TESTING THE MIRRORING HYPOTHESIS IN THE NPD CONTEXT: AN ANALYSIS OF THE RELATIONSHIPS BETWEEN PRODUCT ARCHITECTURE, NPD TEAM STRUCTURE, TEAM KNOWLEDGE CREATION AND NPD PROJECT PERFORMANCE

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ABSTRACT

Although prior studies increased our understanding of the performance implications of the intra-organizational mirroring effect, they remained confined to certain methodologies. These confined methodologies limits, in essence, any opportunity to involve more variables and observations from a diverse sample of organizations into the analysis of the mirroring effect and to increase the external validity of any results derived from this research. Furthermore, the use of the knowledge creation model in the new product development (NPD) context is also limited. This study therefore broke with the predominant methodology used in this type of research and made use of the knowledge creation model to gain additional insights in the mirroring effect and more importantly, its effects on project performance. Confirming the mirroring hypothesis based on a wide scale of team structural and knowledge creation variables, while examining its effect on project performance formed the primary goal of this research. Based on survey data derived from twenty two managers involved in NPD projects gathered over an equal amount of Dutch manufacturing organizations, hypotheses about whether the mirroring effect was apparent and its effects on NPD project performance were tested. The analysis of scatter plots suggest that teams involved in the development of modular products will display more externalization, combination activities while displaying less socialization and internalization activities than teams developing integral products. For the team structure dimensions it was found that teams developing modular products can be characterized as displaying more team stability, more team member autonomy and make more use of Information Technology (IT) systems when compared to teams developing integral products. The data showed that the effect on project performance changed for separate subgroups based on the modularity of product architecture. This indicates that effects of the knowledge creation variables and team structure variables on NPD project performance are contingent on the modularity of product architecture. This moderating effect of product architecture can have significant impacts on NPD project performance. These findings contribute to the academic discussion of the mirroring hypothesis and NPD team knowledge creation by showing that a change in methodology opens up opportunities to test more diverse variables over a larger sample of organizations. Furthermore the use of the knowledge creation model in the NPD context has shown to yield interesting results in this research and is a promising measure for future research. Practical implications of this research suggests that managers could benefit from monitoring the product architecture of a product under development and facilitate or hinder certain knowledge creation modes and team structure dimensions to improve NPD project performance.

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1. INTRODUCTION

New products form the basis for organizational survival as one-third of the organizations revenue is generated from products which are developed in the last five years (C.-J. Chen, 2007). Organizations thus invest vast resources in order to outperform their competitors through the delivery of qualitative new products. Previous research has highlighted the importance of product architecture in successfully completing New Product Development (NPD) projects as architecture influences product design which in turn affects quality and costs (Eppinger, Whitney, Smith, & Gebala, 1994)(Sanchez & Mahoney, 1996). Here product architecture dictates how separate components are linked together and how they function (Ulrich, 1995).

Scholars have recognized the relationship between product architecture and organizational characteristics of the organization that undertakes the development of the product (Henderson & Clark, 1990)(Sosa, Eppinger, & Rowles, 2004). This essentially is the basis of 'the mirroring hypothesis' which suggests that product architecture will mirror organizational structure (MacCormack, Baldwin, & Rusnak, 2012). In this context organizational structure is defined as the scheme by which the function of an organization is allocated in distinct entities (Colfer, 2007). The reasoning behind the idea that organizational structures will mirror technical dependencies of a product under development is threefold. Firstly, the product architecture dictates where certain technical interdependencies arise in product design. Product architecture can differ in terms of modularity. Here integral product architectures are characterized by the absence of standardized interfaces and high technical interdependence between components. In modular product architecture a standardized interface can be observed without unnecessary technical dependence between components (Ulrich, 1995). Secondly, division of labor dictates whether personnel can work independently from one another and lastly, division of knowledge dictates where knowledge resides in organizational entities and how it is distributed (Colfer & Baldwin, 2010). Intuitively it is clear that these three aspects are differently influenced when dealing with the described different types of product architectures. The direction of this mirroring is unclear and evidence is scattered among studies (Colfer, 2007). Some researchers suggest that organizational structure should follow product architecture (Colfer, 2007) or that organizational structure influences product architecture (Henderson & Clark, 1990). Whichever way the direction of causality may be, meta-analysis has shown that studies find significant support for the hypothesis indicating there is a link between product architecture and organizational ties of 68% at the intra-organizational studies and 47% in the inter-organizational studies sample (Colfer & Baldwin, 2010).

Research examining the mirroring hypothesis considering intra-organizational context tend to focus on the need to align team communication with the technical dependencies of a single New Product Development (NPD) project (MacCormack et al., 2012). Technical communication patterns are compared to the technical dependencies of components of a product under development (Sosa et al., 2004). However in this intra-organizational study, the mirroring hypothesis will be taken outside of this context and subjected to a wider scope. By examining the mirroring hypothesis on project level and taking knowledge creation modes and NPD team structure dimensions as the organizational entity, this study will increase our understanding on the dynamics governing the mirroring hypothesis as more factors than just technical communications od teams are examined. Additionally the empirical research across a variety of NPD teams from development organizations in diverse industries will lead to an increase in external validity of the results and conclusions drawn from them.

As said the knowledge creation model plays an important role in this study as division of knowledge is an integral part of the mirroring hypothesis(Colfer, 2007). This model could help to explain why certain team structure dimensions are important for certain projects as it describes the knowledge creation process in the innovation projects. By examining the four knowledge creation modes; socialization, externalization, combination and internalization, in each product architecture type allows for examination in detail what kind of knowledge is exchanged. Furthermore the knowledge creation model is applicable in the context of NPD as innovation projects are the primarily knowledge creating environments of an organization. The empirical use of this model in innovative context is however limited (Schulze, 2006). Contributors of development projects engage in technical communication to solve development problems or create a shared understanding concerning technical dependencies of components which they develop as was the case of the study of Sosa et. al (2004) where the development of an aircraft engine was examined. In this study it is proposed that this solving of a development problem and engaging in design iterations is better reflected with the use of the knowledge creation model rather than just technical communication as it more aptly describes how knowledge is created and exchanged rather than just passed on to team members. The knowledge creation model is slowly gaining momentum as a measure for knowledge creation in NPD teams and has been validated as a reliable and valid measure in previous research (Schulze, 2006).

The results of this research have several theoretical and practical implications. By adopting a two step approach, where firstly the mirroring effect is established over several team structure and knowledge creation dimensions and secondly it's affect on project performance is analyzed. This provides a richer image rather than if the mirroring hypothesis is examined through the use of analyzing the alignment of just team communication and technical dependency and allows form more accurate managerial recommendations. The importance of team member proximity, team member autonomy, team stability, information technology use and knowledge creation is uncovered, adding to the literature concerning the mirroring hypothesis and solving the apparent gap in literature. Furthermore the use of data from several organizations increases the external validity of this research's outcomes and conclusions. Additionally the use of the knowledge creation model in the context of NPD teams is also relatively new. The effect of the separate knowledge creation modes have never been examined in combination with product architecture and could better portray team members' interaction during a development project.

2. THEORETICAL FRAMEWORK

2.1 Mirroring Hypothesis

Most prominent in the observation that organizations will structure their developing processes in a way that resembles their organizational architecture, Henderson and Clark (1990) started a stream of literature which linked product architecture and organizational structure together. This formed the basis for what became later known as the 'mirroring hypothesis'.

The mirroring hypothesis states that organizational patterns will correspond to the technical patterns of dependency in a system or product under development (Colfer & Baldwin, 2010). In short, an organization's structure will duplicate the product architecture where teams developing integral products will be also structured in a way which can be deemed integral. Alternatively modular products will lead to a modular structuring of teams (Colfer, 2007). The reasoning for following the technical architecture of the product under development is the nature of task interdependencies. In complex NPD projects the design interface is the most important reason for team interdependence (Mihm, Loch, & Huchzermeier, 2003). This leads to the creation of teams whom are concerned with specific components. The two mayor inputs of the mirroring hypothesis are thus technical dependency and team structure.

In the NPD context, the mirroring hypothesis suggests that communication patterns between individuals or teams should line up with dependencies between components in order to share or create knowledge (Colfer & Baldwin, 2010). Management of knowledge associated with architecture of products is an important challenge. It is embedded in the structure of the organization and it is especially difficult to manage in complex product development due to the large number of components and employees involved (Sosa et al., 2004).

Many scholars have focused on the relationship between technology and organizations in various fields such as strategy, innovation management and economics. Results suggest that technical interdependencies and thus task interdependencies, require changes from the organization concerning its structure and communication channels (Hao, Feng, & Frigant, 2015). The organization thus has the option to adapt team structure to product architecture or to adapt product architecture to team structure. As NPD projects are primarily executed by cross-functional NPD teams facing the need to solve design problems and thus simultaneously create knowledge , this research will therefore focus on the relationship between product architecture, NPD team structure and the knowledge creation model, where other studies only examined the technical design and the explicit coordination relationship of product architecture and technical communication (Hao et al., 2015).

As said the direction of causation of the mirroring effect is not unanimously accepted as it was believed that when the product architecture was clear from the beginning of the development project, product architecture would dictate organizational structure. This is however a rarity in most cases so an organization would design the product around its own structure where product architecture is thus likely a result of organizational structure (Colfer & Baldwin, 2010). Recent studies however favor the direction of causality where product architecture will dictate organizational structure. The reasoning focuses on the fact that problem solving and knowledge exchange relies on the potential solutions for the product under development which does not consider organizational boundaries (Sorkun & Furlan, 2016).

Typically the mirroring hypothesis is tested by examining the overlap of communication patterns of organizational forms and technical dependencies of a product under development (MacCormack et al., 2012). The reasoning behind the importance of communication is the interdependence of components. When dealing with complex integral development projects a change in one component is almost certain to incur an adjustment of components who are connect with the changed component (Ulrich, 1995). These interdependencies need to be addressed between contributors of a development project by means of communication. Only few researchers deviate from this methodological setup when examining the mirroring hypothesis within an organization. For example a study researched the difference in product architecture of software products developed by different organizational forms (commercial organizations versus open-source communities) (MacCormack et al., 2012). Another inter-organizational study examined the relationship between technical modularity and tacit inter-firm coordination (Hao et al., 2015).

This research is another attempt to deviate from the prevailing methodology to gain a richer understanding in the dynamics governing the mirroring hypothesis. This study therefore aims to give some insights in the mirroring hypothesis by explaining the connection of product architecture, NPD team structure, team knowledge creation and project performance. Hypothesizing, that team structures and team knowledge creation activities differ when examining the type of architecture of the product innovation pursued as knowledge needs and division of labor intensity differs. The knowledge creation model offers new insights in how knowledge is shared and created within the team. Furthermore this study feels that the knowledge creation model more aptly describes the interaction between team members as their information exchanges result in the creation and exchange of knowledge.

Evidence of the positive effect of mirroring on project performance, is scattered and limited across studies in diverse fields (Colfer & Baldwin, 2010). Previous research has shown that misalignment of product architecture and organizational structure during NPD projects lead to more warranty claims, indicating product quality problems (Gokpinar, Hopp, & Iravani, 2010). Additionally unmatched product architecture and organizational communication leads to unforeseen design iterations and even disassembly of assembled products. This increased project duration and costs (Sosa et al., 2004).

There are also some exceptions when mirroring of the product architecture and organizational structure does not occur. In some cases richly communicating NPD team developed a product with a highly independent architecture. The explanation for this contradiction lies in the fact that this team did adhere other aspects of modular architecture such as information hiding and design rules that further cement independence between components (Colfer & Baldwin, 2010). Another exception was found where independent and geographically dispersed contributors to a development project delivered a product with highly integral product architecture. Here it was found that active effort was made to create a shared understanding of the project, there was a protective atmosphere and there were no conflicts of interests. Furthermore the project was transparent and all members of the NPD team could contribute to the project at any time from any location due to sophisticated IT-systems. This reduces the need for traditional face-to-face communication and could thus mirror the artificial integral organizational structure, resulting in a integral product structure (Colfer & Baldwin, 2010).

2.2 Product Architecture

An important aspect of the mirroring hypothesis is naturally product architecture as it is portrayed as one side of the mirror. Product architecture can be defined as the schematics of a product which dictates how functions are generated by the different components (Ulrich, 1995). Product architecture provides the basis for partitioning the development tasks needed to be executed. It is therefore used as a tool to determine the optimal partitioning of structure of the organization that develops it (Sanchez & Mahoney, 1996)(Henderson & Clark, 1990).

Modularity is a special form of product architecture which seeks to partition a product in completely functionally specialized units which operate as independently as possible. This in turn creates the possibility to easily remove or replace these units or modules. An important aspect is the standardized interface to which modules connect (Colfer, 2007). This standardized interface creates an one-to-one mapping of modules (Meyer & Utterback, 1992). This standardized interface is not permitted to change over a period of time. This control of output of design activities provides a form of information structure encouraging separation of organizational structure allowing component developers to complete their tasks without explicit managerial control (Sanchez & Mahoney, 1996).

Modular product designs offer significant advantages. The easily separation of modules allows organizations to quickly introduce new products and adjust product qualities to specific markets tastes. This type of interface allows for fast and easily upgrade of products. All of these improvements can be made with shorter lead times and at a significantly lower costs (K. M. Chen & Liu, 2005). Considering innovation, modularly designed products are usually developed faster. This can be explained as modular product architecture allows for concurrent development of components and learning. In this process separate components are developed at the same time, where in comparison the traditional sequential process requires some components to be developed before development of the other components can start (Sanchez & Mahoney, 1996). Furthermore the mirroring hypothesis states that organizational entities are highly independent, narrowly specialized, and like the components in the modular product architecture, easily replaced (Schilling & Steensma, 2001).

Products can also feature an integral architecture, which sharply contrasts the properties of the modular product design. Typical integral product designs feature multi-functional components which subsequently have many ties with other components. The one-to- one mapping in modular product architecture is therefore not applicable. These products require a NPD team to communicate more frequently and work in co-located situations to ensure adequate performance of the developed products (Ulrich, 1995). In light of the mirroring hypothesis it is stated that these kinds of integral products require an integral organizational structure (Colfer, 2007).

Product modularity is applicable on three levels. On component level, where the modularity of a single component is assessed. on sub-system level where modularity of a sub-system is analyzed and on final product level where the technical dependencies of the final product is described (Sorkun & Furlan, 2016). This research focuses on product modularity on final product level as this is the output of NPD projects. To call a product modular in its architecture it must adhere two key characteristics. The components are coordinated through standardized interfaces and each component performs purely one function (Ulrich, 1995). In practice it is seen that truly modular or truly integral product architectures are rare and are positioned on a continuum where modular and integral architectures form the extremes on opposite ends of the continuum (Colfer, 2007). Such a measure is ultimately used in this research, to measure modularity of product architecture.

2.3 Development Process

The modular architecture allows for easy partitioning of the complex development project in smaller and easier to cope with sub-problems. The development process as a whole is also easier to split among NPD team members as the architecture emphasizes minimal dependency. The dividing of development tasks in turn fosters parallelism. Several components can be developed concurrently or in parallel as contributors do not depend on knowledge from other contributors which makes them highly independent (Parnas, 1972). When dealing with the development of products with a modular architecture the concept of information hiding becomes important (C. Baldwin, 2007). This design rule states that separate developers should avoid sharing assumptions. As each component is developed separately and performs a different specialized function, sharing of knowledge is not needed and could even be detrimental to product performance (C. Baldwin, 2007). Guiding the interaction between components is the standardized interface which characterizes the modular product architecture (Colfer, 2007). In short the modular product architecture reduces complexity of the development of the product by creating smaller sub-problems. Furthermore it makes portioning and coordination of these sub-problems over a NPD team easier. Partitioning design tasks is needed, as individuals are limited in their ability to fully comprehend large design decisions and the potential outcome of these decisions (Simon, 1973).

Interdependencies between components need to be addressed and effectively communicated across the NPD team. This explains why researchers concerned with the mirroring hypothesis tend to focus on communication patterns in the within-firm study sample. By reducing the need of communication through standardization, the problem of frequent component change is solved. Alternatively organizational structures can change by improving communication through co-location (Colfer & Baldwin, 2010). Alternatively formulated the knowledge and information processing structure of the organizational entity should mirror the internal structure of the product underdevelopment (Henderson & Clark, 1990).

Products with an integral product architecture thus require face-to-face communication, physical co-location and formal authority to coordinate interdependencies of such architecture and complex design problems associated with it (Colfer & Baldwin, 2010)(Sanchez & Mahoney, 1996). The lack of the opportunity to partition the development project in smaller sub-problems in the development of products with an integral product architecture means that the concurrent and overlapping design process of modular product designs is not an option. This further reinforces the need for co-location and frequent communication as design tasks are interdependent (Sanchez & Mahoney, 1996).

