (2006) in their turn showed that an increased level of communication is positively related to knowledge creation. So both interdependency and tenure homogeneity may increase, via more frequent communication and social integration, the creation of knowledge.

The *integration of knowledge* within an organization is defined by Yang (2005) as “the process of translating the raw knowledge into actionable knowledge by means of an acute understanding of the business context”. Meaning that the people in the company or the team members know what the value of the knowledge to the company or the products a team develops is. Gebert et al. (2010) refer to it as the degree to which a group makes use of the voice ideas by combining them, valuing them, setting priorities and find use for the ideas. There is an interesting symbiosis between the generation of knowledge and the integration of knowledge. Without the generation of knowledge integration into the team or organization is obviously not possible. Conversely, the generation of knowledge without finding use for it or integrating it is pointless as the team or company does not benefit from it (Schulze and Hoegl 2006, Hoegl and Schulze 2005, Smith et al. 2005, Gebert et al. 2010).

One of the aspects of team performance was previously defined as the ability to adopt and use new knowledge. This is closely related to the ability to integrate new knowledge into the team and to use it. Therefore it is suggested that teams which are able to integrate knowledge also show better performance on team creativity.

2.5 LEADERSHIP

There is a difference between leadership and management, these terms are not synonyms for the same role of heading a group (or team) of people. Management is the act of getting people together to accomplish certain goals by setting targets, create plans and by defining budgets. They promote efficiency and follow the rules. Leadership is a process of social influence, it is about motivation and behaviors that cause other people to follow them (Birkinshaw 2010). The behavior of leaders can be characterized by the diversity of leadership styles. For example, Burns (1978) and Bass (1985) distinguish transactional and transformational leadership. These are both active forms of leadership where the leader actively intervenes or tries to prevent problems (Den Hartog et al. 1997). She also describes a passive form of leadership: Laissez-faire leadership. Here the leader does not take responsibility and avoids making decisions. When the leader is extremely inactive in guiding the group or organization this can hardly be seen as leadership. On the other hand, a light form of Laissez-faire leadership can be a useful component of transformational leadership as it could increase empowerment of the team members (Den Hartog et al. 1997, Bass 1985). Empowerment of team members (via empowering leadership) may also increase their

motivation and sense of responsibility and can therefore increase team performance (Somech 2006).

Empowering leadership behavior has been reviewed from different perspectives in the literature on leadership. It can be seen from the perspective of the leader, such as power sharing and giving more autonomy and responsibility (Kirkman and Rosen 1999) and from the view of the employees' response to empowerment such as motivation and meaningfulness of their tasks (Conger and Kanungo 1988, Kirkman and Rosen 1999, Spreitzer 1995). Srivastava et al. (2006) has defined empowering leadership behavior as sharing of power with subordinates resulting increased levels of intrinsic motivation. The increased levels of motivation are caused by a higher experienced potency and autonomy in performing tasks (Kirkman and Rosen 1999). Additional to this, four dimensions of the experience of empowerment can be recognized: potency, the collective believe of a team that it can be effective; meaningfulness, the extent to which team members care for the value of their tasks; autonomy, the degree to which team members have the freedom to make decisions; and impact, the extent to which team members experience are of significance for the organization (Thomas and Velthouse 1990, Kirkman and Rosen 2000). Research has also shown that empowerment of teams affects individual empowerment (Chen et al. 2007). This implies that a team leader does not have to balance between motivating the individual team members or the entire team. The team leader can therefore focus more on the core tasks and at the same time ensure that the empowerment process is in place and becomes successful. Empowered team members have more responsibilities, oversight, and the ability to make decisions. Empowering leadership is expected to be a relevant form of leadership and leads to improved team performance (Somech 2006, Combs 2002). Leaders can encourage the participation of team members, for example by facilitating in the open exchange of ideas and analytical perspective across different functions. That way team leaders present team members with new information and encourage them to think about different possibilities and solutions. This could create an atmosphere where ideas are openly proposed, discussed and reflected on (Somech 2006).

Empowering leadership is positively related to both knowledge sharing and team efficacy which are both positively related to the performance of teams (Srivastava et al. 2006, Pathirage and Jayawardena 2011). On the other hand, empowerment of subordinates may lead to overconfidence and even misjudgments by the subordinates (Conger and Kanungo 1988). In this study empowering leadership is employed as a moderating variable on the relation

between team attributes and team performance. This is of interest as this leadership style may influence team performance and will answer the questions whether it emphasizes or reduces the effects that certain team attributes have on the performance of the team.

2.6 MANAGEMENT SUPPORT

The role of middle management is crucial for the development of an atmosphere where autonomy is accepted and promoted (Burgelman 1983a, Burgelman 1983b). They play an important role in facilitating and championing in the process of organizational learning and act as an intermediate between different inputs and demands which gives them a unique role in the organization to evaluate new information in the context of the company (Floyd and Lane 2000). The role of Top Management is required for recognition of the (New Product Development) activities, for giving direction to the organization and the NPD teams and for making decisions (Floyd and Lane 2000). Hornsby (1993) defines management support as “the extent to which the management structure itself encourages employees to believe that innovation is, in fact, part of the role set for all members of the organization. Some of the specific conditions reflecting management support would be: quick adoption of employee ideas, recognition of people who bring ideas forward, support for small experimental projects, and seed money to get projects off the ground”. So, following this definition, the support of middle and senior management on the work of an NPD team encourages the team members to work on new ideas and is likely to increase the performance of these teams. The aspect of championing plays an important role with respect to team enthusiasm and confidence and (senior) management support could be seen as a critical project resource (Howell and Shea 2001, Howell et al. 2005) that leads to increased levels of performance (Pathirage and Jayawardena 2011). It may be obvious by now that this study seeks for factors that positively influence the performance of NPD teams and that the role of middle and senior management is also a factor of great interest because it is needed to communicate across different levels in the organization and to motivate people so they feel that their work is appreciated.

2.7 TEAM PERFORMANCE

The efforts of a team finally lead to new or improved products. But there are differences in teams, some are better than others. In order to make that distinction one can look at the performance of a team and attempt to measure the outcome. The performance of NPD teams is defined by Devine and Philips (2001) as the extent to which this team is able to accomplish

its goals or targets. This definition, however, gives room for many interpretations of what the exact goals and targets are. When we take that aspect of time-to-market into consideration the need for fast development seems obvious as it is about the time it requires to develop a new product and a shorter amount of time is likely to benefit time-to-market. Also the aspect of creativity can be used as performance parameter because a new product needs to provide the customer with a new feature, approach or improvement. In other words, it needs to be novel and useful for the firm (Amabile 1988). But modern businesses not only require speed or only creativity, they need both ingredients to be in balance. Both speed and creativity are important to achieve successful NPD projects which hopefully lead to good (future) company profits. (Kratzer et al. 2008, Bonner et al. 2002)

This illustrates the importance of both aspects of performance as a dependent variable and that just the term ‘performance’ is too broad to allow for proper measurement of the achievements of a team. In this thesis the constructs creativity and speed are chosen because the existing knowledge base shows little previous studies where this combination was used.

The *speed* of new product development is essential for meeting time-to-market requirements set by senior management in order to be able to make more money on a new product. Mohammed and Nadkarni (2011) illustrate that differences in temporal orientation within a team can occur but that this can enhance team performance as a balance between long-term and short-term goals can be achieved. On the other hand the ambiguity of different orientations existing in parallel could lead to conflicts among team members and could hinder the team output. As these goals have been set by senior management one would also expect continuous support during the entire development process. Missing or insufficient support may negatively influence the team’s results (Hornsby et al. 2002). This indicates that time related targets should not only be set by management but that the required support, like resources, should also be made available to the NPD teams.

Creativity can be defined in several different ways and is often the subject of disagreement among researchers (Amabile 1996). It can be associated with features of products, thought processes or persons. Alves et al. (2005) describe four different concepts of creativity that are frequently used: 1) as the individual traits facilitating the generation of new ideas, 2) as the process of generating new ideas, 3) as the results, as for example products, of creative processes and 4) as conditions supporting and promoting new ideas and behavior. So the differences in perspectives lead to a variety of definitions and depend on the differences in

organizational context (Martins and Terblanche 2003). For this study creativity is defined as the ability to generate and use new ideas for products and processes, the ability to look at problems in an unconventional way, to be able to make a distinction between valuable and less valuable ideas (Bonner et al. 2002, Schilling 2008). So, creative teams distinguish themselves from others in a way that they are able to adopt new knowledge, to use it and to come up with a product that differs from previous products or versions. They are able to use new techniques or approaches instead of only improving a previous version on some aspects. The latter, however, is not necessarily a bad product or design (because it may be much faster or much cheaper to deliver) but a creative team is able to choose between these options.

A balance between creativity and speed is also suggested by Kratzer et al. (2008) and relates to the various ways of communication. Two forms of communication networks are described: the design structure matrix (DSM), a formal description of team specific project interfaces and a more dense informal communication matrix (ICM). Both forms of communication allow for alignment between and within teams and influence both creativity and time efficiency. This is illustrated in Figure 2 and shows the relation between creativity and the amount of misalignments to be inversely U-shaped and decreasing time efficiency in relation to the degree of misalignments.

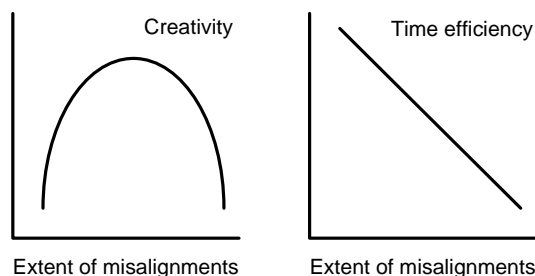


Figure 2: Extent of misalignment and its impact on creativity and time efficiency (Kratzer et al. 2008).