2.4 Organizational Structure

The other side of the mirror is the organizational structure. Organizational structure reflects how organizational entities are located and if a clear distinction can be made between them. This research takes cross-functional NPD teams as the organizational entity as NPD projects are primarily executed by such teams.

Organizations can be viewed as complex systems comprised of various elements with different degrees of coupling between them (Orton & Weick, 1990). Organizational coupling can be analyzed on many facets, which fall in three broad categories; goals, structure and behavior. Where organizational structure can be further divided in membership, autonomy and location (Orton & Weick, 1990). These separate dimensions represent a continuum measuring the degree of coupling between participants. On one end of the continuum lies tightly coupled organizational forms with shared and explicit goals, closed membership, formal authority, co-located members and planned behavior. On the other end of the continuum loosely-coupled organizational forms can be uncovered characterized by diverse goals, open membership, informal authority, decentralized located members and emergent or independent behavior of participants (MacCormack et al., 2012). This distinction between tightly coupled and loosely coupled organizational forms reflects the distinction between integral and modular organizational forms (Colfer & Baldwin, 2010).

The degree of organizational coupling is easily translated to NPD teams and shows some similarities with established theories concerning NPD team structures. The research on team structures is relatively refined, where the research of Clark and Wheelright is most renowned (Clark & Wheelright, 1992). This paper describes four dominant team structures executing development projects. These structures can be described as functional, lightweight, heavyweight and autonomous teams. These teams differ in their location, degree of autonomy and degree of specialization. Here a one-dimensional scale is suggested with functional team structures at one end of the continuum and autonomous teams at the other end of the scale. Lightweight and heavyweight teams are situated in between these extremes (Clark & Wheelright, 1992).

This research however suggests that in reality different innovation types might be performed by teams that display some elements of typical heavyweight or autonomous teams and some elements might be taken from lightweight or functional teams. The fit between a one-dimensional approach of structure and product architecture might therefore not yield significant statistical results. This multidimensional approach will focus on the structural characteristics of organizational coupling; team membership, autonomy, location (MacCormack et al., 2012).

2.5 Depicting Team Structure

This multidimensional approach will focus on characteristics deemed important to discriminate between integral and modular structures and relate to the structural elements of organizational coupling of organizational entities and will therefore define team structure as; team member stability, team member autonomy and team member proximity (MacCormack et al., 2012)(Clark & Wheelright, 1992).

2.5.1 Team Member Proximity

Team member proximity might differ among NPD teams as the product architecture of the product under development differs. In increased complexity and uncertainty situations in certain innovation projects might require in-depth knowledge transfer and refinement which only physically co-location might provide (Nonaka, 1994). On the other hand, in situations where development activities can be divided in separate tasks without a high degree of interdependence, co-location might not be as important in influencing development projects success. Research is divided in the effect of team member proximity on project performance and no real link has been found between the type of innovation and the effect of team member proximity on NPD project performance (Kim & Kim, 2009).

2.5.2 Team Stability

Team stability's importance has been proven in several studies, as team member turnover disrupts the functioning of a team due to a reducing knowledge pool from which members can draw (Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005). Team member stability therefore influences NPD project success. This is however only the case when dealing with the development of products with a integral product architecture. This research suggests that team member stability would depend on knowledge needs of the project at hand. More fluid participation is expected when dealing with NPD projects which are characterized by low task interdependence and concurrent development process.

2.5.3 Team Member Autonomy

Autonomy can be defined as the degree of freedom and independence a NPD team member is given in setting their tasks, rules and even budgets (Carbonell & Escudero, 2011). Team member autonomy is considered to be positively related to NPD project performance. Outcomes and procedures cannot be clearly set by management and a NPD team member requires the autonomy to coordinate activities, tasks and resources to complete independent design tasks based on decentralized decision making to improve project efficiency and flexibility (Carbonell & Escudero, 2011). Greater autonomy also signals a sense of importance to the development project (Nakata & Im, 2010).

2.6 Knowledge Creation Model

2.6.1 The SECI Model

Knowledge embedded in cross-functional New Product Development (NPD) teams needs to be leveraged in order to achieve its project goals (Slotegraaf & Atuahene-Gima, 2011). It is widely accepted that product development is a highly knowledge intensive process where knowledge is created, stored and reshaped (Söderquist, 2006). This forms the basis to deviate from traditional mirroring hypothesis methodology and focus on the mirroring effect of product architecture on team structure dimensions and knowledge creation modes rather than just technical communication.

This research relies on the knowledge creation model in order to explain how the division of knowledge influencing the mirroring hypothesis. The reasoning for this is that division of knowledge takes up an important place influencing the mirroring hypothesis as NPD is a knowledge intensive process (Colfer & Baldwin, 2010).

The knowledge creation model or SECI model was first developed in Japan and featured a framework explaining knowledge creation (Nonaka, 1991). The model dictates that knowledge can be composed of two dimensions tacit and explicit. The tacit knowledge is based on experience, thinking and feeling and is highly context specific. The explicit dimension is knowledge which is codified in tangible objects or procedures (Nonaka, 1994) (Popadiuk & Choo, 2006). The knowledge creation model describes the transition of tacit knowledge to tacit or explicit knowledge and the transition of explicit knowledge to explicit or tacit knowledge as can be seen in figure 1 (Nonaka, 1994). The transition between the knowledge dimensions were defined as Socialization, Externalization, Combination and Internalization (SECI). Completing these knowledge transitions would allow for knowledge creation to occur in an organization (Nonaka, 1991).

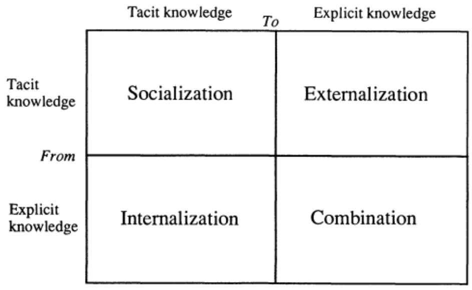

Figure 1: The knowledge creation model (Nonaka, 1994, p.19)

In the SECI model, socialization is seen as a method to transfers tacit knowledge to tacit knowledge. Socialization features joint activities with various actors which lead to shared experiences. Meetings are informal, fostering trust. Knowledge is captured through interaction with customers, suppliers or colleagues (Nonaka, 1994). Socialization furthermore stimulates knowledge creation and sharing as in a social context ideas are refined and discussed (Becerra-Fernandez & Sabherwal, 2001). Externalization transfers tacit knowledge to explicit knowledge. In the externalization mode knowledge is crystallized and can be shared through visual aids or metaphors (Nonaka, 1994). This knowledge creation mode also captures knowledge and is an important knowledge creation process, due to the exchange of tacit knowledge into explicit knowledge which additionally makes it sharable (Karim, Razi, & Mohamed, 2012). Combination transfers explicit knowledge to explicit knowledge. In this mode knowledge is reconfigured by categorizing and combining tangible knowledge sources such as documents. In this stage knowledge can be disseminated (Nonaka, 1994). Internalization transfers explicit knowledge to implicit knowledge. Internalization mode ensures knowledge is captured in individuals mental models (Nonaka, 1994). Internalization allows explicit knowledge to be used in specific situations. Internalization is also seen as learning as explicit knowledge is assimilated in a individuals knowledge base, creating tacit knowledge (Karim et al., 2012).

The SECI processes of knowledge creation are seen as the mechanisms not only for knowledge creation but also for knowledge sharing. SECI model encompasses thus not only knowledge creation but also knowledge sharing dimensions (Becerra-Fernandez & Sabherwal, 2001). The study of Darroch (2003) in fact uses the SECI model to explain knowledge dissemination or sharing in organizations (Darroch, 2003).

2.6.2 The SECI Model in NPD Context

As product innovation is a collective effort relying on a NPD team, knowledge creation and sharing is quite important. Especially since the NPD process draws from existing knowledge basis and simultaneously creates new knowledge as the NPD project continues. Existing knowledge needs to be retrieved while new knowledge needs to be validated (Söderquist, 2006). In this context the socialization dimension of the SECI model fulfills the creating and validating roles needed. The knowledge creation model is gaining momentum in research concerning NPD context and is validated as a reliable measure for team level of knowledge creation (Schulze, 2006). Knowledge ambiguity comprehends uncertainty on specification of the underlying knowledge components and sources, and their interaction. It is closely related to tacitness. Knowledge ambiguity therefore hampers knowledge transfer (Van Wijk, Jansen, & Lyles, 2008).

Knowledge dissemination includes knowledge transfer and sharing. The distinction between tacit and explicit knowledge becomes again important as in knowledge transfer explicit knowledge is transferred through formal communication channels (IT-systems). Knowledge transfer is quite fast due to its low ambiguity (Söderquist, 2006). The combination and internalization processes allow explicit knowledge to be extended and allows for transfer of this knowledge to individual team members. The rules are clear to all participants which is not the case with tacit knowledge sharing. Knowledge sharing however is a social process where explicit en tacit knowledge dissemination through inter-personal interaction, cognitive models can be shared. An important influence to organizational knowledge transfer is knowledge ambiguity.

This means the sharing of tacit knowledge is only facilitated by socialization and that it is highly context specific. Tacit knowledge is shared and created when participants come together and when people learn by doing. This indicates that tacit knowledge is only created when people perform non-routine tasks (Söderquist, 2006). Creating a shared mental model and using metaphors allows for the externalization process to take place which makes tacit knowledge explicit.

When viewing the NPD process in separate stages, it becomes clear that all knowledge creation modes are addressed. In the planning stage knowledge will reside in the functional groups and this tacit knowledge is only shared when team members work together. This socialization mode enables refinement, sharing and creation of tacit knowledge. Formalization of the product idea is however still necessary (Chang, Tsai, & Tsai, 2011). Socialization furthermore embodies the people component which is important for each knowledge creation mode (Esterhuizen, Schutte, & Du Toit, 2012). In the development stage formalized concepts are turned into prototypes. Tacit knowledge is made explicit following the externalization mechanism (Chang et al., 2011). The shared cognitive model of the team has now become explicit and can be transferred. The marketing stage marks the beginning of the combination mode where knowledge from the different departments is brought together through formal mechanisms (Chang et al., 2011).In the commercial stage internalization takes place as team members learn from explicit sources turning explicit knowledge into tacit knowledge (Chang et al., 2011). This again creates knowledge at the individual level by transferring explicit knowledge. Through internalization an organization can provide access to institutionalized knowledge (Esterhuizen et al., 2012).

2.7 IT-systems and Knowledge Creation

The fact that widely distributed team members could develop a project with an integral product architecture due to the ability to have an overview of the development project, access to all information and the ability to communicate frequently through digital communication channels, suggest that IT-systems usage is an important factor in knowledge creation and sharing. The internet, e-mails and teleconferencing are a few tools available to NPD team members to store information or communicate. These tools help to acquire and share information throughout the NPD team (Akgün, Dayan, & Di Benedetto, 2008). The ability to quickly access all knowledge and information concerning the development project naturally improves NPD project performance.

2.8 NPD Project Performance

The mirroring hypothesis suggests that a team's structure will match the structure of the project (MacCormack et al., 2012). This indicates that the importance of team structural elements could differ in importance in influencing NPD project performance. This study measures relative NPD project performance on a product dimension and market dimension. Furthermore project efficiency is examined. These are relative performance measures which allows for the examination of effect of team structures on NPD performance given the different types of innovation projects concerning their product architecture (Salomo, Weise, & Gemünden, 2007).

3. HYPOTHESES

3.1 The Effect of Product architecture on Team Structure

Based on the properties of modular and integral product architectures it is clear that some structural differences will occur within comparing teams developing these products as is the basis for the mirroring hypothesis. Based on technical interdependencies between components and the size of the development problems these teams encounter it is expected that task interdependencies and uncertainty differ. Task interdependence entails the degree organizational members depend on each other to complete their tasks (Savelsbergh, Storm, & Kuipers, 2008). Here task interdependency degree affects employee dependencies, which subsequently influences the coordination requirements needed to achieve organizational performance outcomes. Studies have shown that task interdependence increases communication and information sharing among employees (Savelsbergh et al., 2008). A fundamental aspect of the mirroring hypothesis, technical dependencies will lead to task dependencies between team members developing different components (Colfer & Baldwin, 2010).

Task interdependence can even be seen as the driving force that promotes shared responsibility and lead to team learning (Piet Van den, Wim H., Segers, & Kirschner, 2006)(Wageman, 2016). Next to task interdependence, uncertainty is an important predictor of communication intensity. Large complex tasks generally are typically characterized by high uncertainty concerning performance outcome and tasks needed to be executed. This requires increased interpersonal contact to resolve these uncertainties (Albano & Suh, 1994).

Furthermore the design process of the two product architecture types, integral and modular architecture, is also expected the differ as the first relies on the more sequential design process where the latter offers an opportunity for a more concurrent design process (Sanchez & Mahoney, 1996).

3.1.1 Integral Product Architecture

Integral product architecture is characterized by its high connections between components due to lack of standardized interface. In this case there are no clear design rules which dictate how a product should look like and to which specifications the design should adhere (Ulrich, 1995). The lack of separation of the large design task in smaller sub-problems results in a design task with high uncertainty and high technical interdependence between components typically designed in a sequential design process (Colfer & Baldwin, 2010).

To cope with these high uncertainties and task dependencies team structures move to a tightly coupled structure for their teams featuring high team stability, close team member proximity and low team member autonomy. High uncertainty in architectural innovation requires a lot of direct communication, fostering socialization (Magnusson, Lindström, & Berggren, 2003). As interface specifications form the output of products with a integral product architecture intensive managerial coordination is needed reducing team member autonomy (Sanchez & Mahoney, 1996). The product architecture is effectively evolving as the project moves along (Sanchez & Mahoney, 1996).

The high uncertainty connected to scope of the design task leads to high task interdependencies eliminating the chance for division of tasks. NPD teams are traditionally chosen to tackle complex design tasks as they require on face-to-face communication, physical co-location and low team member autonomy and information technology usage to coordinate highly interdependent tasks (Colfer & Baldwin, 2010). Research has shown that when task interdependencies are strong the knowledge needs and information requirements increase. This will in turn lead to greater team interaction, again fostering socialization (Loch, Christoph ; Tierwiesch, 1998).The high task interdependence and uncertainty indicates that such teams will most likely depend on a sequential development process rather than a concurrent one, increasing the importance of team stability (Sanchez & Mahoney, 1996).

As earlier indicated it is believed that NPD teams complete the whole knowledge creation cycle during the course of the NPD project. However this research assumes some knowledge creation modes may be more important than others given product architecture in NPD projects. In terms of the knowledge creation model the high knowledge needs and tacit nature of this knowledge makes it most likely that NPD teams concerned with development of products with an integral architecture will rely on socialization and externalization. Socialization is needed to form common ground, share mental models and generate new knowledge which is subsequently refined (Nonaka, 1994). Communication is very important in the context of NPD projects. Communication drives knowledge from diverse sources through the team. This knowledge is subsequently transformed in a product strategy or product design (Leenders, Van Engelen, & Kratzer, 2003). This reduces uncertainty. These new parts of tacit knowledge can be shared throughout the NPD team by making them explicit using the externalization creation mode. This crystallizes the new information further (Nonaka, 1994).

3.1.2 Modular Product Architecture

Products with a modular architecture start with a set of design rules where most of the product architecture is known. The one to one mapping of components results in components to have an isolated effect when changed, as changes in a component will not alter the component interface(Ulrich, 1995). This reduces project uncertainty allowing for formal planning in modular innovation where individual specialists solve their own problems. This modular design reduces task interdependencies (Salvador & Villena, 2013). This allows for concurrent development instead of the sequential development stages used in development of products with an integral product architecture (Sanchez & Mahoney, 1996). Concurrent engineering has led to lower costs while achieving higher quality knowledge creation and shorter development times (Valle & Vázquez-Bustelo, 2009). This concurrent design process has an impact on team structure as these teams will depict lower levels of team member proximity, team stability and higher levels of team member autonomy and information technology usage, due to technical interdependence of components, task dependence and knowledge dependence.

Research has suggested that with increased uncertainty en complexity, concurrent engineering will not lead to reduced development time and product quality in highly uncertain innovation projects and this could explain why this development process is not beneficial when developing integral products. It is thought that complexity and uncertainty causes problems concerning communication, integration and rework. These problems will lead to inefficiencies decreasing project performance (Valle & Vázquez-Bustelo, 2009).

Modular product architectures create furthermore information structures that do not require excessive coordination. The parts are most likely loosely coupled where product interfaces dictate how components should come together. These standardized component interfaces provide the embedded coordination needed to ensure project success. The lack of need for authority allows for independent development of components and increases team members autonomy (Sanchez & Mahoney, 1996).

The increased distance and independent nature of design tasks of teams dealing with the development of modular products suggests they rely on the creation and sharing of explicit knowledge. This suggests that these teams will rely more heavily on combination and internalization knowledge creation activities. The effect of using standardized components reduces the need for face-to-face communication and thus socialization activities. Scholars have argued that due to the technical modularity a self sustained coordination mechanism is created, making explicit and ongoing communication unnecessary (Sanchez & Mahoney, 1996). It is expected that these teams will rely more on IT-systems to overcome the distance between team members.

The premise of this research is that team structure and knowledge creation dimensions will differ for teams completing different types of NPD projects given the product architecture, as the division of knowledge, division of labor and development process differ in each type of innovation project. The mirroring hypothesis relies heavily on the division of knowledge and division of labor to explain why structural dimensions follow project characteristics (Colfer & Baldwin, 2010). For modular product architectures the low task interdependencies allow for decentralized decision-making in this type of innovation (Sanchez & Mahoney, 1996). This reduces the need for communication and co-location of team members. The way modular products are developed suggests that team membership is more fluent in these kinds of teams, reducing team stability. When design tasks are completed for separate components, team membership within the NPD team is no longer needed as design tasks are more independent.

In terms of the knowledge creation model, it is expected that product development with this kind of product architecture relies more on explicit knowledge sources. This indicates that internalization can play an important role. The separation and concurrent engineering of development tasks requires a form of integration when the project is finalized. This could be done with the combination creation mode where explicit knowledge sources are combined. The lack of co-location and face to face communication due to low technical interdependence will lead to a decrease for the need of socialization and externalization knowledge creation modes.

Thus to provide evidence for the presence of the mirroring effect stated by the mirroring hypothesis, the first hypothesis is stated as follows;

Hypothesis 1: *NPD teams completing a NPD project with a modular product architecture feature higher degrees of combination and internalization, team member autonomy, IT-systems usage and lower degrees of socialization and externalization, team stability and team member proximity than NPD teams completing a NPD project featuring an integral product architecture.*

3.2 The Impact of the Mirroring Hypothesis on NPD Project Performance

The knowledge creation model is important in the context of the mirroring hypothesis, given the prominent place division of knowledge has in generating mirroring effect. The independent knowledge creation modes should thus be included to complete the analysis of the mirroring hypothesis.

3.2.1.1 Knowledge Creation Modes and NPD Project Performance.

Socialization, externalization, combination and internalization can be seen as beneficial to project performance as this process is needed to create and disseminate new knowledge through the team (Chang et al., 2011). However based on the characteristics of each innovation type we can hypothesize that given product architecture of a product under development, certain knowledge creation modes become more important.

Given the characteristics of these products with a modular architecture, it is clear that internalization and combination of this knowledge creation mode are important as they predominantly rely on explicit knowledge. The separated design tasks are more explicitly shared rather than tacitly. Combination is especially important as products are improved by adding to the explicit knowledge base (Chang et al., 2011). Socialization and externalization should be hinder increase in project performance as the active search and discussing of new knowledge can harm project efficiency as resources are dedicated to redundant alternatives. Furthermore it would hamper with design rules as knowledge hiding which could lead to sharing of assumptions, increasing redundant technical dependencies between components (Ulrich, 1995). In the development of products with integral product architecture, this relationship is reversed as the need for information sharing about components changes reduces the reliance on explicit knowledge sources and active socialization is needed to uncover technical dependencies. Once uncovered these technical dependencies steer interactions between team members by utilizing socialization and externalization, to guide design iterations between components and modules. When dealing with products with an integral architecture, we would expect a heavy reliance on socialization and externalization as there is a high degree of uncertainty when developing interface specifications for different modules. Extensive socialization is expected to deal with these uncertainties. Once these interfaces are clear these need to be communicated effectively throughout the team using externalization processes. In modular innovation it is the fact that the high division of labor and active information hiding which would suggest that there is no reliance on socialization and externalization.

These differences between the development of products with the two distinct product architectures would indicate that product type moderates the influence of socialization, externalization, combination and internalization on project performance which leads to following hypotheses;

Hypothesis 2a: *The positive impact on project performance from socialization will be greater for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

Hypothesis 2b: *The positive impact on project performance from externalization will be greater for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

Hypothesis 2c: *The positive impact on project performance from combination will be smaller for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

Hypothesis 2d: *The positive impact on project performance from internalization will be smaller for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

3.2.1.2 Team Stability and NPD Project Performance

Team stability is positively associated with project performance as team members are seen as units which contain information (Akgün & Lynn, 2002). When team members are removed from the team, knowledge available to the team is lost. Intuitively this suggests that product development projects where there is little reliance in tacit knowledge sources, this relationship is not as important for NPD project performance. This would indicate that development projects dealing with products displaying modular product architecture are less affected by this relationship than NPD projects developing products with an integral architecture. This leads to the following hypothesis;

Hypothesis 3: *The positive impact on project performance from team stability will be greater for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

3.2.1.3 Team Member Proximity and NPD Project Performance

Team member proximity has also been the focus of mirroring hypothesis research in examining overlap with technical patterns of dependency (Colfer & Baldwin, 2010). Close team member proximity is known to have a positive impact on communication within a team which in turn increases NPD project performance. Research has shown that the tendency to communicate tends to increase when the distance between individuals is reduced (Bulte & Moenaert, 1998). This in turn increases trust and cohesion within a team (Bulte & Moenaert, 1998). Innovation projects which deal with high uncertainty will rely on explorative processes and will thus benefit from close team member proximity. Also the nature of task interdependence plays an important role. When tasks are highly interdependent they most likely will require a collocated team, due to the ambiguity associated with task interdependence (Söderquist, 2006). In situations tasks are easily divided and team members can operate concurrently, the effect of this relationship will be less important. Close team member proximity could also hamper with design rules such as knowledge hiding and the avoidance of assumption sharing. This could be detrimental to NPD project performance where products with a modular architecture are being developed. The situations portrayed resemble the challenges of NPD teams dealing with the development of either integral or modular products. This leads to hypothesis four;

Hypothesis 4: *The positive impact on project performance from team member proximity will be greater for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

3.2.1.4 Team Member Autonomy and NPD Project Performance

Team member autonomy is an important antecedent for project performance as it allows the NPD team members to make decisions based on local information, instead of waiting for senior management to make a decision based on centralized information which reduces project speed and flexibility (J. Chen, Damanpour, & Reilly, 2010). Team member autonomy is very contingent on the type of product development project executed. In NPD projects dealing with integral product architectures there is no clear independence between components which reduces the autonomy of team members. This calls for the need for active managerial control as the product architecture does not offer a substitution (Sanchez & Mahoney, 1996). In the development of products with a modular product architecture contributors are relatively free to complete their design tasks associated with their components as there is a low technical dependence between components created by the standardized interface (Ulrich, 1995)(Sanchez & Mahoney, 1996). This leads to hypothesis five:

Hypothesis 5: *The positive impact on project performance from team member autonomy will be smaller for NPD projects regarding the development of products featuring integral product architecture than for NPD projects regarding the development of products displaying modular product architecture.*

3.2.1.5 IT-system Usage and NPD Project Performance

Information technology systems play an important role as they facilitate supporting and reinforcing knowledge management practices. It allows for the retrieval of information from every location and facilitates communication. For this reason the intensity of IT-usage positively influences NPD project performance (Akgün et al., 2008).

Product architecture is likely to have a moderating effect on this relationship as in integral product architectures the tacit nature of the knowledge needed to be exchanged between team members, does not allow this knowledge to be exchanged through the use of IT-systems. IT-systems are primarily used to exchange more explicit knowledge. In terms of NPD performance, IT systems play an important role as with modular project architectures the result of separate design tasks need to be integrated into one product. IT-systems play an important role in this process. Furthermore distributed teams rely on IT-systems for communication as this is likely to be the only viable option for swift and frequent communication. This is likely to positively influence NPD project performance. This leads to hypothesis six;

Hypothesis 6: *The positive impact on project performance from IT-system usage will be greater for NPD projects regarding the development of products featuring modular product architecture than for NPD projects regarding the development of products displaying integral product architecture.*

The research model concerning the hypotheses dealing with NPD project performance and the moderating effect of product architecture, consists thus of the variables relating to team structure dimensions, knowledge creation modes, NPD project performance dimensions and product architecture. A visual representation can be found in figure 2.

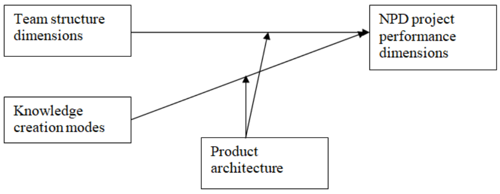

Figure 2: Research model

4. METHODOLOGY

The research design can be classified as cross-sectional, where data is collected using questionnaires at a specific point of time. Prior to data collection, organizations were informed of the goal of the research and confidentiality and anonymity was stressed.

Data was collected among organizations situated in technology-intensive manufacturing industries where product design activities were undertaken in the Netherlands.

The generation of the sample followed a similar approach to the Community Innovation Survey performed by the governmental organization CBS. This research included all organizations registered by the chamber of commerce with two hundred employees or more. Research has shown that organizations with a large amount of employees are most likely to generate new products relative to smaller organizations and in the same industry. Furthermore these organizations are most likely to perform these innovative activities within the company rather than outsourcing these design tasks (Meinen, 1998). This is most likely due to the fact that these organizations have more resources available to invest in their innovative activities. This research took a 150 personnel cutoff point as this ensures that startups are excluded which usually do not possess a formalized innovation process (van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009). To include only innovations suitable to this research (innovations generating physical products which are composed of several parts to indicate modularity of product architecture) this research focused on organizations operating in industries defined by the Standard Industry Classification (SIC) code in divisions A, B, C, D and E. This yielded a sample of 2044 organizations. Further scrutiny where only organizations were selected that were still in business and who manage their product development projects from the Netherlands produced a sample of 184 organizations. These organizations were contacted and asked to fill out the questionnaire keeping in mind a development project completed within the past five years. Prior to data collection, organizations were informed of the goal of the research and confidentiality and anonymity was stressed (Schulze, 2006). Respondents were explained that there was no wrong or right answer to avoid satisfaction bias (Hao et al., 2015).

Respondents were contacted through company email addresses listed on their websites and directly through the use of LinkedIn. Respondents were given an anonymous link which lead respondents to the interactive version of the questionnaire, generated by the survey program Qualtrics. This program documented the answers of the respondents and was used to extract the SPSS file for further analysis.

Ultimately data collection yielded a sample of 22 respondents, this is a response rate of 11,96%. The mean age of respondents in this sample was 44 years, average tenure was 10 years. This sample consisted predominantly of males, where most of the respondents were associated with the R&D department. Occupation of the respondents varied between directors of R&D, vice presidents of engineering, R&D managers, project managers and product managers. Questions concerning the NPD projects answered by the respondents showed that average project duration was 24 months and mean team tenure was 20 months. Average team size of this sample was determined to be 13.

In order to test for any response bias, in particular non-response bias, the time trends extrapolation method was used. This method assumes that late respondents are the same as non-respondents (Armstrong, 1977). We can conclude that there is no non-response bias when the results of various variables do not significantly differ between the subgroups early and late responders (Armstrong, 1977). This analysis showed that only for the variable Socialization of the knowledge creation modes and product dimension and market dimension of project performance, there was a significant difference. So there are some reliability issues when dealing with these variables. Furthermore the low response rate of 11,96% could further hamper the external validity of the results of all variables.

Analysis of outliers using the Inter Quartile Range (IQR) rule showed no outliers were present in all the variables(Hoaglin, Iglewicz, & Tukey, 1986).

4.1 Dependent Variables

4.1.1 NPD Project Performance

This study focuses on the examination of the effect of team structure and knowledge creation on project performance. In order to measure project performance a measure was adopted from Salomo, Weise and Gemünden (2007), which analyses NPD project performance on three dimensions. These dimensions are product dimension, market dimension and project efficiency, each construct containing three items measured on a seven-point likerts scale (Salomo et al., 2007). A principal component factor analysis showed some where all items were included showed that three factors were present, the items however did not load as expected. The last product dimension performance measure showed a higher factor loading on project efficiency dimension for example. Subsequent reliability analysis showed that product dimension would benefit from including only the first two items in the construct and yielded a Cronbach's alpha of 0.630, this suggests that this measure is not as reliable as desired. For the market dimension, again the first two items were included and yielded significant reliability of 0.939. For the dimension of project efficiency all measures were included. The reliability analysis of this three item construct generated a Cronbach's alpha of 0.830, well above the 0.7 cutoff point.

4.2 Independent variables:

4.2.1 Knowledge Creation Modes

The measure for the knowledge creation modes were adapted from Schulz & Hoegl (2006). In their study knowledge creation was measured for the very first time on NPD project level (Schulze, 2006). This measure showed sufficient reliability and validity to be seen as a suitable measure for the knowledge creation model. Again all the modes are again scored on a seven point likert scale ranging from 'strongly agree to 'strongly disagree' and were constructed out of four items each. Socialization comprised of the items focusing on informal interaction and discussions of employees as this enables sharing of mental models and refines knowledge (Schulze, 2006). Factor analysis and reliability analysis indicated that all items should be included for this measure and yielded a Cronbach's alpha of 0.739. The items designed to measure externalization focused on how tacit knowledge is transferred to explicit knowledge through dialogue (Schulze, 2006). Factor analysis and reliability analysis suggested that this construct could benefit from excluding the last item. This generated a Crobach's alpha of 0.847. Combination featured items measuring to what extent explicit knowledge was combined and structured (Schulze, 2006). All items were included in generating this construct as factor analysis and reliability analysis did not lead to indications to do otherwise. This constructs reliability was determined to be a Cronbach's alpha of 0.658. Internalization was based on the degree of experimentation as this is the primary vehicle to convert explicit knowledge in tacit knowledge as individuals are 'learning by doing' (Schulze, 2006). Factor analysis and reliability analysis indicated that this measure could benefit from excluding the first variable, leading to a Cronbach's alpha of 0.882.

4.2.2 Modularity of Product Architecture

Product architecture was determined by the use of the measure of technological modularity which adopted from the study of Tiwana (2008). This study refined the measure used in the study of Worren et al (2002). However as this study takes place in the software industry the measure of technological modularity needed some adaptation (Tiwana, 2008). Where the original measure focused on the relationship between outsourced systems and the base system, this study will focus on the interrelationship of physical components thereby determining whether architecture of the product under development can be deemed integral or modular (Worren, Moore, & Cardona, 2002). This four item construct was subjected to a factor analysis using principal axis factoring to identify the underlying dimension. Furthermore this method is more robust against measurement error as it only uses the common variance. The first item showed little factor loading on the construct and the subsequent reliability analysis indicated that the construct of modularity of product architecture would benefit from deleting the first item of this construct as α would increase from 0.79 to 0.856.

4.2.3 Team Structure

To measure team structure, several dimensions were considered and measures examined. Eventually team stability, team member autonomy, team member proximity were chosen to represent team structures, based on the structural components of organizational coupling.

Team stability was adopted from the study of Akgün & Lynn (2012) and consisted of three items. Again, this measure was scored on the seven-point likert scale. Factor analysis and subsequent reliability analysis showed that the construct could benefit from excluding the first item. This construct generated a Cronbach's alpha of 0.832. Team member autonomy was measured using four items which was adopted from the study of Amabile et al, (1996). Again factor analysis and reliability analysis indicated that this measure would benefit from deleting the second item, yielding a cronbach's alpha of 0.782. Team member proximity was measured on a one to seven scale which indicated increasing distance between team members. This ordinal scale was created after reviewing the study of Cabigiosu & Camuffo (2012) which displayed a similar ordinal scale measuring distance between an organization and its supplier(Cabigiosu & Camuffo, 2012).

4.2.4 Supportive IT-systems

As stated earlier, the mirroring effect of product architecture is not always true. There are exceptions. One of these exceptions revolved around a highly dispersed team which in contrary to the effect of the mirroring hypothesis, created a highly integral product. This was partly contributed to the fact that all aspects of the project were made transparent for all contributors and the team members could contribute to the project from every location. This transparency and ability to have access to all information of the project was due to the fact a highly sophisticated IT-system was in place which enabled these project characteristics (Colfer & Baldwin, 2010).

This suggests that support from IT-systems can influence the effect of the mirroring hypothesis and should be included in this research. The reasoning behind this is that IT-systems provide an infrastructure to acquire and diffuse information needed by contributors of a development project (Hunter, 2002). The usage of IT-systems was measured using six items (Akgün et al., 2008).The measures were adopted form the study of Akgün et al(2008). Factor analysis and reliability analysis indicated that the first and last item should be excluded as this yielded the highest reliability for this construct, a Cronbach's alpha of 0.707.

4.3 Control variables

It is important to include control variables, which have a known effect on the dependent variables to ensure that the effect measured in subsequent analysis is attributed to the independent variables. The selected control variables were deemed important in predicting team performance on effectiveness, efficiency and speed-to-market (Sivasubramaniam, Liebowitz, & Lackman, 2012).