This suggests that a focus on time-to-market or time efficiency may have a negative impact on the creativeness of the teams and vice versa, when the focus is merely on the development of new techniques and products time-to-market targets may not be met and the company could lose significant amounts of money. On the other hand, the focus on creativity or time efficiency may not have to be constant during the course of a project and could transfer from creativity in the early product development stages to time efficiency in later development stages.

2.8 SUMMARY OF CONSTRUCTS

In the previous paragraphs the literature on the various constructs of this study has been discussed. The following table (Table 2) shows an overview of variables team performance, team attributes, leadership behavior, management support and knowledge related processes and their respective constructs, together with several the relevant authors.

Table 2: Overview of variables, constructs and relevant authors.

Variable	Construct	Description	Authors
Team Attributes	Diversity	Differences in functions and educational background and level.	Sethi (2001, 2002), Campion (1996, 1993), Egan (2005), McDonough (1993), Ancona and Caldwell (1992), Van Knippenberg and Schippers (2007), Schippers (2003)
	Interdependence	Interdependency between team members with respect to workflow, goals and outcomes.	Kozlowski (2006), Campion (1996, 1993), Guzzo (1996), Salas et al. (1992), Marks et al. (2001), Gully (2002)
	Tenure	Time that team members are working in the project.	McDonough (1993), Ancona and Caldwell (1992), Gladstein (1984)
	Psychological safety	Relation among team members, discipline, stretch, support, trust.	Ghoshal and Bartlett (1994), Gibson and Birkinshaw (2004), Sethi (2001), Kuenzi (2009), Carmeli (2009)
Knowledge Management	Creation	The creation of new knowledge or the combination of existing information to new knowledge	Gebert et al. (2010), Smith et al. (2005), Schulze and Hoegl (2006), Hoegl and Schulze (2005), Siemsen et al. (2009), Edmondson (1999).
	Integration	The integration of new knowledge into the team or organization.	Yang (2005), Smith et al. (2005), Schulze and Hoegl (2006), Hoegl and Schulze (2005)
Empowering Leadership		Aims at sharing power and giving more autonomy and responsibility to subordinates.	Somech (2006), Conger and Camungo (1988), Srivasta (2006), Combs (2002), Kirkman and Benson Rosen (1999)
Management support		Support for NPD teams from middle and top management in facilitating and championing.	Burgelman (1983a, 1983b), Floyd and Lane (2000), Hornsby (1993), Pathirage and Jayawardena (2011), Howell (2005)
Team Performance	Creativity	The amount of creativity or inventiveness of a team.	Bonner (2002), Gebert et al. (2010), Sethi (2001)
	Speed	The amount of time needed for a team to develop a product.	Mohammed (2011), Bonner (2002)

2.9 HYPOTHESES

This paragraph describes the hypotheses for this study and is formed along the setup of the conceptual model that was presented in chapter 1. The presumed relationship between team attributes and knowledge management will be described along with the moderating role that empowering leadership and management support plays. The presumed relationship between knowledge management and team performance will also be described.

2.9.1 TEAM ATTRIBUTES AND KNOWLEDGE MANAGEMENT

As shown in the previous paragraphs knowledge management consists of two important aspects. First, knowledge creation, where knowledge is created from new information or by combining existing information in a new way. Moreover, the integration of knowledge is important, without the integration of the knowledge, or putting it to use in the organization, new knowledge can hardly be called useful.

The creation of knowledge is the degree to which new and (perhaps) useful new ideas are communicated towards others (Schulze and Hoegl 2006, Gebert et al. 2010). This means that communication among the members of the team and even across the team limits, for example with other teams in the organization or with parties outside the company, is an important or even crucial aspect of knowledge creation. In fact, Leenders et al. (2003) described communication as the vehicle of NPD, the team members must be able to tap into the right network of information and knowledge flows. More frequent communication, either via formal or informal ways, gives more moments of the exchange of information, ideas and thoughts. This seems rather straightforward, with more frequent communication there is simply more time for discussions and conversation about (new) topics and enables to look at them from various perspectives. The other aspect of knowledge management, integration of the created knowledge, runs along similar lines. The micro-level interactions among team members, or communication, are a large contributor to the integration of knowledge (Yang 2005). While people discuss topics or share new insights they may be integrated in the existing knowledge base. Over a longer period of time this leads to improvements of current knowledge and the development of new skills. Because of the close relation and similarities of knowledge creation and integration these aspects are combined to knowledge management. So, when we want to paint a picture that shows the relation between team attributes and knowledge management, the aspect of communication is very important and we could question what the role of these attributes is.

The diversity in teams enables to approach problems from different angles (Schulze and Hoegl 2006, Hoegl and Schulze 2005, Egan 2005) and could trigger discussions within the team. This ensures that different aspects of a problem or idea are being discussed and that previously unrelated information can be combined. Different team members provide input from several perspectives from which new information can be created. On the other hand, when there is too much dissimilarity among the team members the discussions may not lead to generation or integration of new knowledge but may even lead to the impairment of team

functioning (Kearney et al. 2009). And although team diversity may, in extreme cases, lead to the dysfunction of a team it is believed that diversity is more likely to trigger discussions that have a positive effect on knowledge management. Hence the following hypothesis is formulated:

Hypothesis 1a: Team diversity is positively related to knowledge management.

When the members of a team are depending on one another they form a sort of mini organization by themselves. They become members of a social system. When team members depend on their colleagues for the information they need to properly do their job, for example specialist in depth knowledge of one of the aspects of a product, they need to communicate frequently. They have to inform each other on the latest developments and will discuss the impacts on their current and future projects and rely on their coworkers for specific information. Also, when the interdependency among team members increases the amount and the intensity of interaction between them (Cole et al. 2011) also increases. And, as stated above, interaction and communication is an important aspect of both knowledge creation and integration so interdependency is likely to have a positive effect on knowledge management. This results in the following hypothesis:

Hypothesis 1b: Team interdependence is positively related to knowledge management.

As also described in previous paragraphs, tenure is likely to have a positive influence on the frequency of communication among team members because people who work together for a longer period of time know each other better. They are therefore better able to understand each other and communicate easier and more often. Their level of social integration is higher than for teams who have just started to work together frequent (Ancona and Caldwell 1992, O'Reilly III et al. 1989). And, again, as interaction and communication are important aspects of knowledge management, team members who participate in a team for a longer period of time, could positively affect knowledge creation and integration; hence the following hypothesis has been formulated:

Hypothesis 1c: Team tenure is positively related to knowledge management.

The fourth and last team attribute of this study is *psychological safety*. People feel safe to take interpersonal risks (Edmondson 1999) and therefore communicate easier about their thoughts, they know their ideas are taken serious and can be discussed freely. In a team with higher levels of psychological safety it is possible to make mistakes without these being held against them. This means that data and information can be shared openly and that the members of the team do not keep the information to themselves as they may do in a less safe team. Bringing up errors or issues can be done without the fear of embarrassment. When they feel respected they will easier speak up and are more open for discussions. This openness towards others is increases the amount of communication and leads to increased knowledge sharing. Following the work of Siemsen et al. (2009) who showed that an increased level of psychological safety increases the motivation to share knowledge among the colleagues, and Edmondson (1999) who showed a positive association between psychological safety and learning in work teams, the following hypothesis is formulated for NPD teams:

Hypothesis 1d: Psychological safety is positively related to knowledge management.

2.9.2 MODERATING EFFECTS OF EMPOWERING LEADERSHIP AND MANAGEMENT SUPPORT

The literature on leadership can be said to be very comprehensive. Many forms of leadership have been described. As mentioned previously, this thesis looks for the effects of empowering leadership on the process of knowledge management. More explicit, it looks for the moderating effects of empowering leadership on the relation between team attributes, knowledge creation and knowledge integration.

Empowering leadership implements conditions that enable sharing of power among the team members. Their roles in the organization and their significance for the organization are made clear and they understand how their job fits in the bigger picture. They how and where they can contribute to the success of the company (Zhang and Bartol 2010). By sharing power and allowing team members to make their own decisions the leaders express confidence in their performance which motivates them to properly do their job. Providing autonomy also improves self-confidence as they know that their leaders allow them to make choices on their own, without direct supervision or intervention.

In order to work effectively empowered teams need to have strong information networks and also need to communicate well within the team and outside the team (Mathieu et al. 2006). Furthermore, in empowered teams are encouraged to think of different solutions and

there is an atmosphere of open communication where these solutions can be discussed (Srivastava et al. 2006, Somech 2006, Combs 2002, Pathirage and Jayawardena 2011). This means that team empowerment leads to more frequent communication among the team members and that they will share more information in order to be able to make their decisions. In the previous paragraph it was shown that communication is a key vehicle for NPD (Leenders et al. 2003) and that there is an important relation between the team attributes and the knowledge related processes. Thus, when empowering leadership leads to more communication, via shared power, increased motivation and awareness of the contribution to the company, it is expected that empowering leadership enhances the team attributes resulting in a better knowledge management. This is combined in the following hypothesis:

Hypothesis 2: Empowering leadership positively influences the relation between team attributes and knowledge management processes.