4.3.1 Team Tenure

Team tenure is typically defined as the duration in months which team members have worked together. Typically it takes some time to for a team to become a high performing one (Gibson & Gibbs, 2006).

4.3.2 Team Leadership

Team leadership encompasses the extent to which team leaders can be seen as transformational leaders which are charismatic and empowers the development team. Research has shown that these types of leaders are more likely to motivate people who work towards completing the teams objective (Burke et al., 2006). This measure contained six items (Wang, Law, Hackett, Wang, & Chen, 2005).

4.3.3 Team Cohesiveness

Team cohesiveness can be seen as the level of trust among members of the NPD team. Team cohesiveness play especially an important role when dealing with more independent workflow patterns (Beal, Cohen, Burke, & McLendon, 2003). Team cohesiveness was measured using five items (Lee, 2007).

4.3.4 Goal Clarity

Goal clarity can be defined as the level of consensus concerning the development goals. There is a strong link between clarity of goals and employee motivation. This is in particular the case when dealing with challenging goals. Research has shown that teams with specific goals outperformed teams with more ambiguous goals (Locke & Latham, 2002). Goal clarity was measured using six items (Lynn, Skov, & Abel, 1999).

4.3.5 Team size

Team size is an important control variable as most studies tend to find a positive effect of team size and knowledge creation and transfer. Team size can influence knowledge creation and sharing as network characteristics influence the availability of knowledge (Van Wijk et al., 2008). Organizations industry might relate to current state of technology and the rate of technology development which might emphasize the need for knowledge creation.

4.3.6 Project Innovativeness

This research also controls for project innovativeness as radical innovation influences technology design (Verganti, 2008). Radical innovation departs from existing practices and provides significant improvements considering current technology (Hao et al., 2015). This increased uncertainty further and will likely influence team structure as conceptualized by, team member proximity, team member autonomy, team stability and IT-usage. The measure was adopted form the study of Zhou and Li(2012) which measured project innovativeness on three items concerning major improvements over previous technologies, hard to imitate products and changing consumption patterns of markets (Zhou & Li, 2012). These items were scored on a seven-point likert scale. Factor and reliability analysis of showed that this measure should include all variables and generated a

Cronbach's alpha of 0.463. This measure falls far below the cutoff point of 0.7 for Cronbach's alpha indicating that this measure is not reliable.

4.3.7 Team Functional Diversity

Cross-functional teams are inherently connected to NPD projects as most organizations today design teams which consist of members of different functional departments to complete their innovation projects (de Visser et al., 2010). Such teams offer several advantages as they can rely on multiple sources of information which offer several perspectives. Inclusion of downstream concerns can be taken into account in upstream design activities which reduces design iterations. Furthermore a more complete picture of customer demands are available and speed to market is increased (Keller, 2001). However some research suggests that Cross-functional teams are also prone to have less group cohesion and display less internal communication within the team (Keller, 2001). This is naturally detrimental to some of the knowledge creation modes, in particular the Socialization knowledge creation mode. This in turn can affect overall project performance which makes Cross-functionality measured through the functional diversity concept an important control variable.

Functional diversity was measured using the measure recommended by Ancona and Cadwell (1992). This measure is created by filling out the formula displayed in figure 3 (Ancona & Caldwell, 1992). This measure increases in score when the team exhibits a greater distribution of project team members across the different functional departments. Here, H is seen as heterogeneity of the team and P is the proportion of project team members as seen from each functional department (Teachman, 1980).

$$H = -\sum_{i=1}^{s} P_i (\ln P_i).$$

Figure 3

An overview of all items can be found in the questionnaire in Appendix A.

4.4 Method of Analysis

Unfortunately the low response rate of the sample which resulted in a dataset of 22 respondents does not allow for extensive statistical testing. This means that conclusions drawn from this research is not backed up by statistical proof. However with the use of scatter plots some conclusions can be drawn from this dataset. By looking at trend lines in these scatter plots some indications can be given about the effect of certain independent variables on dependent variables. Furthermore by analyzing certain subgroups, the moderating effect suggested in this research can be examined. The results of these analyses lead to some surprising conclusions and opens up new opportunities for future research.

5. RESULTS

5.1 Descriptive Statistics

Table 1 displays the descriptive statistics and correlations of the most important dependent and independent variables. In table 1 some a significant correlations can be observed between the variables. A positive correlation occurs between product modularity (PM) and product dimension of project performance (PPPD). A significant negative correlation can be observed between the knowledge creation mode internalization (KCI) and product dimension of project performance (PPPD). Team member autonomy (TMA), information technology usage (ITU) and knowledge creation mode socialization (KCS) positively correlate with market dimension of project performance (PPMD). Knowledge creation mode internalization negatively correlates with project efficiency dimension of project performance (PPPE). Team member autonomy (TMA) positively correlates with KCS and negatively correlates with project innovativeness (PI). ITU positively correlates with knowledge creation socialization and externalization (KCS&KCE). KCS positively correlates with KCE and negatively correlates with project innovativeness (PI). Knowledge creation mode externalization (KCE) positively correlates with knowledge creation mode combination (KCC).

5.2 Impact of Control Variables on the Performance Dimensions

In order to test if the data behaves as expected, scatter plots and trend lines of control variables were created. Reliability of the conclusions drawn from the results relating to the mirroring hypothesis and its effect on project performance are increased when known effects can be observed by the same data. The scatter plots of the control variables and

	mean	st.deviation	TM_prox	PM	PPPD	PPMD	PPPE	TS	TMA	ITU	KCS	KCE	KCC	KCI	PI
Team member proximity (TM_prox)	4,73	2,028	1	0,09	0,031	0,272	0,18	0,297	0,22	0,001	-0,08	-0,287	-0,31	0,006	-0,082
Product modularity (PM)	8,1385	1,31366	0,09	1	0,57	0,165	0,291	0,172	0,347	0,251	0,168	0,173	0,062	-0,26	-0,414
Product performance product dimension (PPPD)	8,4416	1,02534	0,031	0,57	1	0,093	0,38	0,153	0,087	0,199	0,202	0,285	0,321	-0,473	-0,193
Product performance market dimension (PPMD)	7,1429	1,79081	0,272	0,165	0,093	1	0,243	0,224	0,55	0,521	0,486	0,384	0,373	0,296	-0,157
Product performance project efficiency (PPPE)	6,0606	1,82475	0,18	0,291	0,38	0,243	1	0,131	0,228	0,119	0,221	0,073	0,2	-0,558	0,008
Team stability (TS)	6,8506	2,06384	0,297	0,172	0,153	0,224	0,131	1	0,266	-0,242	-0,08	-0,122	0,03	-0,154	-0,317
Team member autonomy (TMA)	7,381	1,63478	0,22	0,347	0,087	0,55	0,228	0,266	1	0,346	0,604	0,286	-0,07	0,05	-0,587
Information technology usage (ITU)	5,6818	1,62235	0,001	0,251	0,199	0,521	0,119	-0,242	0,346	1	0,523	0,508	0,204	0,187	-0,409
Knowledge conversion; socialization (KCS)	6,8344	1,38231	-0,08	0,168	0,202	0,486	0,221	-0,08	0,604	0,523	1	0,584	0,263	0,275	-0,523
Knowledge conversion; externalization (KCE)	6,1688	1,76639	-0,287	0,173	0,285	0,384	0,073	-0,122	0,286	0,508	0,584	1	0,461	0,203	-0,371
Knowledge conversion; combination (KCC)	6,3799	1,31012	-0,306	0,062	0,321	0,373	0,2	0,03	-0,066	0,204	0,263	0,461	1	0,013	0,072
Knowledge conversion; internalization (KCI)	5,7143	1,83547	0,006	-0,26	-0,47	0,296	-0,558	-0,154	0,05	0,187	0,275	0,203	0,013	1	-0,008
Project innovativeness (PI)	4,3723	1,49604	-0,082	-0,41	-0,19	-0,157	0,008	-0,317	-0,587	-0,409	-0,523	-0,371	0,072	-0,008	1
correlation is significant at 0,01 level (2-tailed)															
correlation is significant at 0,05 level (2-tailed)															

Table 1: Descriptive statistics and correlations

the three performance dimensions can be found in appendix B. All control variables showed significant relaibility in subsequent tests.

Team cross-functionality shows a positive trend line with the product dimension as seen in figure B1. For the market dimension of NPD project performance no clear positive or negative association can be observed in figure B2. A negative trend line is seen in the dimension of project efficiency in figure B3. Team size has shown to have a positive impact on the product dimension and a undetermined effect on the market dimension of project performance in figure B4 en B5. Outliers in the scatter plot relating to team size and project efficiency change the trend line positively in figure B6. A negative association can be seen when these outliers are excluded from the analysis. Goal clarity is depicts a positive trend line over all performance dimensions as depicted in figures B7,B8 and B9. Team leadership depicts a positive trend line when this variable is plotted with the dependent variable product dimension of project performance as can be seen in figure B10. The relationship with the market dimension and project efficiency is not that clear as shown in figure B11 and B12. Team cohesiveness shows a positive association with the product and market dimension of project performance in figure B13 and B14. For project efficiency this relationship is not that clearly visualized in figure B15. The scatter plot of team tenure and the project performance dimensions depicts a positive trend line over all dimension as can be seen in figures B16, B17 and B18. Innovative climate of the organization positively influences all performance dimensions as seen by the positive trend lines found in figures B19, B20 and B21.

5.3 Impact of Modularity of Product Architecture on Team Member Proximity, Team Stability, Team Member Autonomy, Information Technology Usage and the Knowledge Creation Modes; Socialization, Externalization, Combination, Internalization.

Originally this study aimed to compare subgroups through the use of an MANCOVA analysis to examine whether the mirroring effect was present in the sampled NPD projects. Here subgroups based on the modularity of the product architecture, should significantly score higher or lower as predicted in the hypotheses. Unfortunately the data collection effort yielded only a sample of twenty two respondents which does not allow such statistical testing. Subsequent t-test's did not yield any significant results. This could be due to the lack of inclusion of control variables which these tests do not allow.

This research therefore relies on scatter plots in order to either confirm or reject hypotheses concerning whether the mirroring effect is apparent and what impact this has on the performance measures. Scatter plots do not allow for drawing statistically proven conclusions but can give an indication whether the hypotheses based on this sample should be accepted or rejected. All the scatter plots relating to the examination of the mirroring effect can be found in the appendix C.

A difference between the teams developing integral or modular products is expected when a linear line can be drawn with some steepness. Horizontal or nearly horizontal lines would indicate that no differences are expected between the two teams, concerning the variables plotted.

5.3.1 The Effect Modularity of Product Architecture on the Socialization Knowledge Creation Mode.

Concerning the socialization aspect of the knowledge creation modes it was hypothesized that teams developing products featuring more modular product architecture would display less socialization activities. This means modularity of product architecture would have a negative effect on socialization. This would implicate that a scatter plot featuring knowledge creation mode socialization and a measure of modularity of product architecture would display a negative trend line. This is not the case when this scatter plot is created. A positive trend line is visible in figure 4 rejecting the hypothesis. The hypothesis is rejected as this would indicate that teams developing more modular products would engage in more socialization activities.

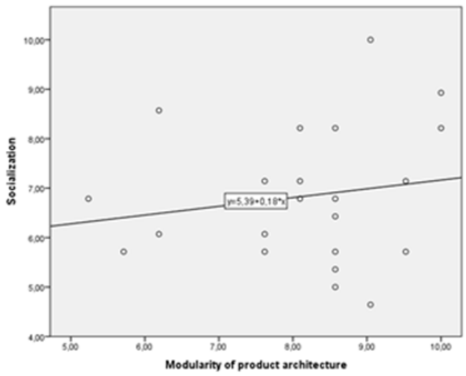

Figure 4: Scatter plot featuring socialization and modularity of product architecture

5.3.2 The Effect of Modularity of Product Architecture on the Externalization Knowledge Creation Mode.

It was hypothesized that the externalization aspect of the knowledge creation modes would be more prominently displayed in teams developing a product featuring a more integral product architecture. Based on the scatter plot in figure 5 it can be seen that this is not the case. Again the trend line is positive indicating that teams developing a product with a more modular product architecture perform more externalization activities.

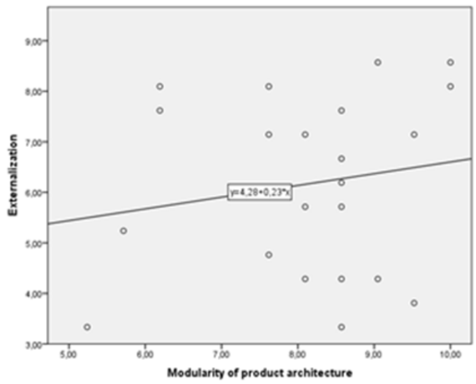

Figure 5: Scatter plot featuring externalization and modularity of product architecture

5.3.3 The Effect of Modularity of Product Architecture on the Combination Knowledge Creation Mode.

This study hypothesized that teams developing a product featuring a more modular product architecture would display more activities related to the combination knowledge creation mode. This hypothesis is confirmed when looking at the first scatter plot in figure 6 where the trend line displays a slight positive association.

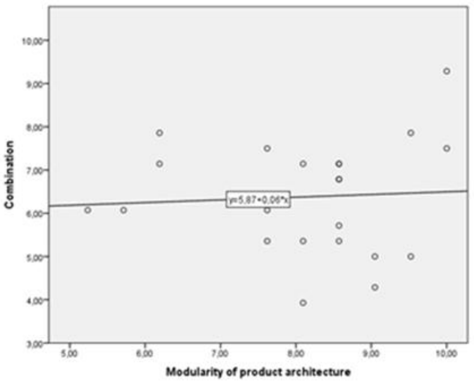

Figure 6: Scatter plot featuring combination and modularity of product architecture

5.3.4 The effect of Modularity of product architecture on the internalization knowledge creation mode.

The hypothesis concerning internalization suggested that teams developing a product with a more modular product architecture would display more internalization activities than teams developing a product with a more integral product architecture. This hypothesis would suggest a positive association between product architecture and the knowledge creation mode externalization. Plotting a trend line in the scatter plot in figure 7 suggest that this is not true, rejecting this part of the hypothesis.

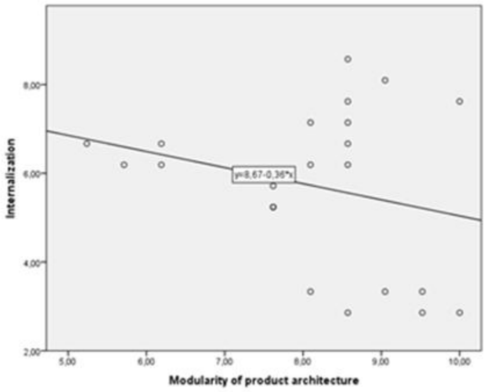

Figure 7: Scatter plot featuring internalization and modularity of product architecture

5.3.5 The Effect of Modularity of Product Architecture on Team Stability

It was hypothesized that teams developing a product with a more integral product architecture would score significantly higher on the team stability measure than teams developing a product featuring an integral product architecture. It was thus expected to see a negative association between modularity of product architecture. This is not reflected in the positive trend line in the scatter plot in figure 8, rejecting this part of the hypothesis

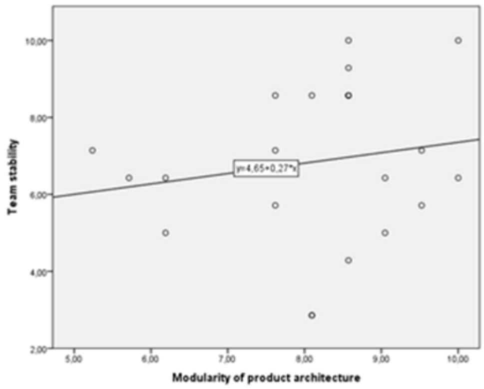

Figure 8: Scatter plot featuring Team Stability and modularity of product architecture

5.3.6 The effect of Modularity of Product Architecture on Team Member Autonomy

Hypothesis 1 which includes team member autonomy stated that teams developing a product with a modular product architecture would score higher on the team member autonomy measure than teams developing more integral products. This would suggest a positive association between team member autonomy and modularity of product architecture. This association is supported in the first scatter plot in figure 9.