When we consider the middle and senior management support of the NPD teams in the organization it was found that this support will contribute to an atmosphere where autonomy is promoted and accepted (Burgelman 1983a, Burgelman 1983b). As stated previously, the championing role of managers is very important, they play an important role in the information flows between different management levels in the organization and ensure that the right information is communicated to the teams (for example, by giving direction) and by communicating the team efforts towards higher hierarchical levels (Floyd and Lane 2000). Additionally, middle management can support by facilitating the NPD teams in their work and by implementing new developed or created knowledge. This is a form of acknowledgment of the work that has been done within the teams, they know that their efforts are important to the company and help to bring the organization to a higher level or are strengthening the competitive position of the company. An example of (formal) support for implementation of new knowledge is organizing training or information sessions. Furthermore, the adaptation of new ideas and recognition of people encourages team members to work on these new ideas, generate new information and to discuss this within the team and with management. This motivates people as they feel confident in support from management for their activities (Pathirage and Jayawardena 2011). The earlier hypothesized relations between team attributes and knowledge management may be enhanced by the knowledge of team members that their management supports their work, guides them in the right direction

by providing the information they need, by facilitating and by recognition of their achievements. Combining these aspects leads to the following hypothesis:

Hypothesis 3: Management support positively influences the relation between team attributes knowledge management processes.

2.9.3 KNOWLEDGE MANAGEMENT AND TEAM PERFORMANCE

In the previous paragraphs I have explained the mechanisms that could influence the knowledge management processes, knowledge creation and knowledge integration. This paragraph describes the next step. What are the aspects that lead to increased team performance on the two aspects considered in this study, NPD speed and creativity? Edmondson (1999) showed that organizational learning, which shows great resemblance with knowledge creation as it is about constant reflection and action and discussing problems on team level, leads to a higher level of team performance. She uses a self-reported measure of performance where customer satisfaction is measured. This is different from this study as it is not clear what the customers' expectations are and is limited to one aspect. On the flip side, the team's psychological safety has a positive effect on these learning processes which, in turn affect team performance. Learning behavior mediates between psychological safety and team performance (Edmondson 1999). When teams consist of members, who are really part of the team and not just the owner of specialist or explicit knowledge, higher levels of performance are expected (Politis 2003). These teams are better able to communicate and understand the problems a team has to cope with and are better able to use their knowledge to the benefit of team performance. Consequently, knowledge processes may influence the performance of teams. Teams that are able to absorb new information from other sources and are also able to implement it in the team could outperform teams that lack these capabilities. And the ability of a team to absorb and use the knowledge could result in higher performance (Gebert et al. 2010). This leaves the two aspects of performance open, speed and creativity. They are of course different forms of NPD performance and the effects of knowledge management may therefore be different. First development speed, Edmondson (1999) demonstrated that the effectiveness of teams increases when their learning capabilities increase. Creating and integrating knowledge helps to create more effective routines (Sarin and McDermott 2003) and more effective routines where the latest information, or state-of-the art knowledge, is available future routines are performed more efficiently. For example, a mistake that was

made in the past will not be made again by that team because they have analyzed and discussed the problem and integrated an improved method in their daily activities. Making fewer mistakes and working more efficiently will increase the speed at which products can be developed. This results in the following hypothesis:

Hypothesis 4a: Knowledge management is positively related to NPD speed.

The second aspect of team performance in this study is creativity. Creativity requires the creation and implementation of new knowledge (Sarin and McDermott 2003, Schoonhoven et al. 1990). It requires new skills and better understanding of the matter at hand. The new knowledge must also be available in the team, it needs to be discussed and integrated in the existing knowledge base in order to be able to apply it and to produce more creative solutions (Moorman 1995). And when people work for a longer period of time in the same team or in the same knowledge domain they become more experienced in that area. So they often possess more knowledge on a specific topic which will result in more creative ideas (Gino et al. 2010), they do not make the basic mistakes or come up with solutions that are already available as may be possible with less experienced team members. Furthermore, when team members discuss non-routine problems they go through a process of trial and error, this generates knowledge but also gives the opportunity to introduce creative solutions in new products. This leads to the following hypothesis:

Hypothesis 4b: Knowledge management is positively related to NPD team creativity.

2.10 CONCEPTUAL MODEL

The aforementioned hypotheses lead to an update of the conceptual model, which was depicted in chapter 1, and is shown in Figure 3:

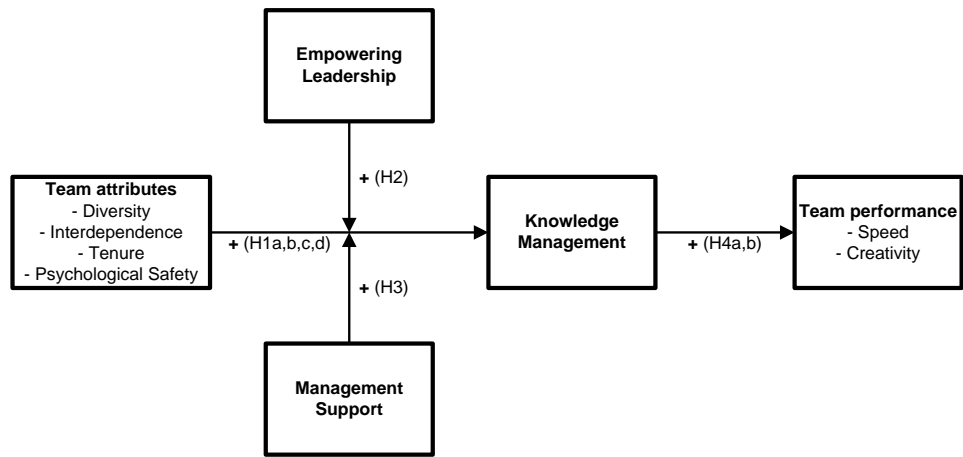


Figure 3: Updated conceptual model.

3. METHODOLOGY AND DATA

In this chapter the method of data collection and the level of analysis are described. Furthermore, the measurement and validation of the constructs will be presented which will be used to answer the research questions.

3.1 METHODOLOGY

This research is an explaining study which tries to find correlations between various team attributes and team performance. Secondly it seeks for the role of knowledge management on this relation and thirdly it tries to find a moderating role of leadership style and managerial support on this relation. By means of a quantitative approach the hypothesized constructs (as presented in the previous chapter) can be tested on a large collection of teams and is considered to be a suitable approach (Denzin and Lincoln 2011). Two questionnaires have been presented to the teams, one for each member of the team and another for the team leader. People were asked to answer questions on a seven point Likert scale, ranging from ‘fully agree’ to ‘fully disagree’, furthermore there were several open questions to define general respondent characteristics as for example ‘how long have you been a member of this team?’. The questionnaires for both the team leader and the team members can be found in Appendix 1.

This study contributes to an ongoing research project at ERIM (Erasmus Research Institute of Management) and investigates how companies can compete on knowledge, with a focus on innovational excellence. This research will also be performed at several high tech companies in The Netherlands. In these companies the same questionnaires have been issued in order to be able to compare the results to the results of this study. The data for this study were collected from ASML Netherlands B.V., a high tech company which develops and manufactures complex lithography systems for the semiconductor industry. These systems are used to print complex patterns onto silicon wafers, the basic raw material for microchips. This lithographic printing process is one of the most critical and expensive steps in wafer fabrication and the costs for the development of lithography equipment are high (in 2011 ASML has invested 590 million Euros in Research and Development), which results in the presence of only a few primary suppliers.

ASML competes primarily with two companies, Nikon Corporation (‘Nikon’) and to a lesser degree with Canon Kabushi Kaisha (‘Canon’). These two Japan based competitors both

have substantial financial resources and broad patent portfolios and frequently introduce products with improved price and performance characteristics to the market. This may cause a decline of sales volume or a loss of market acceptance for ASML products. In order to maintain a firm market position the long-term relationship with the customers is essential; this means that customer service is tailored toward the specific customer requirements and also by a number of well-trained service engineers to support the equipment at customer locations. ASML operates in 16 countries with 55 sales and service locations and employs approximately 10,000 people, including nearly 2,000 temporary workers, globally. These people were responsible for net sales of 5.7 billion Euros and a gross margin of 43% in 2011.

Although ASML is located in several countries most of the research and development activities are performed in The Netherlands, this is therefore the location where the data was collected.

3.2 LEVEL OF ANALYSIS

The level of analysis describes the primary unit of measurement of the objects being researched (Bryman and Bell 2011). The level of analysis for this study are New Product Development teams. These teams vary in size and each team has a team leader who is in charge of daily control of team, for setting priorities and as formal interface between projects that require the team's competencies. These teams all have specific competencies like software, mechanics, electronics or optics and work simultaneously on different projects. They are involved as members of multi-disciplinary project teams for their specific expertise on topics that are required for the development of a new product or module. In practice they are therefore members of different teams. First of all their own mono-disciplinary expert teams (the level of analysis for this study) and secondly the project teams where the expertise of different individuals is combined. These teams have been chosen over project teams for two reasons. They are teams that are clearly defined in the organization. Project teams are unstable; they change over time due to the need for other competencies and also change with respect to the people who are working on it. They show similarities with the temporary groups that work together on a project for a limited amount of time as described by Edmondson (2012) they are not the well trained basketball unit but show often more resemblance with an on-the-fly team. This makes it more difficult to approach a project team. Hence, there are also some practical considerations in choosing the mono disciplinary teams.

3.3 RELIABILITY AND VALIDITY

For an accurate representation of the variables in this study both the validity and the reliability of the measurements should meet certain requirements (Bryman and Bell 2011). The validity in this study was established by usage of questions from previous studies, thus ensuring that the concepts that were intended to be measured actually represented these concepts. The reliability of the data was measured by means of calculation of Cronbach's α for each construct. By adding similar questions to the questionnaires the validity and reliability was increased.

3.4 DATA ANALYSIS

This paragraph describes the data that was collected in terms of response rate and the constructs that shall be used during further analysis. The data has been analyzed using IBM's SPSS statistics software package.

3.4.1 RESPONSE RATE

The sample for this research consisted of 31 teams (N=31) from the Development & Engineering department of the aforementioned company. The method used to identify the teams is known as snowball sampling, initial groups were contacted and from these contacts more teams have been identified (Bryman and Bell 2011). Of the 32 teams that have been approached, one team leader decided not to co-operate with this project. This resulted in a response rate of 97%.

Both team leaders and team members participated in this study; in total 173 employees responded to the questionnaire, of which 31 team leaders and 142 team members. The size of the participating teams ranged from 3 to 18 team members ($\bar{x} = 6.74$, $\sigma = 2.83$) and the average response rate per team was 72% ($\sigma = 19\%$). Although this can be considered as a good response rate, it is slightly lower than expected due to the amount of time needed to fill the questionnaires. The time needed to complete the questionnaire was estimated and confirmed by four pilot teams at approximately 15 minutes but several team members reported a time of 30 minutes which reduced the willingness of other team members to fill the questionnaires, leading to higher non-response bias in larger teams. Two other reasons leading to non-response of the team members were mentioned by the team leaders (sometimes during the initial conversations, sometimes during or afterwards the answering period): On a regular

basis the company sends several other questionnaires to the employees to measure employee satisfaction, project status and progress and as input for leadership training programs. This reduced the willingness to participate in yet another survey. A second point which was mentioned frequently is the high work pressure and tight project deadlines, simply reducing the available time for secondary activities.

3.4.2 MEASUREMENT AND VALIDATION OF CONSTRUCTS

This section describes the constructs in operational terms to enable testing and measurement. In Table 3 an overview of the different measurement scales is provided.

3.4.3 INDEPENDENT VARIABLES

Diversity was part of the surveys of both groups, both the team leaders and the team members were asked, by means of identical questions, about their creative output. In order to be able to define whether the answers from both groups could be combined, two scales were computed, one for each group. A Cronbach's α .863 for Team Leaders and .845 for Team Members indicates good reliability, while skewness (-.019 and -.555) and kurtosis (-.981 and -.140) indicated a normal distribution of the data (Klijn 2007) allowing a t-test for comparison of the answers of both groups. This t-test, $t(31) = .737$, $p < .05$, showed that there is no significant difference between the responses of the team leader and the team members ($p = .467$). Cronbach's α of the combined scale for diversity is .832.

Interdependence, measured with the team members showed a skewness of -.565 and kurtosis of -.096, both well within acceptable limits. Also reliability was good as indicated by a Cronbach's α of .923.

Tenure, the time in months that people work for the team, was measured for both the team leaders and the team members. Because of too high values for skewness (2.806) and kurtosis (7.848), the natural logarithm was used in the analysis. These logarithmic values for skewness (.415 and -.472) and kurtosis (-.185 and -.501) allowed to test for differences. This t-test, $t(31) = -1.246$, $P < .05$, showed that no significant differences are present ($p = .222$) and that combination of the data from team leaders and team members is allowed.

Psychological safety related questions were asked to the team members. Skewness (-.134) and kurtosis (1.009) indicated normally distributed data and reliability was good ($\alpha = .754$).

3.4.4 DEPENDENT VARIABLES

NPD Speed was part of the surveys of both groups, both the team leaders and the team members were asked, by means of identical questions, about their creative output. In order to be able to define whether the answers from both groups could be combined, two scales were computed, one for each group. A Cronbach's α .798 for Team Leaders and .802 for Team Members indicates good reliability, while skewness (-.042 and -.687) and kurtosis (-.065 and 1.058) indicated a normal distribution of the data allowing a t-test for comparison of the answers of both groups. This t-test, $t(30) = .124$, $p < .05$, showed that there is no significant difference between the responses of the team leader and the team members ($p = .902$). Cronbach's α of the combined scale for speed is .804.

Creativity was also part of the surveys of both groups, both the team leaders and the team members were asked, by means of identical questions, about their creative output. In order to be able to define whether the answers from both groups could be combined, two scales were computed, one for each group. A Cronbach's α .828 for Team Leaders and .927 for Team Members indicates good reliability, while skewness (.637 and .874) and kurtosis (-.841 and .845) indicated a normal distribution of the data allowing a t-test for comparison of the answers of both groups. This t-test, $t(30) = -1.103$, $p < .05$, showed that there is no significant difference between the responses of the team leader and the team members ($p = .279$). Cronbach's α of the combined scale for creativity is .769.

3.4.5 MEDIATING VARIABLES

Information on *knowledge creation* was collected from team members and showed good reliability, Cronbach's $\alpha = .884$, and normally distributed data.

Input on *knowledge integration* was also collected from the team members and reliability is good ($\alpha = .798$).

3.4.6 MODERATING VARIABLES

For *Empowering Leadership* behavior the data was collected from team members, a Cronbach's α was calculated to be .923 indicating that the construct is reliable. Skewness (.170) and kurtosis (-1.060) indicate that the responses were normally distributed.

Management support, collected from team leaders, showed skewness -.193, a kurtosis of -.521 and reliable information as indicated by a Cronbach's α of .728.

3.4.7 CONTROL VARIABLES

Following other studies several relevant control variables have been included in this study. Both team size and team age have been included.

Team size was included as a control variable because literature on NPD teams showed that the size of the team influences effectiveness as team learning and success (Dayan et al. 2009, Kearney and Gebert 2009). As kurtosis was too high (2.905), the natural logarithm of team size was used in the analysis.

Team age, measured in the number of months since the team was started was included as previous studies showed that increased cumulative experience enhances innovation (Jansen et al. 2006). As kurtosis was too high (3.765), the natural logarithm of team size was used in the analysis.

Table 3: Summary of variables and constructs

Variable type	Construct	Items	Valid N	Cronbach's α	Mean	σ	Skewness	Kurtosis
Dependent	Creativity	6	30	.769	32.237	2.940	-.186	-.042
	Speed	5	31	.804	46.869	5.851	-.251	-.337
Independent	Diversity	18	31	.832	91.255	7.77	-.140	-.219
	Interdependence	4	31	.923	18.773	2.054	-.565	-.096
	Tenure ^a	n.a.	31	n.a.	5.440	1.453	.365	-.731
	psychological safety	6	31	.754	33.726	2.594	-.134	-1.009
Moderating	Empowering Leadership	11	31	.923	54.715	5.597	.170	-1.060
	Management support	3	31	.728	13.807	2.810	-.193	-.521
Mediating	Knowledge creation	8	31	.884	35.178	4.065	-.135	-.858
	Knowledge integration	3	31	.798	15.297	1.549	.024	-.036
Control	Team size ^a	1	31	n.a.	2.022	.435	.523	.753
	Team age ^a	1	27	n.a.	3.071	.755	-.091	-.181

^a Log

4. ANALYSIS AND RESULTS

This chapter elaborates on the analysis of the data and the results of this study. The first paragraph shows the descriptive statistics and the second paragraph shows the result from hierarchical regression analysis.

4.1 DESCRIPTIVE STATISTICS

For the 31 teams that responded to the questionnaire the following. On average the team's tenure (the amount of time a team exists) was 28.1 months, $\sigma = 33.3$. The high numbers for standard deviation, skewness (1.853) and kurtosis (3.765) indicate that there are quite some teams that do not exist for a long period of time (63% exists for two years or less). Team leaders work on average for over ten years in this industry ($\bar{x} = 10.3$ years, $\sigma = 6.1$), work for 8.5 years ($\sigma = 4.4$) in the organization and are 2.2 years ($\sigma = 3.2$) leader of this team. Team members work on average for a period of 8.3 years in this industry ($\sigma = 7.9$), work for 5.3 years in the organization ($\sigma = 5.0$) and are 1.7 years ($\sigma = 1.6$) member of this team. Of the Team leaders zero (0) indicated to have a vocational background, 8 (25.8%) have received a bachelor's degree, 18 (58.1%) have obtained a Master degree and 5 (16.1%) received a PhD. Of the team members is 10 (7.0%) has a vocational education, 47 (33.1%) has a bachelor's degree, 53(37.3%) holds a master degree and 28 (19.7%) received a PhD, finally 4 team members (2.8%) chose not to disclose the level of education.

The mean value (as shown in Table 3) for speed is significantly higher ($p < .01$) than for creativity (46.9 versus 32.2). This indicates that new product development speed is preferred over creativity. This illustrates the importance of time to market for the teams that were analyzed for this study.

In Table 4 the correlation between the different variables are presented. The correlation coefficient is a measure for the strength of the relationship between two variables. A correlation factor greater than .80 may be an indication for multicollinearity (Field 2009). In this study the maximum correlation coefficient is .680 indicating that multicollinearity is not present. A more detailed approach has been performed by calculating the variance inflation factor (VIF) for each equation. The maximum value was 3.658 which is well below the maximum value of 10 (Myers 1990) while the minimum value of .10 was also not observed indicating no risk for multicollinearity.

Table 4: Spearman's correlation between variables.