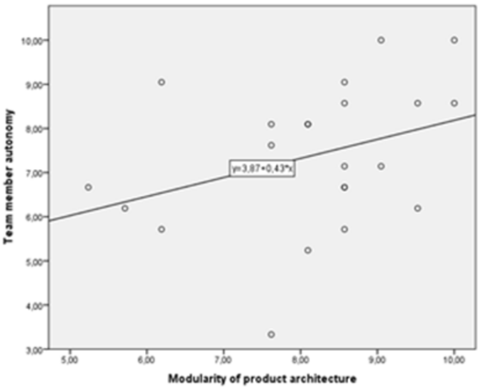

Figure 9: Scatter plot featuring Team Member Autonomy and modularity of product architecture

5.3.7 The Effect of Modularity of Product Architecture on Team Member Proximity

The hypothesis stated that it was expected that teams developing a more modular product architecture would be positioned farther away from each other when compared with teams tasked with developing an integral product. This would indicate a negative association between modularity of product architecture and team member proximity. This association is not seen in figure 10. This scatter plot indicates that teams developing a modular product are located closer together from each other than in teams developing integral products, rejecting this part of hypothesis 1.

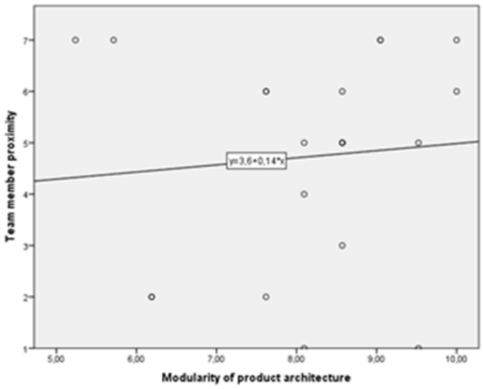

Figure 10: Scatter plot featuring Team member proximity and modularity of product architecture

5.3.8 The Effect of Modularity of Product Architecture on Information Technology Usage

Hypothesis one suggested that teams developing a more modular product would score higher on the information technology usage measure than teams developing more integral products. A positive association between modularity of product architecture and information technology usage is thus expected. This is confirmed by the first scatter plot in figure 11, leading to the acceptance of hypothesis 1 concerning this variable.

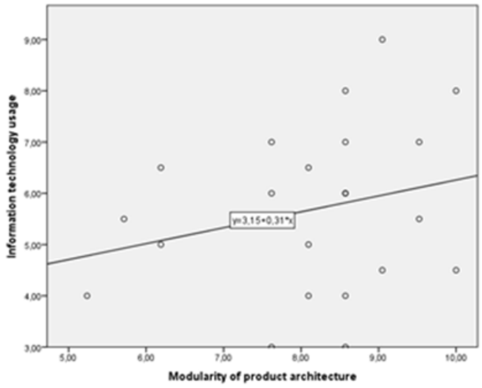

Figure 11: Scatter plot featuring Information Technology Usage and modularity of product architecture

5.4 Examination of the Interaction Effect of Product Modularity and Team Member Proximity, Team Stability, Team Member Autonomy, Information Technology Usage and the Knowledge Creation Modes; Socialization, Externalization, Combination, Internalization on Project Performance; Product Dimension, Market Dimension and Project Efficiency.

Multiple scatter plots were created in order to thoroughly understand the moderating effect of product architecture modularity on the relationship between the several independent variables and dependent variables. This in turn, allows for finding evidence in support of the hypothesis or evidence to reject the hypotheses concerning the effect of the mirroring effect on the performance dimensions. In appendix D it can be seen that the analysis starts with a normal scatter plot depicting the effect of the independent variables on the dependent variables. Then a moderator variable is introduced based on the subgroups above and below average level of product architecture modularity. Where group one represents the subsample scoring below average and group two representing the subsample above average. Group one in this sample can be thus considered as projects with an integral product architecture design and group two can be considered projects with modular product architecture designs.

5.4.1 The Moderating effect of Modularity of Product architecture on the Socialization Knowledge Creation Mode and Product Dimension of Project Performance Relationship.

It can be seen that the knowledge creation mode socialization has a positive effect on the product dimension of project performance when looking at the first scatter plot in figure D1. Introducing two subgroups based on product architecture modularity shows that the trend lines change for the subgroups in figure 12. The subgroup relating to the integral product design displays a negative trend line. Whereas the group, deemed modular, displays a positive trend line. This is the opposite of what was hypothesized in hypothesis 2a. Here a positive trend line was expected for the products which could be deemed more integral and a negative trend line for products which display more modular qualities concerning product architecture.

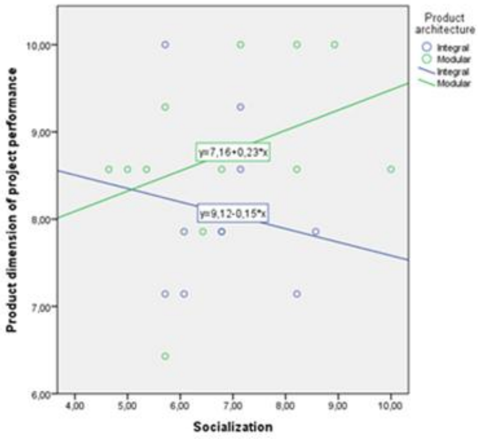

Figure 12: Scatter plot featuring knowledge creation mode socialization and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.2 The Moderating Effect of Modularity of Product Architecture on the Socialization Knowledge Creation Mode and Market Dimension of Project Performance Relationship

As can be seen in the first scatter plot, Socialization positively influences the market dimension of project performance in figure D2. Opposite of what was hypothesized in hypothesis 2a, a steeper trend line can be observed for modular products than for products featuring an integral product architecture as can be seen in figure 13.

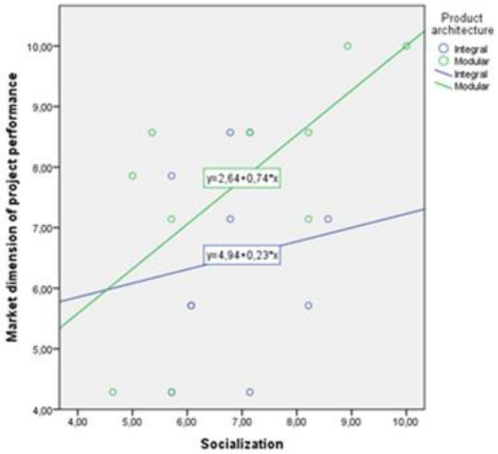

Figure 13: Scatter plot featuring knowledge creation mode socialization and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.3 The Moderating Effect of Modularity of Product Architecture on the Socialization Knowledge Creation Mode and Project Efficiency Dimension of Project Performance Relationship

The first scatter plot depicts a positive trend line between Socialization and the project efficiency dimension of project performance in figure D3. The inclusion of the two subgroups in figure 14 shows that observations relating to development projects with a modular product benefit more from socialization than the subgroup relating to integral product architecture. This supports hypothesis 2a.

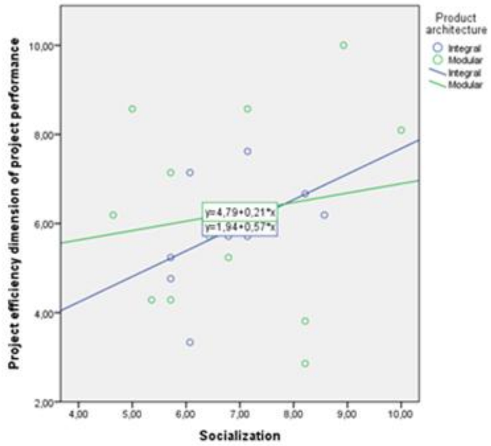

Figure 14: Scatter plot featuring knowledge creation mode socialization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.4 The Moderating Effect of Modularity of Product Architecture on the Externalization Knowledge Creation Mode and Product Dimension of Project Performance Relationship.

The first scatter plot in figure D7 shows a positive trend line between externalization and product dimension of project performance. Splitting the sample into subgroups in figure 15 based on the modularity of product architecture generates two exactly the same trend lines and does not allow us to draw any conclusions on the moderating effect of product architecture which is encapsulated by hypothesis 2b.

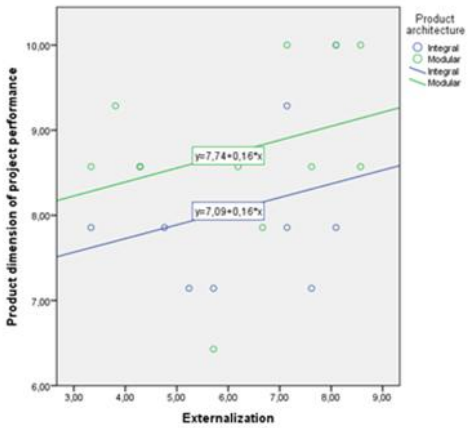

Figure 15: Scatter plot featuring knowledge creation mode externalization product dimension of project performance with subgroups relating to modularity of product architecture

5.4.5 The Moderating Effect of Modularity of Product Architecture on the Externalization Knowledge Creation Mode and Market Dimension of Project Performance Relationship.

The first scatter plot shows a positive association between externalization and market dimension of project performance in figure D8. Splitting the sample in subgroups based on modularity of product architecture, shows that products that are deemed modular show a steeper trend line than the integral products in figure 16. This evidence does not support hypothesis 2b.

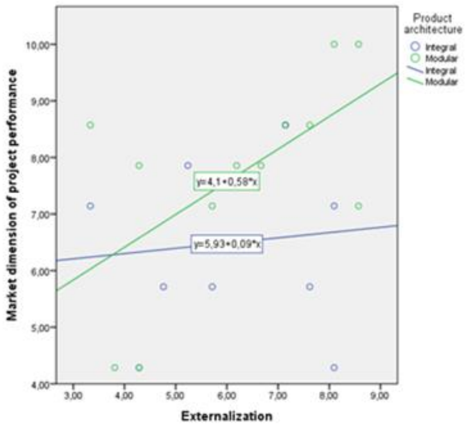

Figure 16: Scatter plot featuring knowledge creation mode externalization and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.6 The Moderating Effect of Modularity of Product Architecture on the Externalization Knowledge Creation Mode and Project Efficiency Dimension of Project Performance Relationship.

Plotting externalization and the project efficiency dimension of project performance in a scatter plot reveals a slight positive trend line in figure D9. Adding subgroups reveals that the positive association remains for modular products and integral products generate a negative trend line as can be seen in figure 17. This again contradicts the relationship as proposed in hypothesis 2b.

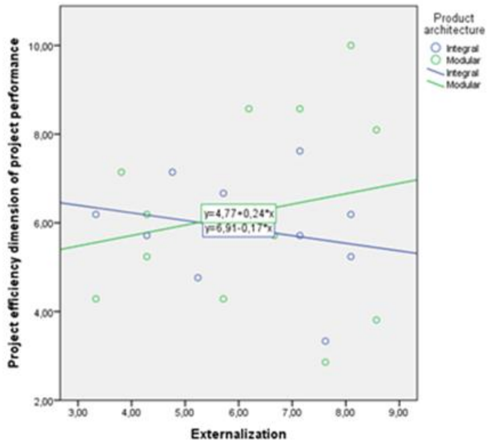

Figure 17: Scatter plot featuring knowledge creation mode externalization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.7 The Moderating Effect of Modularity of Product Architecture on the Combination Knowledge Creation Mode and the Product Dimension of Project Performance Relationship.

The scatter plot containing Combination and product dimension of project performance shows a positive association resulting in a positive trend line in figure D13. As proposed in hypothesis 2c the data shows a steeper trend line for products with a modular product architecture as can be seen in figure 18.

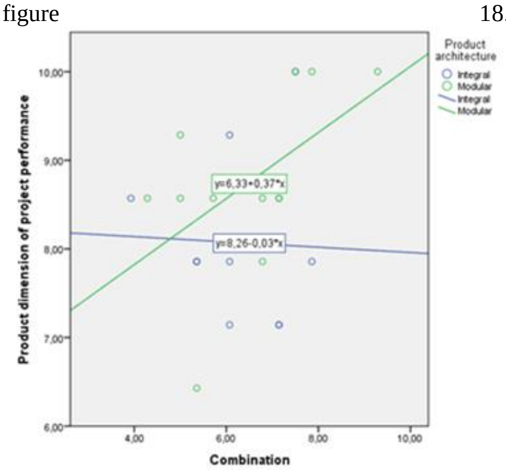

Figure 18: Scatter plot featuring knowledge creation mode combination and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.8 The Moderating Effect of Modularity of Product Architecture on the Combination Knowledge Creation Mode

and the Market Dimension of Project Performance Relationship.

Combination and the market dimension of project performance show a positive trend line in figure D14. The scatter plot depicting the two subgroups reveals that a stronger positive association between combination and the market dimension of project performance is apparent for modular products as can be seen in figure 19.

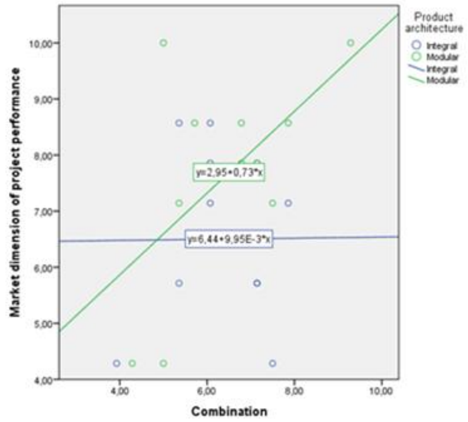

Figure 19: Scatter plot featuring knowledge creation mode combination and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.9 The Moderating Effect of Modularity of Product Architecture on the Combination Knowledge Creation Mode and the Project Efficiency Dimension of Project Performance Relationship.

Plotting Combination and project efficiency dimension of project performance reveals a positive trend line in figure D15. In line with hypothesis 2c a positive trend line can be observed for the modular products and a negative trend line for integral products in figure 20. This indicates that project efficiency increases when development teams increase their combination activities while developing modular products.

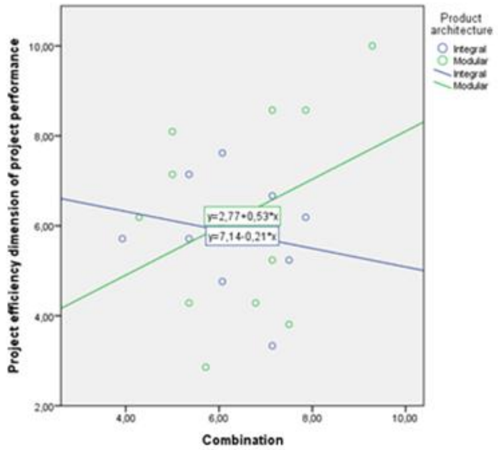

Figure 20: Scatter plot featuring knowledge creation mode combination and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.10 The Moderating Effect of Modularity of Product Architecture on the Internalization Knowledge Creation Mode and the Product Dimension of Project Performance Relationship.

Plotting Internalization and product dimension of project performance reveals a negative trend line in figure D19. Opposite as was predicted in hypothesis 2d. Including the two subgroups in figure 21 reveals an even stronger negative association for products with an integral product architecture which again contradicts hypothesis 2d.

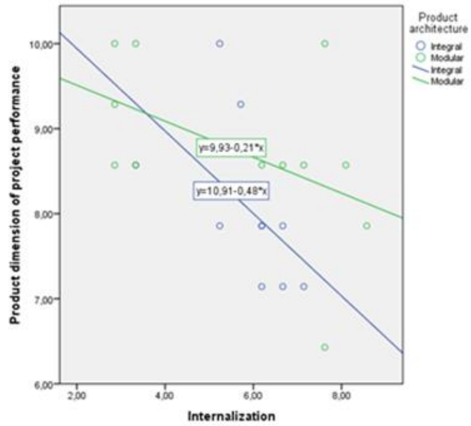

Figure 21: Scatter plot featuring knowledge creation mode internalization and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.11 The Moderating Effect of Modularity of Product Architecture on the Internalization Knowledge Creation Mode and the Market Dimension of Project Performance Relationship.

Generating a scatter plot for internalization and the market dimension of project performance reveals a positive trend line in figure D20. Adding subgroups to the scatter plot reveals a stronger trend line for integral products than for modular products in figure 22. This contradicts hypothesis 2d.

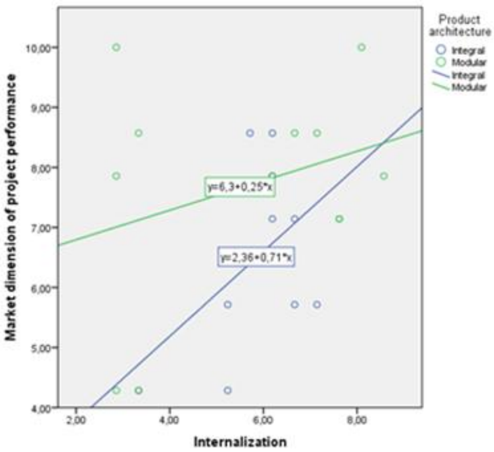

Figure 22: Scatter plot featuring knowledge creation mode internalization and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.12 The Moderating Effect of Modularity of Product Architecture on the Internalization Knowledge Creation Mode and the Project Efficiency Dimension of Project Performance Relationship.