		Spearman's correlation coefficients											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Creativity	-											
2	Speed	.602**	-										
3	Diversity	.423*	.499**	-									
4	Interdependence	.567**	.424*	.515**	-								
5	Tenure ^a	.328	.308	.218	.368*	-							
6	psychological safety	.628**	.441*	.338	.612**	.368*	-						
7	Empowering Leadership	.310	.321	.241	.345	.219	.519**	-					
8	Management support	.040	.173	.430*	.070	-.128	-.316	-.121	-				
9	Knowledge creation	.543**	.331	.300	.440*	.153	.602**	.395*	-.034	-			
10	Knowledge integration	.577**	.383*	.212	.665**	.224	.676**	.485**	-.154	.589**	-		
11	Team age ^a	.165	.191	-.109	.038	.680**	.370	.168	-.293	.287	.171	-	
12	Team size ^a	.052	.250	.310	.184	-.063	-.332	.118	.554**	-.119	.010	-.323	-

^a Log

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

4.2 TESTING HYPOTHESES

In chapter 2 the hypothesized relationships between the various constructs have been described. These have been tested by means of multiple regression analysis. The following paragraphs describe the results of these tests.

4.2.1 RELATIONSHIP BETWEEN TEAM CHARACTERISTICS AND KNOWLEDGE MANAGEMENT

In order to be able to test the relationship between team attributes and knowledge management initial models consisting of the control variables and the dependent variables are created. These models, based on standardized z-scores, function as reference for further analysis and are presented in Table 5. This table shows the reference models for knowledge creation (model 1) and knowledge integration (model 7). These base models contain the control variables and show that there is no significant effect on knowledge creation or knowledge integration ($p > .10$).

First we will look at the effect of team attributes on knowledge creation. When the independent variables are added to model 1, the predicting strength of the linear model increases from 30.9% to 54.6% ($R^2 = .0546$; model 2) which means that adding the team attributes enables better prediction of the influencing parameters of knowledge creation. As the values for R^2 are greater than .18 these models can be considered good (Klijn 2007). The effects of these independent variables are non-significant for diversity, interdependence and tenure ($p > .10$), psychological safety however has a positive significant ($\beta = .854$, $p < .01$) effect on knowledge integration. The control variables show that also team size is positively related to knowledge creation ($\beta = .429$, $p < .10$) which means that larger teams are better able to create knowledge. The time that a team exists, (team age) does not show this relation with knowledge creation.

When looking at knowledge integration similar influences have been found, the predicting value of model 8 is 57,4% and psychological safety has a positive and significant effect on knowledge integration processes ($\beta = .694$, $p < .05$) while the other team attributes and the control variables show a non-significant effect on the integration of knowledge in the team.

Concluding, for knowledge management it has been found that the influences of the team attributes are similar for both knowledge creation and integration and that the diversity, interdependence and tenure don't play a significant role. Hence hypothesis 1a, 1b and 1c are

not supported with empirical evidence. Psychological safety however does play a significant role, it has a significant positive effect on knowledge management, thus supporting hypothesis 1d.

4.2.2 MODERATING ROLE OF EMPOWERING LEADERSHIP

In order to test the influence of empowering leadership and management support on the relation between team attributes and knowledge management additional hierarchical modeling has been used. First the moderating effect of empowering leadership will be analyzed for knowledge creation and secondly for knowledge integration. The data is presented in Table 5, as a starting point the base model for knowledge integration was used (model 2), to this the moderating variable (empowering leadership) has been added which does not show a significant effect ($\beta = .113$, $p > .10$; model 3), secondly the interaction effects between the team attributes and empowering leadership were added stepwise. Some non-significant interactions are not presented here; these are the intermediate models where only one interaction effect was added which did not show significant contributions to the model. For example, models 3c and 3d did not result in significant numbers. It can be seen from model 4 that empowering leadership has a positive significant influence on diversity ($\beta = .195$, $p < .01$) which indicates that empowering leadership enhances the aspects of diversity among the team members and has a positive contribution to the creation of knowledge. The size of the team remains a significant positive influencing factor, also when an empowering leader is part of this team ($\beta = .460$, $p < .05$).

On the flip side, when we examine the effects that empowering leadership has on the integration of knowledge it can be seen that no significant direct effect ($\beta = .212$, $p > .10$; model 9) or significant interaction effect (model 10) has been found. An interesting side effect is that the control parameter for team age shows a significant negative influence ($\beta = -.195$, $p < .10$) indicating that teams that exist for a longer period of time have more difficulties in integrating new knowledge in their daily activities when they are (more or less) free to do so due to an empowering leader.

Concluding, for knowledge management it is clear that empowering leadership positively enhances the diversity within a team resulting in increased levels of knowledge creation. No evidence for other (positive or negative) influences has been found. This means that hypothesis 2 is partly supported, as stated above.

4.2.3 MODERATING ROLE OF MANAGEMENT SUPPORT

In order to test the influence of management support on the relation between team attributes and knowledge management additional hierarchical modeling has been used, analogue to the method described in the previous paragraph. First the effect on knowledge creation will be described and secondly the effects of management support on knowledge integration will be shown. The base model for the effect of management support on the relation between team attributes and knowledge creation is model 2 in Table 5, consisting of the control and the independent variables, to this model the direct effect of management support was added (model 5) which does not show a significant effect ($\beta = .227$, $p > .10$) in a rather strong model ($R^2 = .573$). When adding all interaction effects to the model (resulting in model 6) the predicting value increases to 73.6% ($R^2 = .736$) which is good. At his moment we see that management support has a negative significant effect on the influence of tenure ($\beta = -.472$, $p < .05$) which means that management support negatively affects the (otherwise non-significant) effects of the time that people work in the team in relation to the creation of knowledge. Psychological safety on the other hand benefits from management support, there is a positive significant effect ($\beta = .298$, $p < .10$) on the relation between psychological safety and the creation of knowledge.

Secondly, looking at the influence on knowledge integration we learn from model 11 that there is no direct effect ($\beta = -.007$, $p > .10$) and that also no empirical evidence for interaction effects has been found ($p > .10$; model 12).

Concluding on the moderating effects of management support on the relation between team attributes and knowledge management evidence was found for significant effects on knowledge creation but not for knowledge integration. Management support has a positive effect on psychological safety but influences tenure in a negative way. Hence hypothesis 3 is partly supported.

4.2.4 EFFECTS OF KNOWLEDGE MANAGEMENT ON TEAM PERFORMANCE

The final stage of the analysis is the effect that knowledge management has on the performance of team (i.e. when we want to test hypothesis 4a and 4b). For this step we need to create another analytic model. In this model the independent variables are the aspects of knowledge management and the aspects of team performance are the dependent variables. In Table 6 the standardized z-scores and the results of the regression are presented. Model 13 shows the base model for the relation between knowledge management and development

speed. With an R^2 of .219 the predictive capabilities of this model is just above the threshold of .18 which is considered to be good (Klijn 2007). When the knowledge management parameters are added in the partial models 14a and 14b it can be seen that knowledge integration has a positive significant effect on the NPD speed ($\beta = .387$, $p < .05$; model 14b). While the strength of the full model increases to an R^2 of .366 when both knowledge creation and integration are present, no significant relation with NPD speed is present, the positive effect of knowledge integration drops just below significant levels ($\beta = .374$, $p = .120$). Consequently, hypothesis 4a is not supported. Noteworthy is that the control parameters for team age and team size do have a significant effect on development speed.

The quality of the base model for the analysis of the second performance indicator of team performance, creativity, is rather poor ($R^2 = .057$, $F = .724$; model 16). Adding the independent variables to the equation results in a strong increase of the explanatory value of the models. Again, the presence of both knowledge creation and integration results in a degradation of the impact of both parameters. Still the effect of knowledge integration on the creativity of the team is positively and significant ($\beta = .418$, $p < .10$; model 18) which means that teams who take care of the integration of their newly acquired knowledge in their daily activities will be better in producing creative solutions than teams who are less capable of doing this. This partly confirms hypothesis 4b, only the aspect of knowledge integration leads to better performance on team creativity.

Table 5: Results of hierarchical regression analysis: The effects of team attributes on knowledge management and the moderating role of empowering leadership and management support.

	Knowledge creation								Knowledge integration						
	1	2	3	3a	3b	4	5	6	7	8	9	9b	10	11	12
<i>Independent variables</i>															
Diversity		.072	.055	-.112	.190	-.112	-.047	-.064		-.193	-.225	.178*	-.339 [†]	-.191	-.265
Interdependence		-.155	-.146	.228 [†]	.269	.228 [†]	-.176	-.262		.238	.253	.251	.035	.239	.310
Tenure ^a		-.233	-.225	.150	.197	.161	-.231	-.096		.073	.088	.108	.100	.073	.282
psychological safety		.854**	.789*	.227***	1.213**	1.132**	.915**	1.063**		.694*	.573*	.977**	1.008**	.692*	.865*
<i>Moderating Variables</i>															
EL			.113	.137	-.010	.001					.212	.172	.080		
MS							.227	-3.427						-.007	.168
<i>Interaction effects</i>															
Diversity * EL				.124***		.195**							.127		
Interdependence * EL					.440*	.128					.174*		.401		
Tenure ^a * EL						-.102							-.285		
PS * EL						-.080							.450		
Diversity * MS								-.268							-.309
Interdependence * MS								.195							.002
Tenure ^a * MS								-.472*							-.162
PS * MS								.298 [†]							-.182
<i>Control variables</i>															
Team size ^a	.093	.429 [†]	.405	.446*	.629*	.460*	.356	.383	.061	.206	.161	.374	.318	.209	.379
Team Age ^a	.327	.283	.268	.011	.084	.022	.310	.488*	.131	-.188	-.216	-.392	-.398 [†]	-.189	-.130
R ²	.309	.546	.555	.808	.671	.819	.573	.736	.016	.574	.605	.710	.752	.574	.667
Adjusted R ²	.096	.410	.391	.723	.525	.686	.416	.542	-.066	.446	.459	.581	.570	.417	.440
Δ Adjusted R ²	-	.314	-.019	.332	.134	.295	.006	.126	-	.512	.013	.122	.111	-.029	-.007
F-Value	1.270	4.015**	3.387*	9.479**	4.592**	6.155**	3.640**	3.800**	.192	4.490**	4.151**	5.502**	4.133**	3.657*	2.861*

^a Log

[†] p < .10; * p < .05; ** p < .01; *** p < .001

N = 31, Standardized regression coefficients are reported

EL: Empowering Leadership, MS: Management Support, PS: Psychological Safety

Note: Several partial models are not shown as there were no significant effects to present. For this reason models 3c and 3d, 5a-d, 9a,c,d and 11 a-d are not shown here.

Table 6: Results of hierarchical regression analysis: The relation between knowledge management and team performance.

	Speed				Creativity			
	Model 13	Model 14a	Model 14b	Model 15	Model 16	Model 17a	Model 17b	Model 18
<i>Independent variables</i>								
Knowledge creation		.274		.022		.505*		.225
Knowledge integration			.387*	.374			.557**	.418 [†]
<i>Control variables</i>								
Team size ^a	.406*	.380 [†]	.376*	.375 [†]	.114	.067	.079	.067
Team age ^a	.401 [†]	.310	.341 [†]	.339 [†]	.250	.085	.177	.122
R ²	.219	.287	.366	.366	.057	.287	.362	.389
Adjusted R ²	.151	.190	.280	.246	-.022	.195	.279	.278
Δ Adjusted R ²	-	.039	.129	.095	-	.217	.301	.300
F-Value	3.229 [†]	2.948 [†]	4.233*	3.034*	.724	3.093*	4.350*	3.499*

^aLog[†] p < .10; * p < .05; ** p < .01; *** p < .001

N = 31, Standardized regression coefficients are reported

5. DISCUSSION AND CONCLUSION

There is much interest from many different groups of people like researchers, managers, team leaders and team members, to get a better understanding of the factors that influence the performance of teams and the aspects that affect knowledge management. With knowledge on these topics they may be able to influence (and enhance) the performance of teams, especially NPD teams. This, in its turn, could lead to shorter product development times, shorter time to market and increased company revenues (Langerak et al. 2010, Chen et al. 2010, Cohen et al. 1996). While there have been many researchers that have investigated influencing factors of NPD team performance and knowledge management, ranging from management styles and managerial support to team attributes, this topic is still very interesting for both academics and organizations that operate compete in today's markets.

The main research question for this study is *'What is the interrelationship between team characteristics, knowledge management and team performance? And how does empowering leadership and management support moderate the effectiveness of team characteristics?'* By defining several sub questions and hypotheses I have attempted to find answers to these questions.

The hypotheses and outcomes are summarized in Table 7, showing that not all hypothesized relations that were derived from the literature have been confirmed by empirical evidence in this study. In the following paragraphs these outcomes will be discussed and compared to the results of other studies.

Table 7: Overview of hypotheses and outcomes.

Hypotheses	Result
1a Team diversity is positively related to knowledge management.	not supported
1b Team interdependence is positively related to knowledge management.	not supported
1c Team tenure is positively related to knowledge management.	not supported
1d Psychological safety is positively related to knowledge management.	supported
2 Empowering leadership positively influences the relation between team attributes and knowledge management processes.	partly supported
3 Management support positively influences the relation between team attributes knowledge management processes.	partly supported
4a Knowledge management is positively related to NPD speed.	not supported
4b Knowledge management is positively related to NPD team creativity.	partly supported

5.1 IMPLICATIONS

The implication of these findings has been divided into two sections. In the first section for the theoretical implications, or where this study contributes to the existing knowledge base, will be discussed. And secondly, the managerial implications or the practical use of this study will be pointed out.

5.1.1 THEORETICAL IMPLICATIONS

When we consider the relation between team attributes and knowledge management it was pointed out by several scholars that communication among the team members plays an important role (Schulze and Hoegl 2006, Gebert et al. 2010, Leenders et al. 2003). The diversity among team members can function as a trigger for discussions ensuring that all aspects of a topic are brought to the attention of other team members and are being discussed. That way information can, for example, be combined and new knowledge can be created and integrated. The results however do not show that diversity plays a significant role among the teams that participated in this study (hypothesis 1a was rejected). This may be related to the nature of these teams, they are mono disciplinary teams meaning that the team members have similar (educational) backgrounds and don't start discussions based on just these differences as these are perhaps too small. Other NPD teams (like for instance multi-disciplinary project teams) may start discussions driven from differences in background. These kinds of teams, however, were not part of this study.

The interdependence among team members is frequently mentioned as one of the essentials of teams, without this, teams would not be teams but more a group of people. With increased interdependency there would be more communication (Cole et al. 2011, Un and Cuervo-Cazurra 2004) which in its turn would lead to more knowledge creation and integration as discussions on various subjects, where team members need each other's expertise, leads to the possibility of combining previously unrelated knowledge and to the generation of new knowledge. By discussing it the knowledge could be implemented. It was not demonstrated that interdependency among team members contributes to the creation of knowledge (Hypothesis 1b was not supported). Perhaps this is also related to the nature of the NPD teams in this study, as they work in single disciplines they are a group (team) of people that share knowledge on the same subject. In some cases they fulfill each other's jobs when one of the members is not in the office or busy with another project. This indicates that they share common knowledge and do not depend on one another for specific areas of expertise.

The aspect of interdependency does, in this situation, not lead to more frequent communication or to increased levels of knowledge management. This is not in line with previous studies where communication promotes social integration and feeds a feeling of interdependence which encourages knowledge sharing (Un and Cuervo-Cazurra 2004).

The third attribute, tenure, also has to do with communication among team members, it was expected that due to an increased tenure people would communicate more frequent (Ancona and Caldwell 1992) because they know each other better due to the longer amount of time they already have spent together and that this characteristic therefore would have a positive relation to knowledge management. On the other hand, job tenure may also lead to reduced knowledge sharing as experienced employees already know what is needed to perform their job. There is no need for them to share information (Gray and Meister 2004).

Regarding the psychological safety which team members experience the theoretical expectations were met, hypothesis 1d is confirmed. Psychological safety has a positive and significant effect on the team's ability to generate and to integrate knowledge. This is in line with the previous studies where the importance of a safe environment where people take interpersonal risks without the fear of being judged (Siemsen et al. 2009, Edmondson 1999). This will motivate people to share their knowledge with the coworkers and will also ensure that people accept the information which is given by the (trusted) colleague. Apparently this aspect prevails over the other aspects as diversity, interdependency and tenure, and is the key driver for knowledge management. In other words, teams where the team members trust each other, where they feel safe and where they know they can make mistakes without being rejected will be able to manage their knowledge better. They will be able to develop new knowledge and to integrate that in the team.

Two different moderating effects are part of this study; the effect of the behavior of the (team) leader, more specific the effect of empowering leadership behavior and the effects of management support. It was expected that empowering leadership would positively affect the relation between the team attributes and knowledge management because this form of leadership provides a shared responsibility for the tasks of a team and the individual members and allows them to make their own decisions. In order to make team decisions and choose direction an atmosphere of open communication where ideas and knowledge are being shared (Srivastava et al. 2006, Somech 2006, Pathirage and Jayawardena 2011). The findings of this study are only partly in line with these expectations; there is a positive effect of empowering

leadership on the diversity of team members in relation to the creation of knowledge, but not in relation to the integration of knowledge. An explanation could be that teams who are stimulated to make their own decisions are more likely to consult other team members and to evaluate different aspects of new information. They want to evaluate all aspects and want to prevent that they use the wrong assumptions or choose the wrong direction which could lead to mistakes and cause future problems or issues.

This study also suggests that the effects of empowering leadership do not play a (significant) role in enhancing the other team attributes nor does this leadership behavior affect knowledge integration. And although it was suggested that knowledge creation and knowledge integration are very closely related (Yang 2005), and are therefore combined as knowledge management, empowering leadership does not affect the latter aspect. This, at first sight, logical step in knowledge management ensures that information or knowledge is also available in the future, for the same team, or for the benefit of others. So (also at first sight) simple things as for example recording lessons that have been learned from previous experience is not enhanced by empowering leadership.

The second moderating effect is the effect that management support has on the relation between the team and knowledge management. It was suggested that there would be a positive influence of management support on the relation between team and knowledge management. It was suggested that the ratifying and facilitating role management has would stimulate the workers (Pathirage and Jayawardena 2011, Floyd and Lane 2000). This relationship was indeed found for psychological safety, support from management increases the effect of psychological safety. People feel appreciated for their work and know that their knowledge generating work is promoted towards higher hierarchical levels. But management support showed also a negative contribution to the creation of knowledge. The direct role of tenure in the creation of knowledge was found to be non-significant and negative in the analysis but when management support was taken into account a negative significant interaction effect was found. Counter to the theoretical expectations, management support has a negative effect on tenure. This means that the effect of tenure, which leads to better social integration (O'Reilly III et al. 1989) is affected negatively by the support of management. Their support may be seen as interference into the group process and perhaps disturbs the internal communication.