The scatter plot featuring internalization and project efficiency dimension of project performance reveals a negative trend line in figure D21. Adding the two subgroups in figure 23, shows a stronger negative trend line for the modular products, contradicting hypothesis 2d.

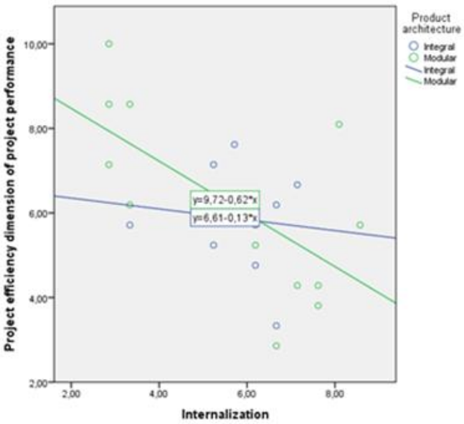

Figure 23: Scatter plot featuring knowledge creation mode internalization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.13 The Moderating Effect of Modularity of Product Architecture on the Team Stability and the Product Dimension of Project Performance Relationship.

The scatter plot containing team stability and product dimension of project performance shows a positive trend line in figure D25. The inclusion of subgroups based on modularity of product architecture reveals a strong positive trend line for integral products and a negative trend line for modular products as can be seen in figure 24, supporting hypothesis 3.

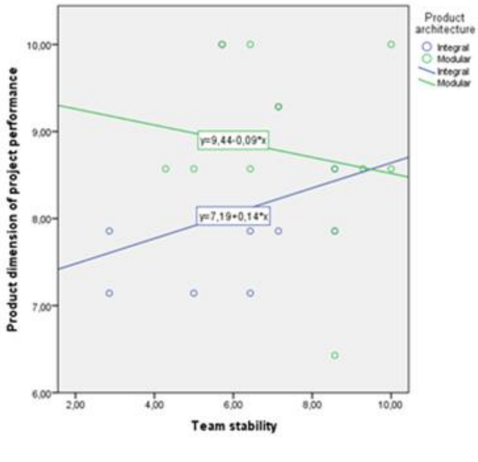

Figure 24: Scatter plot featuring team stability and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.14 The Moderating Effect of Modularity of Product Architecture on the Team stability and the Market Dimension of Project Performance Relationship.

Plotting team stability and the market dimension of project performance reveals a positive trend line in figure D26. Introducing the two subgroups in figure 25 reveals a negative trend line for integral products and a positive trend line for products with a modular product architecture, contradicting hypothesis 3

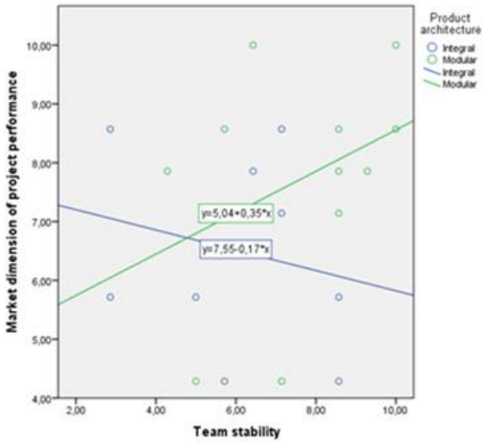

Figure 25: Scatter plot featuring team stability and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.15 The Moderating Effect of Modularity of Product Architecture on the Team Stability and the Project Efficiency Dimension of Project Performance Relationship.

The scatter plot containing team stability and project efficiency dimension of project performance shows a slight positive trend line in figure D27. Adding subgroups in figure 26 reveals a steeper trend line for integral products than for modular products, supporting hypothesis 3.

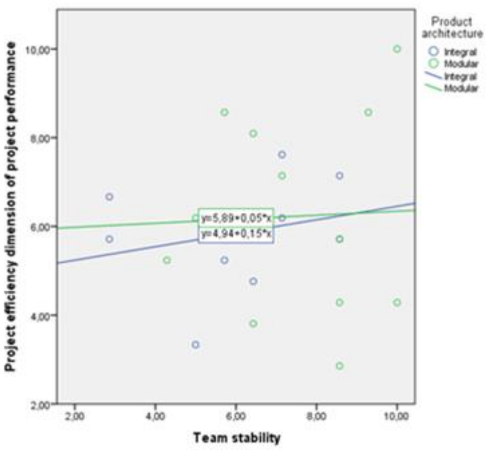

Figure 26: Scatter plot featuring team stability and Project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.16 The Moderating Effect of Modularity of Product Architecture on the Team Member Autonomy and the Product Dimension of Project Performance Relationship.

Generating the scatter plot of Team Member Autonomy and product dimension of project performance, reveals a positive trend line between the variables in figure D31. Inclusion of the subgroups in figure 27 reveals a positive trend line for the subgroup containing modular products. A negative trend line can be seen for integral products. This provides evidence in favor of hypothesis 5.

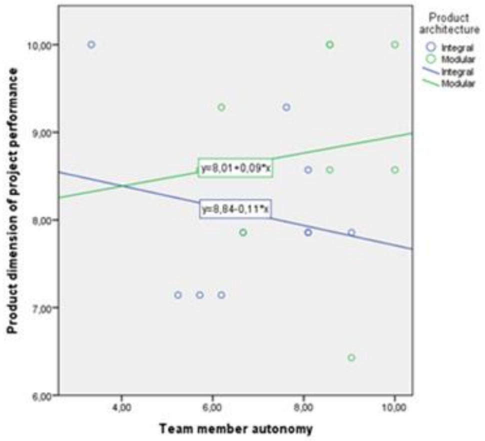

Figure 27: Scatter plot featuring team member autonomy and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.17 The Moderating Effect of Modularity of Product Architecture on the Team Member Autonomy and the Market Dimension of Project Performance Relationship.

Creation of a scatter plot with the variables team member autonomy and market dimension of project performance reveals a positive trend line in figure D32. Inclusion of the two subgroups in figure 28 reveals a steeper trend line for modular products than for integral products, confirming hypothesis 5.

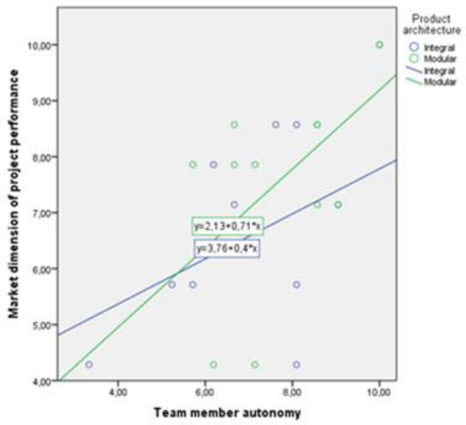

Figure 28: Scatter plot featuring team member autonomy and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.18 The Moderating Effect of Modularity of Product Architecture on the Team Member Autonomy and the Project Efficiency Dimension of Project Performance Relationship.

Plotting team member autonomy against the project efficiency dimension of project performance variable, generates a positive trend line in figure D33. This trend line is steeper for the subgroup characterized by integral products as can be seen in figure 29.

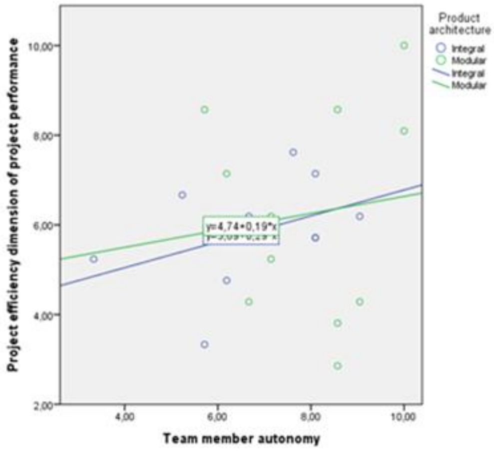

Figure 29: Scatter plot featuring team member autonomy and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.19 The Moderating Effect of Modularity of Product Architecture on the Team Member Proximity and the Product Dimension of Project Performance Relationship.

Plotting the team member proximity and product dimension of project performance creates a slightly positive trend line in figure D37. The inclusion of the two subgroups in figure 30 shows a slight negative trend line for modular products and integral products. The latter being less steep than the former providing evidence in favor for hypothesis 4.

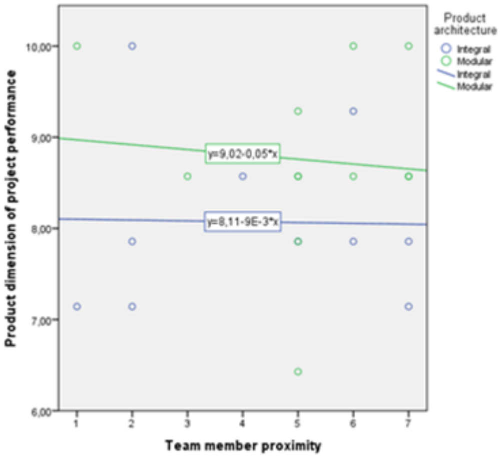

Figure 30: Scatter plot featuring team member proximity and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.20 The Moderating Effect of Modularity of Product Architecture on the Team Member Proximity and the Market Dimension of Project Performance Relationship.

Plotting the team member proximity and market dimension of project performance reveals a positive trend line in figure D38. This positive trend line upholds for projects concerning products with an integral product architecture but changes for modular ones as can be seen in figure 31. The trend line for modular products is negative. This supports hypothesis 4.

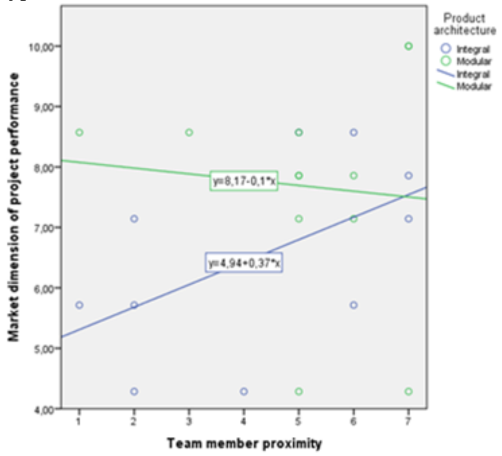

Figure 31: Scatter plot featuring team member proximity and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.21 The Moderating Effect of Modularity of Product Architecture on the Team Member Proximity and the Project Efficiency Dimension of Project Performance Relationship.

Generating a scatter plot containing the variables team member proximity and project efficiency dimension of project performance, reveals a slight positive association in figure D39. The inclusion of two subgroups in figure 32 reveals two almost identical positive trend lines.

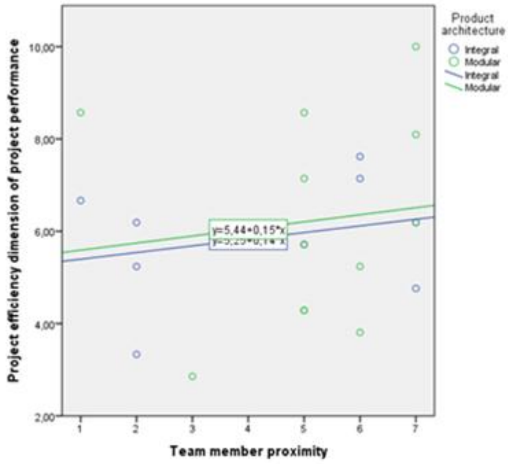

Figure 32: Scatter plot featuring team member proximity and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.22 The Moderating Effect of Modularity of Product Architecture on the Information Technology Usage and the Product Dimension of Project Performance Relationship.

The scatter plot containing Information Technology Usage and product dimension of project performance, displays a positive trend line in figure D43. The inclusion of subgroups in figure 33 reveals that this positive association is stronger for integral products. This evidence would lead to a rejection of hypothesis 6 which state that teams designing modular products could increase their score on the product dimension of project performance.

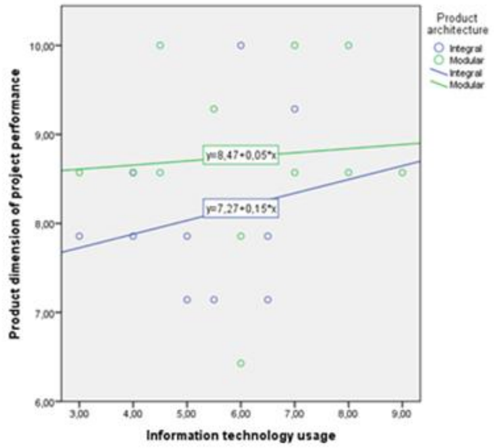

Figure 33: Scatter plot featuring information technology usage and product dimension of project performance with subgroups relating to modularity of product architecture

5.4.23 The Moderating Effect of Modularity of Product Architecture on the Information Technology Usage and the Market Dimension of Project Performance Relationship.

The scatter plot containing Information Technology Usage and market dimension of project performance, displays a strong positive trend line in figure D44. The inclusion of subgroups in figure 34 reveals that this positive association almost equally strong across the subgroups.

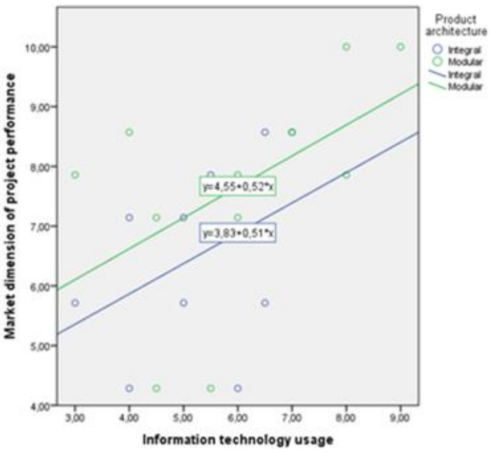

Figure 34: Scatter plot featuring information technology usage and market dimension of project performance with subgroups relating to modularity of product architecture

5.4.24 The Moderating Effect of Modularity of Product Architecture on the Information Technology Usage and the Project Efficiency Dimension of Project Performance Relationship.

Plotting the information technology usage and project efficiency dimension of project performance reveals a slight positive trend line in figure D45. This positive trend line upholds for projects concerning products with a modular product architecture but changes for integral ones As can be seen in figure 35. The trend line for integral products is negative. This does support hypothesis 6.

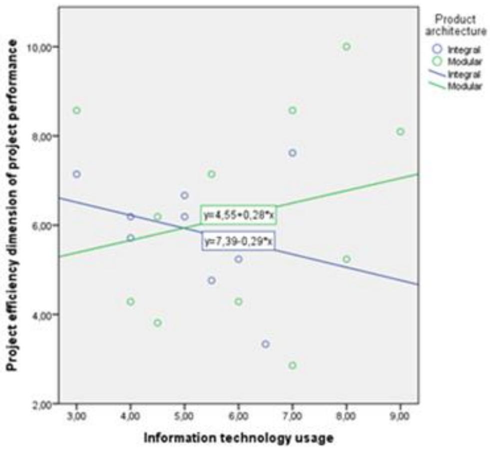

Figure 35: Scatter plot featuring information technology usage and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

5.4.25 The Moderating Effect of Modularity of Product Architecture on the Information Technology Usage and Socialization Relationship

The surprising results of some of the scatter plots and trend lines required additional analysis in order to create some context and to fully comprehend why some variables behave in the way they do. Plotting information technology usage and socialization with the inclusion of subgroups relating to integral and modular product architecture reveals a positive trend line for teams developing modular products and a negative trend line for teams developing integral products, as can be seen in figure 36.

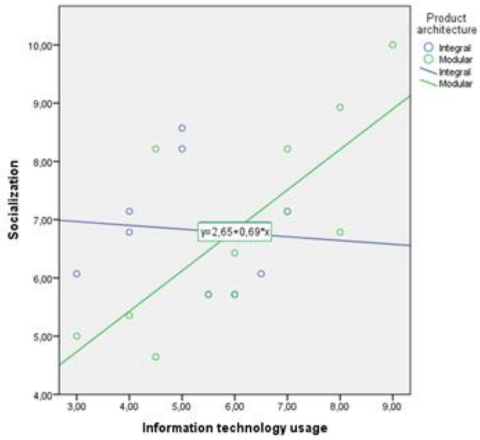

Figure 36: Scatter plot featuring information technology usage and socialization with subgroups relating to modularity of product architecture

5.5 Robustness Checks

The inclusion of multiple scatter plots allows for precise examination of the effect of the independent variables on the dependent variables. Furthermore the examination of the independent variables on multiple dimensions of project performance ensures that all conclusions drawn are based on all facets of the construct of project performance.

By examining the effects of the control variables a conclusion can be drawn whether the data behaves as expected. Analysis of the control variables shows that the data in general behaves as expected. Some control variables show neither positive nor negative effects on some of the performance dimensions but none of the control variables has an undetermined relationship with all the dependent variables.