Finally the effect of knowledge management on the performance of the teams is analyzed. It was expected that knowledge management processes would have a positive influence on NPD development speed and creativity of the team (combined as team performance) because learning teams increase their knowledge of the topics they are working on and are able to put this knowledge to work in new products or enhanced developments speed (Gebert et al. 2010, Politis 2003). Simply because they don't make the same mistake twice within the team and therefore keep on improving. Counter to these expectations knowledge management does not affect the speed at which new product are being developed. A possible cause for the lack of this influence is the following: When the project or the company constantly demands new and innovative ideas the information that has been recorded may be of less use than expected and may not contribute significantly to increased NPD speed. Previously acquired knowledge may not be sufficient to meet the demands for the new products that are being developed, it may very well be useful but perhaps not enough to play a significant role in development speed of new products. Furthermore, when the demand for speed is very high (which it is in the context of this study, the demand for development speed is higher than for creative solutions or products) the team does not really know whether their previous developments were successful or not, they do not know if the new information was useful or if it needs to be part of their daily routine. The feedback loop of success or failure hasn't closed before the team moves on to a new project or technological challenge. This was also noticed by Chen et al. (2012) who argue that development speed can also be too high, that time is needed for absorption of knowledge and learning. The knowledge integration aspect of knowledge management does have a positive effect on team creativity meaning that the team members use previously acquired knowledge on the development of new products.

Summarizing the interrelation between team characteristics, knowledge management and team performance it was shown that the attributes that could be the initiator for more frequent communication (diversity due to differences in background, interdependency because each members has specific knowledge or covers part of the puzzle, and tenure where people know each other better) have no direct effect on knowledge management. Psychological safety does show a positive relationship with knowledge management. Empowering leadership does enhance the aspect of diversity in relation to knowledge creation because people need to communicate with each other in order to be able to make the right decisions and management

support enhances the effect which psychological safety already had on this aspect on the creation of knowledge but also results in a negative contribution of tenure on knowledge creation. Finally, the knowledge integration aspect of knowledge management has positive relation with team creativity.

5.1.2 MANAGERIAL IMPLICATIONS

Although several hypothesized relationships were not supported with empirical evidence it is clear that team's psychological safety plays an important role in the creation and integration of knowledge in NPD teams. Knowledge integration on its turn has a direct effect on the creativity of a team. It is important that the organizational climate (or team climate) is such that people trust each other, are willing to help each other and want to achieve high performance levels. Teams with people who feel safe to speak up will show better results and management needs to take care of that. Managers can contribute to the creation of such a (protective) environment by, for example, develop shared goals and shared respect among the members of the team. For example, by showing respect to others in the team they give a signal that respects is highly valued (Carmeli and Gittel 2009).

Also, empowering leadership plays an important role in the creation of knowledge. It enhances the effects of team diversity by sharing responsibilities. Managers can use this by actively sharing of responsibilities and allowing teams to make decisions. That way the manager or team leader can focus more on his or her core tasks without the need for constant team supervision. Empowering leadership functions as a double edged sword, on one side it motivates and encourages team members and on the other side it enables the leader to work on other tasks.

Management support was found to have a positive interaction effect with psychological safety and will contribute to the creation of knowledge. When this is important for a team, for example for a team which is in very early development phases and needs confirmation that they are working on the right things, support from their management helps in creating knowledge. Care has to be taken with team members who work for a long time in teams, then management support may have a negative effect.

5.2 LIMITATIONS AND FUTURE RESEARCH

Even though this study shows a better understanding of the aspects that play a role in knowledge management and the performance of NPD teams, some limitations are present.

These limitations and suggestions for future research will be described in this section, starting with theoretical limitations to methodological and empirical limitations.

5.2.1 THEORETICAL LIMITATIONS

A possible theoretical shortcoming is the aspect of leadership, there are many forms described in the literature but in this study only for the effects of empowering leadership were tested. It could be possible that other forms, like the classic transactional and transformational leadership styles show another impact on team performance.

The data has been collected from mono-disciplinary teams, teams that are specialized in a specific technical area and work on different projects simultaneously. It could be possible that their work in different projects dilutes the results and that other results would have been found if multi-disciplinary project team were surveyed.

It is known that the cultural background of the team members differs greatly, they have their roots in many different countries and came to this company for (among other) reasons of technical interest. There are only a few companies world-wide that offer the leading technological challenges that can be found here. The cultural background of the team members has not been recorded but may play a role in the leadership styles that are the most effective.

5.2.2 METHODOLOGICAL LIMITATIONS

This study has been executed with a quantitative approach where the data was collected on one moment in time (single shot case study). This way there is no possibility to look at the development of teams. Questions like “does a team’s performance change over time” cannot be answered this way.

Secondly, a quantitative approach will reveal additional information and enables to better understand the relations among team members, their performance and the influence of management support and team leadership. A possibility to do this could be via a series of interviews among team leaders (of project leaders) and team members. This data could be added to the current data set. Another method is by sending a list with several open questions to a subset of the current group. That way they could be asked for suggestions on how to improve the performance of the team. This could lead to surprising results that are currently not found in this study.

5.2.3 EMPIRICAL LIMITATIONS

The amount of teams that were surveyed in this study was limited to 31. This may have affected the significant relations that have been found. It is possible that a larger amount of teams (for example 50) would lead to more significant relations and that more hypotheses would have been supported.

This study has been performed at one company only. This makes it difficult to compare the results with other companies in the sector (high tech industry) and also the results cannot be generally applied to other companies, in other sectors. It would be better to expand this study to other companies, starting with high-tech companies, to enable better comparison or benchmarking of the results. Fortunately this is already planned (and partly in progress) by ERIM, Erasmus University.

5.3 CONCLUSION

The main research question of this study is: *‘What is the interrelationship between team characteristics, knowledge management and team performance? And how does empowering leadership and management support moderate the effectiveness of team characteristics?’*

The most important aspect of teams that leads to good knowledge management in teams are the aspects of psychological safety within a team, namely discipline, stretch, support and trust among the members of a New Product Development team. This has a positive influence on the creation and integration of knowledge among the team members. Other team attributes as diversity, tenure and interdependence are not significantly contributing to knowledge management.

The supporting role of management and an empowering leadership style does have a moderating effect on the creation of knowledge but not on the integration of knowledge. The effects don't influence the same attributes. While an empowering leadership style enhances the diversity in teams so that it contributes to the creation of knowledge, support from management enhances psychological safety on this part of knowledge management (which already showed a clear direct effect on knowledge management). Management support also has a negative influence on knowledge creation; it negatively influences the effects of time that people have spent together which results in reduced knowledge creation.

Knowledge management has a limited effect on the creativity of a team, only the aspect of knowledge integration results in higher degrees of creativity.

Finally, it was clear that the teams in this study were more driven towards reduction in time than there is an interest in achieving more creative solutions or products. So the company strives strongly for the reduction of time-to-market and in a lesser degree to new (creative) solutions for their customers. Knowledge management aspects however do not result in increased NPD speed but only contribute to more creative solutions.

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Appendix 1 QUESTIONNAIRES

Two different surveys have been used, one for the Team Leader and another for the Team Members. These provide additional information.

Team Leader survey

The survey for team leaders consists of four parts: General respondent characteristics, project team characteristics, Individual characteristics and team performance. All questions, except the open questions, have been measured on a seven point Likert scale, ranging from ‘fully disagree’ to ‘fully agree’.

General respondent characteristics

What is your highest level of education? Vocational Bachelor Master PhD

- What is your function title?
- How many members does your team have?
- What is your name? (Note: this survey is strictly confidential, results will be made anonymous)
- How long have you worked in this industry?
- How long have you worked for this organization?
- How long have you been a leader of this team?

Project-team characteristics

Indicate by marking the boxes on the project life cycle below which phase your project is in.

Feasibility	System Design	Detailed design & Realization	Manufacturing & Volume Preparation	Sustaining
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- Please indicate the size of your team (members)
- How long does your team exist? (months)

Project demands

- The client demands/expectations for this project are extremely high.
- The technical requirements for this project are extremely high.
- The time span for the development of this project is very short.
- If we want to complete the project on time we cannot afford any failures.

Marketing–R&D Interface

Please answer the following questions in relation to the marketing and R&D interface in regard to your current product development project:

- Regularly share information about customers' needs and wants.
- Cooperate fully in generating and screening new ideas and testing product concepts.
- Fully cooperate in establishing goals and priorities.
- Technological and market knowledge are fully integrated in the project.
- Regularly communicate about the new product project.

- Marketing and R&D are inadequately represented on the project.
- R&D and marketing rarely share information about competitors' products and strategies

R&D-engineering interface

Please answer the following questions in relation to the R&D and engineering interface in regard to your current product development project:

- Regularly share information about product design and technological features.
- Cooperate fully in generating and screening new ideas and testing product concepts.
- Fully cooperate in establishing goals and priorities.
- Regularly communicate about the new product project.

Management support

In my work team:

- Team members feel supported by the organization.
- You can tell that the company is interested in the members of the team.
- The human resources management is carried out keeping the team members in mind.
- The team manager contributes to creating a friendly and cordial work climate.

Goal Achievement

In my work team:

- Team members try hard to reach the team goals
- Team members aspire to achieving greater performance
- High, difficult goals are viewed as a challenge
- Everyone contributes enthusiastically to reaching the goals

Enabling formalization

The norms and procedures in my team:

- Help our team to function better
- Help us to find the best way to do things
- Facilitate relationships between team members
- Help us to understand the relationship between each person's work and that of his/her co-workers

Knowledge acquisition *(seven point scale ranging from 'to a small extent' – 'to a large extent' plus 'not relevant')*

From which functional department did your team acquire knowledge?