6. DISCUSSION AND CONCLUSION

6.1 The Mirroring Effect

As said before, prior research concerning the subject of the mirroring hypothesis has primarily focused on interaction between either NPD team members in the intra-organizational context or between organizations with different methodologies. In the intra-organizational context the mirroring effect is tested by comparing technical communication patterns with design interfaces and identifying overlapping patterns (Sosa et al., 2004). This methodology limits the researcher to one organization and one development project. This research focused on deviating from this methodology to allow analysis of multiple team structure and knowledge exchange dimensions over multiple development projects originating from a myriad of organizations. This research design would allow for a more general testing of the mirroring hypothesis and identifies important actionable dimensions of team structure and knowledge creation while increasing the external validity of the results as the results are not context specific to one organization and one development project.

Furthermore analysis of 'technical communication' where only frequency and criticalness of team interactions were recorded as measure for team member interaction is considered in this research to be a serious flaw. By defining team member interaction in this manner, context important factors are missed such as manner of interaction. Furthermore it does not tell the researcher the nature of the information exchanged, whether this was tacit or explicit information. This kind of information is critical in coming to a recommendation for organizations to improve project performance through improved team member interaction.

Unfortunately, due to sample size restrictions no statistically sound conclusions can be drawn from the results. However analysis of the scatter plots allows for some determination whether the data suggests if the mirroring effect is present. These indications could form the basis for future research where more statistically proven conclusions can be drawn.

Hypothesis 1 deals with the question whether a difference can be observed in between NPD teams developing products which exhibit integral product architecture or modular product architecture. Here it was hypothesized that teams developing products with a modular product architecture would display lower levels of socialization, externalization, team member proximity and higher levels of combination, internalization, team stability, team member autonomy and IT-systems usage. A negative trend line is thus expected for the scatter plots containing socialization, externalization and team member proximity and a positive trend line for the scatter plots containing combination, internalization, team stability, team member autonomy and IT-systems usage.

6.1.1 Socialization

The hypothesis relating to socialization is rejected by the data. At first glance it seems to be that teams developing modular products would engage more in socialization activities than teams dealing with integral activities. The surprising trend line suggests that teams developing modular products also rely on socialization. Socialization is characterized as a social activity which requires team members to work in close proximity and communicate often and was therefore not expected in teams developing modular products due to the independent nature of the concurrent development process and independency relating to knowledge and tasks concerning other team members. However viewing figure 36, a strong positive relationship between information technology usage and socialization can be observed for teams developing modular products. It seems that using information technology systems facilitates the socialization activities which are typically associated with face-to-face communication. This could be very well due to integration difficulty as drastically different or technologically complex components must merge together to create a new product. Although these modular design projects display modular characteristics concerning technical dependency of components and division of tasks, division of knowledge dictates that team members are dependent on each other to exchange knowledge in highly innovative projects, explaining why the mirroring effect only partially affects socialization (Colfer & Baldwin, 2010)(McCord & Eppinger, 1993). This interdependence concerning knowledge increases communication in order to increase knowledge sharing and leads to the rejection of hypothesis 1 (Savelsbergh et al., 2008).

6.1.2 Externalization

Modularity of product architecture was expected to have a negative effect on externalization as this is knowledge creation mode deals with converting tacit knowledge to explicit knowledge. The data shows an opposite relationship where teams tasked with the design of more modular products displayed more externalization activities. A reason for this surprising relationship can be that teams developing more modular projects spend a lot of time explicitly creating a common frame of mind concerning the product architecture. Formal meetings where customer requirements and product specifications are determined are important for subsequent design activities and division of tasks (Schulze, 2006). This could ensure that all team members work towards a common goal once the team members are assigned to their independent tasks and the project follows a concurrent development structure (Sanchez & Mahoney, 1996). In teams dealing with the design task of more integral products, this common frame of mind could be more emergent and spread out over the whole project duration as interface specifications are also not set at the start of the project (Sanchez & Mahoney, 1996). Furthermore socialization ensures that this knowledge is tacitly created and shared.

6.1.3 Combination

Concerning the knowledge creation modes our hypothesis is confirmed for combination, where teams developing more modular products display more combination activities. The very nature of combination where new explicit knowledge is created out of other explicit knowledge sources makes this kind of knowledge easily transferable through the use of IT-systems (Schulze, 2006). Due to the often increased distance between team members developing modular products, IT-systems are more often used which allows primarily for the exchange of explicit knowledge (Popadiuk & Choo, 2006). This is often the only option for team members to exchange knowledge relating to technical possibilities, customer needs and the development process. However the slight positive trend line suggests that there is not a significant difference in the extant combination activities are performed by teams developing integral or modular products. Teams developing integral products rely therefore also on combination activities to systematically edit information concerning technical knowledge or customer needs(Schulze, 2006).

6.1.4 Internalization

The score on the knowledge creation mode internalization scale was expected to be higher in teams designing modular products as these teams were expected to deal more with explicit knowledge sources which should be internalized by team members. The negative trend line reveals that internalization plays a more important role in teams tasked with designing integral products. A possible explanation could be that complexity concerning the scope and scale of the design tasks requires a lot of testing to remove uncertainty as division of tasks is low due to high technical dependency of components. The easy separation of design tasks of more modular products reduces uncertainty and could explain why internalization does play as an important role in these teams than in teams designing integral products (Colfer & Baldwin, 2010). Internalization increases tacit knowledge of individuals which can be subsequently shared and added to through socialization in group contexts (Schulze, 2006).

6.1.5 Team Stability

Teams developing products with a modular product architecture were thought to score lower on the team stability measure as knowledge needs of team members are not dependent on other team members as design tasks and knowledge needs are seen as highly separate due to low technical dependency of components (Colfer & Baldwin, 2010). The data does not show this relationship. This could be explained due to the fact that integration activities of separate complex and technological advance components requires the assistance of all team members who worked on the separate design tasks, in order to created the completed product. The nature of the tasks change to more interdependence in tasks, reducing the division of tasks and division of knowledge and requiring team members to work more together. The dependence of knowledge during integration of complex components indicates that removing team members would lead to a decrease in knowledge base which is now needed (Akgün & Lynn, 2002).

6.1.6 Team Member Autonomy

Team member autonomy was thought of to be more present in teams developing more modular products as product architecture would substitute some of the managerial control and team members are by the nature of these independent design tasks less dependent on other team members (Sanchez & Mahoney, 1996). This hypothesis was confirmed. The three primarily forces driving the mirroring effect, technical independence of components, high division of labor and division of knowledge allows for a more concurrent design process where team members can complete their task independent from each other and where product architecture specifications substitutes managerial control, increasing their autonomy (Sanchez & Mahoney, 1996)(Colfer & Baldwin, 2010). Here it is quite apparent that team members are granted some leeway to explore opportunities and dictate their own method of completing their design tasks.

6.1.7 Team Member Proximity

Concerning team member proximity teams developing modular products were expected to be positioned further away from each other. This hypothesis was rejected as the trend line shows a positive association between modularity of product architecture and team member proximity. An explanation for this relationship can be the exceptions of the mirroring hypothesis stated earlier. Teams displaying typical integral structures can create products with a highly modular product architecture when this is an explicit design goal(Colfer & Baldwin, 2010). This does require team members to adhere to certain design rules to prevent coordination and negotiation between team members tasked with the design of different components or modules to prevent the product architecture to become more integral(C.Y, Baldwin & Clark, 2000).

6.1.8 Information Technology Usage

The hypothesis stating that information technology is more dominantly used in teams developing products which can be characterized as being modular was supported by the data. The argument stating that the explicit nature of knowledge exchange between team members dealing with modular product innovation relies on communication methods beneficial to this type of knowledge is supported by the data (Popadiuk & Choo, 2006). Furthermore the fact that teams developing modular products are typically located further away from one another could be another reason why these teams rely more information technology in order to communicate. The ability to meet in person is not always there due to geographic distance between team members.

6.2 The Mirroring Effect and Project Performance

6.2.1 Moderating Effect of Modularity of Product Architecture on the Socialization and Project Performance Relationship

The universal positive impact of socialization on the project performance dimensions, stated by hypothesis 2a, is confirmed by the data. However differentiating the data based on modularity of product architecture reveals different associations between the variables than expected in hypothesis 2a. By analyzing the data of the scatter plots of the product and market dimension, a positive trend can be seen between socialization and these dimensions for product architectures which can be deemed modular. Similarly to hypothesis 1, the conclusion can be drawn that teams developing modular products like teams developing integral products rely and benefit from socialization activities. This is most likely due to integration activities of the separate and divided design tasks. The integration activities differ greatly from the earlier and more separate design activities. Integration activities change the division of knowledge and tasks en requires more communication (Colfer & Baldwin, 2010; McCord & Eppinger, 1993). By investing additional effort in ensuring proper integration of all components to ensure that a complete functioning product is developed without flaws, greatly benefits product performance and subsequent acceptance by the market ensuring that sales objectives are met. This however requires increased communication which can only be facilitated by the socialization knowledge creation mode (Schulze, 2006). Confirming a part of hypothesis 2a is the project efficiency dimension of project performance as teams developing integral products benefit more on this dimension from socialization than teams developing modular products. This could be explained due to the fact that these teams have team members which are typically located more closely together increasing the ease of performing socialization activities and its effect on meeting timetable objectives (Bulte & Moenaert, 1998). The negative trend line depicted for teams dealing with the development of integral products in the scatter plot examining socialization and the product dimension of project performance was an unexpected outcome of the analysis. However this could be explained as overemphasizing socialization activities could undermine the project moving forward form the concept phase to the development phase where more explicit knowledge is needed. Another explanation for the effect seen could be the problem of causation. Increased socialization activities could be a sign that the team is failing to understand the project dimensions, for example customer demands. This poor grasp on the project might lead to inferior products which lead to a low score on the product dimension measurement scale.

6.2.2 Moderating Effect of Modularity of Product Architecture on the Externalization and Project Performance Relationship

The universal benefits of externalization activities stated in hypothesis 2b, is confirmed by the data by showing a positive association over all three performance dimensions. Discriminating the data based on modularity of the product under development shows a stronger relationship for teams developing modular products than teams developing integral products. Arguments relating to the increased use of externalization of teams developing modular products can explain why this also benefits project performance. Externalization is the formal process of creating explicit knowledge. Relating this to product architecture and customer demands, it is easy to see that these are important input dimensions for the concurrent development process applicable to modular products (Sanchez & Mahoney, 1996). Once these formal and explicit specifications are established, they ensure that geographically dispersed team members, work towards a common goal which can only be beneficial in terms of product performance and market acceptance. The explicit nature of this knowledge and the fact that team members are positioned further away from each other makes these teams more dependent on communicating through IT-systems (Söderquist, 2006). In teams developing more integral products, the nature of product architecture effectively evolves as the development project progresses (Sanchez & Mahoney, 1996). Socialization could facilitate creating an understanding what the product architecture entails and explains why externalization is in some cases less beneficial to these teams and explains why this part of hypothesis 2b was not confirmed by the data (Schulze, 2006).

6.2.3 Moderating Effect of Modularity of Product Architecture on the Combination and Project Performance Relationship

The data confirms the first part of hypothesis 2c, which states that combination will benefit all project performance dimensions. Adding subgroups reveals that teams developing products which can be categorized as modular, benefit more from executing combination activities which include systematically editing explicit knowledge dealing with customer preference and technical capabilities (Schulze, 2006). Again the reliance of such teams on explicit knowledge relating to interface specifications, explains why combining this explicit knowledge is to such of an importance to these teams (Sanchez & Mahoney, 1996). These explicit knowledge types are the only ones geographically dispersed teams can share through their extended use of IT-systems. Tacit knowledge does not allow for combination activities and explains why teams developing more integral products do not perform any better on the several performance dimensions when they would increase their combination activities, confirming hypothesis 2c (Schulze, 2006).

6.2.4 Moderating Effect of Modularity of Product Architecture on the Internalization and Project Performance Relationship

The relationship between internalization and the several performance dimensions did not behave as hypothesized. Only for the market dimension of performance dimension it was established that internalization had a positive effect as hypothesized in hypothesis 2d. The data suggest that teams developing integral products will score higher on the market dimension if they would increase their internalization activities. Teams tasked with the design of integral products score only less bad on the efficiency dimension of project performance. This creation of explicit knowledge into tacit knowledge is connected to learning by experimenting (Schulze, 2006). The reasoning behind hypothesis 2d, suggesting that explicit knowledge on which teams developing modular products depend, drives internalization in these teams is thus not correct (Sanchez & Mahoney, 1996). It seems that the knowledge creation mode internalization harms project performance of teams developing integral products due to the fact that internalization is an individual activity. By experimenting team members gain individual mental models about technology specifications and customer needs. This will lead to a multitude of mental models of what the project entails in teams developing integral products which should create one single mental model (Schulze, 2006). These multiple viewpoints reduce the chance of creating common ground and communicating this tacit knowledge through the use of socialization. In development projects where there is high technical dependence and team members depend on each other when it comes to knowledge creation and design tasks, multiple mental models can be quite harmful as the data shows (Colfer & Baldwin, 2010; Schulze, 2006). Continuous experimentation also hinders project process as new tacit knowledge continuously alters the knowledge base (Schulze, 2006). This explains why there is such a negative association between the project efficiency and product dimension of project performance and internalization.

6.2.5 Moderating Effect of Modularity of Product Architecture on the Team Stability and Project Performance Relationship

Team stability seems an important factor especially for teams developing products with an integral product architecture, as predicted in hypothesis 3. The loss of knowledge when a team member would leave the team before the project was completed seems to be an important factor (Akgün & Lynn, 2002). The dependence of design tasks, reliance on knowledge creation with team members and the sequential design process in such teams explains why it is important to keep team members of the development team involved until project completion (Colfer & Baldwin, 2010; Sanchez & Mahoney, 1996). Interestingly, a positive association can be seen for teams developing highly modular products. The concurrent nature of these teams and independence of tasks would suggest that the performance dimensions of these teams would not be dependent on team stability (Sanchez & Mahoney, 1996). Furthermore these team members do not depend on each other concerning task interdependence and knowledge creation (Colfer & Baldwin, 2010). The fact that these team members play an important role when it comes to the integration of separate components could explain why a positive association is seen on some performance dimensions and teams stability (McCord & Eppinger, 1993). Integration of distinct complex components requires the knowledge of the whole team to be effectively communicated, to improve project success.

6.2.6 Moderating Effect of Modularity of Product Architecture on the Team Member Autonomy and Project Performance Relationship

The data supports hypothesis 5, which dictates that teams developing products with a modular product architecture will score higher on the performance dimensions relating to team autonomy than teams developing integral products. This relationship together with the fact that the data shows that teams developing modular products experience more autonomy is in line with previous studies stating that these kinds of teams experience less managerial control and have the freedom to perform their design tasks as they please. The independent and concurrent nature of their design tasks and independence of their reliance on knowledge from other team members furthermore ensures that this autonomy does not come into conflict with project performance (Colfer & Baldwin, 2010; Schulze, 2006)(Sanchez & Mahoney, 1996). Moreover the autonomy these team members experience ensures that decisions are made with relative speed and on local relevant information for specific design tasks. This quality of decision making directly translates in a higher score on all performance measures (J. Chen et al., 2010).

6.2.7 Moderating Effect of Modularity of Product Architecture on the Team Member Proximity and Project Performance Relationship

Dealing with the question whether the mirroring effect concerning team member proximity impacts project performance more positively for teams dealing with the development of integral products than for teams developing modular products, hypothesis 4 can be confirmed for some performance dimensions. Integral teams seem to benefit from increasing proximity when it comes to increasing their scores for market and project efficiency dimensions. The effect on the product dimension suggests that this measure does not improve with bringing team members of these teams closer together. For teams developing modular products increasing proximity would lead to a decrease in most of the performance measures. The dependence of team members developing integral teams on each other is greater concerning task interdependence and exchange and creation of knowledge (Colfer & Baldwin, 2010). Furthermore the sequential design process and tacit nature of interface specifications of these projects requires frequent communication (Sanchez & Mahoney, 1996). Bringing these team members closer together increases communication through socialization (Bulte & Moenaert, 1998). This confirms that particular teams dealing with the development of integral products benefit from increasing proximity. The close proximity of team members allows for swift and complete exchange of tacit information through face to face communication (Schulze, 2006). This in turn benefits the project as a whole. In teams dealing with modular product development the need to exchange tacit knowledge is not apparent as the design tasks are more independent and executed concurrently (Colfer & Baldwin, 2010; Sanchez & Mahoney, 1996). Restricting the search of team members to ensure that proximity of team members is quite close in teams designing modular products could lead to the selection of team members which might not be the best option given their expertise or experience. This in turn could be detrimental to product performance and the achievement of subsequent sales objectives.