- Marketing
- Engineering
- Manufacturing
- Sales
- Logistics
- R&D

Team pro-activeness

- This team uses self-starting initiative to make the most of opportunities
- This team engages in future focused action
- This team focuses on preventing problems rather than reacting on them.

Individual characteristics

Skills and Competences

- I find it easy to envision myself in the position of others.
- I am able to make most people feel comfortable and at ease around me.
- It is easy for me to develop good rapport with most people.
- I understand people well.
- I am good at getting others to respond positively to me.
- I usually try to find common ground with others.

- I always seem to instinctively know the right thing to say or do to influence others.
- I have good intuition or savvy about how to present myself to others.
- I am particularly good at sensing the motivations and hidden agendas of others.

Boundary spanning

- I persuade others to support team decisions (e.g. functional departments, senior management, clients)
- I prevent outsiders from 'overloading' the team with too many requests.
- I reach out to individuals outside of your team that can provide project related expertise or ideas
- I absorb outside pressures for the team so it can work free of interference
- I acquire resources (e.g., money, new members, equipment) for the team
- I coordinate activities with external groups
- I scan the environment, inside or outside the organization for marketing ideas/expertise

Team performance

Team outcomes

What are the outcomes of the innovation project?

- The project extends a product range
- The project opens up new markets
- With this project we enter new technological fields
- This project can be regarded as an experiment in our local market
- This project refines an existing product range
- This project improves existing product quality
- This project introduces an improved, but existing project to an existing market.
- This project reduces production costs
- This project improves yield or reduces material consumption

Product quality

In your current product development team:

- In our internal tests, the product performs exactly as it was designed to do.
- The developed products have little probability of malfunctioning in use.
- Performance characteristics of developed products meet the established industry standards.
- Developed product use life meets the required specifications.
- Developed products are reliable, entirely free of errors

Team performance

Rate the performance of the product development team in terms of:

- The quality of the work
- The efficiency with which work is conducted
- The flexibility in dealing with unexpected changes
- Overall performance

Team satisfaction

- All in all I'm satisfied with my team.
- In general I don't like my team.
- I am satisfied with the way I'm treated by my team members.
- I am satisfied with the friendliness of my team members.

Creative output

- Indicate the extent to which the output of the team is creative.
- Indicate the extent to which the output of the team is original and practical.

- The team output shows that the team uses existing information or resources creatively.

Problem solving speed

In your current product development team:

- The project members are fast in defining, finding, and implementing solutions to problems.
- We come up with a large number of alternative solutions for each problem quickly.
- We find and implement the right number of alternative solutions to our problems at the right times.
- For each problem encountered, we are spoiled with the choice of solutions.
- Finding and implementing solutions takes longer than expected.
- Ideas for solving problems are discovered rather late to be useful.

Team Member survey

The survey for team members consists of five parts: General respondent characteristics, project team characteristics, team processes, team leadership and individual characteristics. All questions, except the open questions, have been measured on a seven point Likert scale, ranging from ‘fully disagree’ to ‘fully agree’.

General respondent characteristics

What is your highest level of education? Vocational Bachelor Master PhD

- What is your function title?
- How many members does your team have?
- What is your name? (Note: survey is strictly confidential, results will be made anonymous)
- How long have you worked in this industry?
- How long have you worked for this organization?
- How long have you been a member of this team?

Project team characteristics

Team heterogeneity

- Each team member has specialized knowledge of some aspect of our project.
- I have knowledge about an aspect of the project that no other team member has.
- Different team members are responsible for expertise in different areas.
- I know which team members have expertise in specific areas.
- The specialized knowledge of different team members is needed to complete the project deliverables.

Team climate

- In this team it is considered extremely important to follow the rules
- In this team people can ignore formal procedures and rules if it helps get the job done
- Everything has to be done by the book in this team.
- It's not necessary to follow procedures to the letter in this team
- Nobody gets too upset if people break the rules in this team.
- New ideas are readily accepted in this team.
- This team is quick to respond when changes need to be made.
- Management here is quick to spot the need to do things differently.
- Assistance in developing new ideas is readily available in this team.
- People in this team are always searching for new ways of looking at problems

- This team can quickly change procedures to meet new conditions or solve problems.

Resource availability

- This team has uncommitted resources that can quickly be used to fund new initiatives.
- This team has few resources available in the short run to fund its initiatives.
- We are able to obtain resources at short notice to support new initiatives.
- We have substantial resources at our discretion to funding new initiatives.

Team context

- If you make a mistake on this team, it is often held against you.
- Members of this team are able to bring up problems and tough issues.
- People on this team sometimes reject others for being different.
- It is safe to take a risk on this team.
- It is difficult to ask other members of this team for help.
- No one on this team would deliberately act in a way that undermines my efforts.
- Working with members of this team, my unique skills and talents are valued and utilize

Team discussion

- We talk about different ways in which we can reach our objectives.
- We regularly discuss whether the team is working effectively.
- The methods used by the team to get the job done are often discussed.
- We regularly reflect on the way in which we communicate.
- In this team we modify our objectives in light of changing circumstances.
- The team often reviews whether it's getting the job done.

Social cohesion

- My team has a strong sense of togetherness.
- My team has a unified spirit of excellence.
- My team is a very cohesive unit.
- My team lack team spirit
- Team members are hard to communicate with

Team interdependence

Characteristic for our team is that:

- Goal attainment for one team member facilitated goal attainment for others.
- Success for one team member implied success for others.
- Benefits for one team member involved benefits for others.
- Gains for one team member meant gains for others.

Team process

Coordination

- Our team works together in a well-coordinated fashion.
- Our team has very few misunderstandings about what to do.
- Our team needs to backtrack and start over a lot.
- We accomplish tasks smoothly and efficiently.
- There is much confusion about how we will accomplish the project.

Internal learning activities

- This team takes time to figure out ways to improve the work process
- This team reflects on the team's work progress
- Members of this team speak up to test assumptions about issues under discussion
- Members of this team identify new information leading to changes

External learning activities

- The team gathers information regarding who to contact for advice about how to complete the task
- The team observes the work of others outside the team to extract lessons to be applied to the task
- The team invites people from outside the team to discuss how to avoid repeating past mistakes
- The team often talks to outsiders about past failures to determine ways to improve the work process
- The team often reflects on what has worked in the past together with outsiders with similar experience

Contextual learning activities

- The team finds out what competing firms or teams are doing on similar projects.
- The team scans the environment inside or outside the organization for marketing ideas/expertise.
- The team collects technical information/ideas from individuals outside the team.
- The team scans the environment inside or outside the organization for technical ideas/expertise.

Project presentation

- Care is taken to present a strong link between the product definition and business unit strategy.
- The market for the product is so defined that it appeared consistent with other existing products.
- The product is so defined that its competitive necessity was highlighted.
- Getting this product approved is a big struggle.
- There is reluctance on the part of gate reviewers to approve the product.
- The product encounters a lot of resistance during gate reviews.
- It is quite easy to get this project through the gate review process.
- Other people in the business unit are informally approached to seek their buy-in on the product.
- Support from organizational members is used to convince senior management of the product's potential.
- Support of other people in the company is relied on to show that this would be a feasible product.
- Support of important people in the company is relied on to show that the product can be implemented.
- The product is not exposed to others until it was reasonably developed.
- To increase the likelihood of it becoming a reality, initially the product is kept hidden.
- In order to be approved at gate reviews, the product definition was/is adjusted to satisfy gate reviewers.
- After being approved at gate reviews, the product parameters differed significantly.
- In order to be approved at gate reviews, the product was/is significantly modified to cater to competing demands from various company stakeholders.

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Team leadership

Empowering Leadership

Enhancing the meaningfulness of work:

- My manager helps me understand how my objectives and goals relate to that of the company.
- My manager helps me understand how my job fits into the bigger picture.
- My manager helps me understand the importance of my work in relation to overall firm effectiveness.

Fostering participation in decision making:

- My manager makes many decisions together with me.
- My manager often consults me on strategic decisions.

- My manager solicits my opinion on decisions that may affect me.

Expressing confidence in high performance:

- My manager believes that I can handle demanding tasks.
- My manager believes in my ability to improve even when I make mistakes.
- My manager expresses confidence in my ability to perform at a high level.

Providing autonomy from bureaucratic constraints:

- My manager allows me to do my job my way.
- My manager makes it more efficient for me to do my job by keeping the rules and regulations simple.
- My manager allows me to make important decisions quickly to satisfy customer needs.

Individual characteristics

Skills and Competences

- I find it easy to envision myself in the position of others.
- I am able to make most people feel comfortable and at ease around me.
- It is easy for me to develop good rapport with most people.
- I understand people well.
- I am good at getting others to respond positively to me.
- I usually try to find common ground with others.
- I always seem to instinctively know the right thing to say or do to influence others.
- I have good intuition or savvy about how to present myself to others.
- I am particularly good at sensing the motivations and hidden agendas of others.

Credibility

- I am comfortable accepting procedural suggestions from other team members.
- I trust that other members' knowledge about the project is credible.
- I am confident relying on the information that other team members bring to the discussion.
- When other members give information, I want to double-check it for myself.
- I do not have much faith in other members' "expertise."

Pro-activeness

- No matter what the odds, if I believe in something I will make it happen
- I love being a champion for my ideas, even against others' opposition
- I excel at identifying opportunities
- If I believe in an idea, no obstacle will prevent me from making it happen
- Nothing is as much fun as seeing my ideas become realized
- When I have a problem, I tackle it head-on
- I am always looking for better ways to do this

Team performance

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Team performance (measured on a seven point scale ranging from 'very poor' to 'outstanding')

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