6.2.8 Moderating Effect of Modularity of Product Architecture on the Information

Technology Usage and Project Performance Relationship

As hypothesized in hypothesis 6, the data shows that teams developing modular product benefit from increasing their information technology usage in order to increase their score on all performance dimensions. This suggests that the explicit nature of the knowledge relating to interface specifications on which these teams rely and the fact that these teams are more widely distributed, the use of IT-systems is essential (Sanchez & Mahoney, 1996). Another conclusion can be drawn from analysis of the data concerning teams developing integral products. The positive trend lines in scatter plots relating to product and market dimension of project performance suggests that teams developing integral products also benefit from increasing their IT-systems usage. The availability of sophisticated systems would allow team members to communicate more frequently and faster, increasing product and market performance of the developed product. A strong negative association for these teams can be seen between the project efficiency dimension of project performance and information technology usage. This could suggest that the increased use of information technology could lead to poorer performance. Again this could be due to the mismatch of the nature of the knowledge needed to be exchanged. The tacit nature of the knowledge on which these teams rely cannot be communicated through the use of IT-systems. The knowledge ambiguity of tacit knowledge needs a more information rich communication channel than IT-systems can provide (Söderquist, 2006; Van Wijk et al., 2008). Pieces of information might be lost resulting in poorer results concerning the achievement of time table objectives. Furthermore it could lead team members, developing products with a integral product architecture, to a sense of false security as the same information is not communicated through the use of socialization activities. Plotting the variable information systems usage against the variable socialization while discriminating for the variable modularity of product architecture with the use of subgroups, looking at the scatter plot in figure 36 confirms this. Furthermore it can be concluded that teams developing modular products use information systems as a vehicle for their socialization activities. It allows these team members to engage in discussions with people from other departments, besides planned formal meetings to create a common understanding of the NPD project.

7. MANAGERIAL IMPLICATIONS

The results of this research show that the improvement of NPD project performance is contingent on the product architecture of the product under development. It is thus important for managers or team leaders of such teams to monitor whether the architecture of the product under development project can be considered integral or modular. As said before, it is very rare to be able to characterize a product completely modular or completely integral (Colfer & Baldwin, 2010). Modular products can contain components which are integral in their structure and vice versa. Furthermore product architecture is not always clearly specified in the beginning of NPD projects. The evolving nature of product architecture suggests that managers should frequently monitor and review the nature of the product architecture (Sanchez & Mahoney, 1996).

Based on this knowledge managers can actively support or hinder certain knowledge creation modes. It can be important for teams developing products with an integral product architecture to increase team member proximity this will further increase knowledge creation through the use of socialization (Bulte & Moenaert, 1998). Socialization can be further supported by allowing team members to meet one another face-to-face in informal contexts such as lunch breaks(Schulze, 2006). Increasing team stability by preventing assignment of team members to other projects while the development project is still in development could also benefit these teams. These teams also benefit from increasing team member proximity when this is possible, The results of this research furthermore suggest that the same actions by managers leading modular teams could be very detrimental to project performance. These teams require also stable teams to ensure integration success of components and more autonomy to optimize their decision making concerning their relative independent design tasks (J. Chen et al., 2010; MacCormack et al., 2012). Extensive use of IT-systems should be stimulated and access to sophisticated IT-systems should be facilitated to these teams. Allowing team members of these teams to analyze and explicitly establish interface specifications is very important. These externalization activities transform tacit knowledge into explicit knowledge (Schulze, 2006). Next the ability to use analysis tools to further combine and systematically edit this knowledge is very important in increasing overall project performance.

NPD teams developing modular products benefit most from externalization and combination which should thus be actively supported by managers. This could include setting formal meetings with certain agenda goals which need to be met. This provides the basis for the separation of design tasks and ensures that team members work towards a common goal. By encouraging the use and making available documentation relating to previous development projects or company best practices ensures that combination activities can be performed. Furthermore the use of information technology was seen as an important factor influencing NPD project performance. Partly as it allows for these kinds of teams to engage in socialization activities. Making information technology available for these teams is thus essential.

Managers should keep in mind that increasing internalization activities of team members is not always beneficial to project performance. Especially in teams developing integral products, these activities will lead to the creation of multiple mental models concerning the project which reduces the basis for common ground. This individual activity makes team members less goal oriented (Schulze, 2006). Managers should make sure that experimentation regarding customer requirements and interface specifications is stopped once the development stages of the project start (Schulze, 2006).

8. THEORETICAL IMPLICATIONS

This research tried to solve some apparent gaps in literature concerning the mirroring hypothesis and the knowledge creation model.

Firstly this research shows the added benefit of using the knowledge creation model in the mirroring hypothesis context. Interesting results were generated in this research by recognizing the team interactions of NPD team members as being knowledge creation interactions. It shows that product architecture influences the intensity of certain knowledge creation modes and its impact on NPD project performance.

The break with prevalent mirroring hypothesis methodology concerning intra-organizational product development opens up the opportunity to test more team related variables. One could think of examining the use of intuitive and analytical information processing in teams developing products which differ in terms of product architecture.

The empirical use of the knowledge creation model in the context of NPD teams is also relatively new and has seen limited use in literature (Schulze, 2006). This research shows the validity of the empirical use of this model as it yields interesting results. Additionally the use of this model in an European context is also limited as the majority of studies involving the knowledge creation model focus on Asian organizations as the model originated from this region.

9. LIMITATIONS

The notion that product architecture cannot be deemed clear cut integral or modular creates some uncertainty when to use certain approaches. The evolving nature of product architecture and the fact that this is often not known at the beginning makes any of the suggested managerial actions reactive rather than proactive. This could lead to some loss of performance and organizations resources at the start of the project.

Furthermore this research did not discriminate when team members would engage in certain knowledge creation activities or when they experienced more autonomy, when team members left and whether the use of IT-systems changed throughout the duration of the project. Splitting the project in its concept and development phase as done in previous research, could provide additional insights in the effect of the mirroring hypothesis on project performance (Schulze, 2006). There are some results which might be explained when researchers would discriminate between the front end or back end of product development such as the use of socialization in teams developing modular products or the detrimental effects of internalization.

The most important limitation is the fact that this research draws it conclusions from statistical insignificant analysis. This makes it impossible to say whether the effects seen are truly affecting the variables. The absence of control variables cast even more doubt whether the conclusions drawn are accurate. The effects seen could be perhaps explained by other variables. The conclusions drawn from the trend lines plotted in the scatter plots can be furthermore questioned as some of the trend lines explain very little variance of the variables displayed. Readers should keep in mind that an increase in explained variance does not indicate improved reliability. The results could still be unreliable as the model on which the scatter plots are based are not statistical significant.

The sample size of twenty two respondents furthermore hinder the validity of the conclusions drawn from this study as this only a small part of the approached respondents. It would be wrong to conclude that the results represent the actual relationships of the entire population.

Lastly the data was collected through the use of a survey from one manager per project. Reliability of the results can be increased by surveying another member of the team or by including more objective measures based on documentation.

10. FUTURE RESEARCH

Although the findings of this research are statistically insignificant, future research could aid in either confirming or rejecting the conclusions drawn in this research. Additional data could allow for statistical testing of the hypotheses. This could further consolidate the notion that the use of the knowledge creation model in the NPD context is valid and yields interesting results. The impact on project performance of the mirroring effect can be described in more detail based on certain variables.

Furthermore additional research should take into account the phases of a NPD project. The surprising results yielded by this data, could be explained by examining the activities performed in certain project phases. Knowledge creation modes dealing with explicit knowledge such as externalization and combination could be beneficial in the development phases of a project where knowledge creation modes dealing with tacit knowledge could be beneficial in the concept phase of a NPD project. Understanding when these activities take place could lead to a more precise recommendation for managers.

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APPENDIX A: QUESTIONNAIRE

ORGANIZATIONAL VARIABLES

Name:

Age:

Gender:

Date employed at XXXXX:

Department:

Occupation:

Industries in which XXXXX operates:

Organizational climate: (C. J. Chen & Huang, 2007)

Innovative climate:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree							
Item 1: The firm provides incentive environment to promote innovation.	1	2	3	4	5	6	7
Item 2: The firm stimulates employees to be creative and innovative.	1	2	3	4	5	6	7
Item 3: The firm is actively committed on achieving innovations.	1	2	3	4	5	6	7

Cooperative climate:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree							
Item 1: The firm provides employees with needed support.	1	2	3	4	5	6	7
Item 2: Employees in the firm have a sense of security.	1	2	3	4	5	6	7

PRODUCT VARIABLES

Product modularity: measured on a seven-point likert scale ranging from strongly agree to strongly disagree.

Source:(Tiwana, 2008)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree *How well do the following statements characterize the relationships between components or sub-systems concerning the developed product?*	NPD project						
Item 1: Highly interoperable components or sub-systems.	1	2	3	4	5	6	7
Item 2: Stable, well-defined interfaces between components or sub-systems.	1	2	3	4	5	6	7
Item 3: Well-understood interdependencies between components or sub-systems.	1	2	3	4	5	6	7
Item 4: Minimal unnecessary interdependencies between components or sub-systems.	1	2	3	4	5	6	7

Innovation type: measured on a seven-point likert scale ranging from strongly agree to strongly disagree.

Source:(Sanchez & Mahoney, 1996)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
The NPD project focused on; A conscious change in product architecture or the way components or modules are connected.	1	2	3	4	5	6	7
The NPD project focused on; Developing a new component(s).	1	2	3	4	5	6	7
The NPD project focused on; Developing a new end product through the change of product architecture (the way components are connected) and the development of new component(s).	1	2	3	4	5	6	7

Project innovativeness: measured on a seven-point likert scale ranging from strongly agree to strongly disagree.

Source:(Zhou & Li, 2012)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The developed product displayed qualities that involve major improvements over previous technologies.	1	2	3	4	5	6	7
Item 2: The developed product displayed qualities which makes them hard to imitate or substitute while using older technologies.	1	2	3	4	5	6	7
Item 3: The developed product displayed qualities that brings a substantial transformation in consumption patterns in the market.	1	2	3	4	5	6	7

Product performance

Dependent variables

NPD project performance; measured on a seven -point likert scale ranging from strongly agree to strongly disagree.

Source: (Salomo, Weise & Gemünden, 2007)

Product dimension:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The product technical performance achieved its objectives.	1	2	3	4	5	6	7
Item 2: Product quality achieved its objectives.	1	2	3	4	5	6	7
Item 3: The products' manufacturability achieved its objectives.	1	2	3	4	5	6	7

Market dimension:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The product achieved its sales objectives.	1	2	3	4	5	6	7
Item 2: The product achieved its market share objectives.	1	2	3	4	5	6	7
Item 3: The product achieved its objectives in creating a competitive advantage.	1	2	3	4	5	6	7

Project Efficiency:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The project met planned budget objectives.	1	2	3	4	5	6	7
Item 2: The project met timetable objectives.	1	2	3	4	5	6	7
Item 3: The project met time to market objectives.	1	2	3	4	5	6	7

TEAM CHARACTERISTICS VARIABLES

NPD team characteristics; Control variables

Source:(Schulze, 2006), (Sivasubramaniam et al., 2012)

	NPD project
*Team size: H*ow many team members did the NPD team contain?	
Project duration: How long did it take to complete the NPD project measured in months?	
Team tenure: How long have, the majority of team members of this team, been working together measured in months?	

Functional diversity

Source: (Teachman, 1980) (Ancona & Caldwell, 1992)

Please fill out the functional diversity of the NPD team. Here technical expertise departments represent the diversity in departments dealing with different technologies. (eg. Electronic, chemical or mechanic engineering departments)

Functional Departments	Number of employees represented in NPD team developing the product
Research & Development :Technical expertise department 1 (eg. Electronic, chemical or mechanic engineering department)	
Research & Development : Technical expertise department 2 (eg. Electronic, chemical or mechanic engineering department)	
Research & Development : Technical expertise department 3 (eg. Electronic, chemical or mechanic engineering department)	
Research & Development : Technical expertise department 4 (eg. Electronic, chemical or mechanic engineering department)	
Research & Development : Technical expertise department 5 (eg. Electronic, chemical or mechanic engineering department)	
Manufacturing	
Marketing and Sales	
Information technology	
Human resource management	
Finance and Administration	
Purchasing	
Logistics	

Team leadership

Source: (Wang et al., 2005)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: Overall the team leader fostered collaboration	1	2	3	4	5	6	7
Item 2: Overall the team leader ensured intellectual stimulation	1	2	3	4	5	6	7
Item 3: Overall the team leader provided an appropriate model	1	2	3	4	5	6	7
Item 4: Overall the team leader communicated a high performance expectation	1	2	3	4	5	6	7
Item 5: Overall the team leader clearly articulated a vision	1	2	3	4	5	6	7
Item 6: Overall the team leader provided individual support	1	2	3	4	5	6	7

Team cohesiveness

Source: (Lee, 2007)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: Concerning this project, united employee effort was made in trying to reach the goals of the project.	1	2	3	4	5	6	7
Item 2: Concerning this project, employees really worked together as a team.	1	2	3	4	5	6	7
Item 3: Concerning this project, all team members would take responsibility for poor performance.	1	2	3	4	5	6	7
Item 4: Concerning this project, all employees have similar aspirations for the project performance.	1	2	3	4	5	6	7
Item 5: Concerning this project, team members actively tried to help members who coped with difficult work problems and tried to solve them together.	1	2	3	4	5	6	7

Goal clarity

Source: (Lynn et al., 1999)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The overall project goals were clear.	1	2	3	4	5	6	7
Item 2: The sales goals were clear.	1	2	3	4	5	6	7
Item 3: The team had a clear vision of the target market.	1	2	3	4	5	6	7
Item 4: The team had a clear understanding of target customers' needs and wants.	1	2	3	4	5	6	7
Item 5: The team had a clear vision of required product features	1	2	3	4	5	6	7
Item 6: The technical goals were clear.	1	2	3	4	5	6	7

Independent variables

Information technology usage: measured on a seven-point likert scale ranging from strongly agree to strongly disagree.

Source:(Akgün et al., 2008)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree *During this project, the team relied on the following tools to communicate with team members:*	NPD project						
Item 1: E-mail to fellow team members.	1	2	3	4	5	6	7
Item 2: Team messaging boards or team discussion forums.	1	2	3	4	5	6	7
Item 3: Shared electronic files.	1	2	3	4	5	6	7
Item 4: Electronic newsletters that covered project information.	1	2	3	4	5	6	7
Item 5: Teleconferencing	1	2	3	4	5	6	7
Item 6: Attaching audio/video files to electronic documents.	1	2	3	4	5	6	7
Item 7: A webpage dedicated to this project.							

Knowledge creation model: measured on a seven -point likert scale ranging from strongly agree to strongly disagree.

Source: (Schulze, 2006)

Socialization:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The NPD team spent a lot of time in personal interaction aside from organized meetings with other people in the team to discuss suggestions, ideas, or solutions.	1	2	3	4	5	6	7
Item 2: The NPD team spent a lot of time in personal interaction aside from organized meetings with people from other departments in the company in order to discuss suggestions, ideas or solutions.	1	2	3	4	5	6	7
Item 3: The NPD team spent a lot of time in intense discussions about suggestions, ideas, or solutions in face-to-face meetings with people from other departments in the company.	1	2	3	4	5	6	7
Item 4: The NPD team spent a lot of time in the conscious creation of a common understanding of a problem with people from other departments in the company.	1	2	3	4	5	6	7

Externalization:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The NPD team spent a lot of time reflecting collectively and framing their ideas or solutions with regard to customer needs.	1	2	3	4	5	6	7
Item 2: The NPD team spent a lot of time interviewing competent people about ideas or solutions with regard to relevant technologies.	1	2	3	4	5	6	7
Item 3: The NPD team spent a lot of time interviewing competent people about ideas or solutions with regard to customer needs.	1	2	3	4	5	6	7
Item 4: The NPD team spent a lot of time creating detailed descriptions (e.g., protocols, presentations, reports) containing newly developed knowledge about customer needs	1	2	3	4	5	6	7

Combination:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The NPD team systematically edited the technical knowledge collected.	1	2	3	4	5	6	7
Item 2: The NPD team systematically edited the knowledge collected about customer needs.	1	2	3	4	5	6	7
Item 3: The NPD team systematically edited the knowledge collected about the procedure of creating, evaluating, and selecting a product concept/developing products.	1	2	3	4	5	6	7
Item 4: The NPD team distributed their newly gained insights about customer needs within the organization.	1	2	3	4	5	6	7

Internalization:

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: In general the NPD team spent a lot of time in trial and error (experimenting), thereby developing a sense for the feasibility of their thoughts regarding the functionality of the technology.	1	2	3	4	5	6	7
Item 2: In general the NPD team spent a lot of time in trial and error (experimenting), thereby developing a sense for the feasibility of their thoughts regarding customer needs.	1	2	3	4	5	6	7
Item 3: In general the NPD team spent a lot of time in trial and error (experimenting), thereby developing a sense for the feasibility of their thoughts regarding the procedure of creating, evaluating, and selecting a product concept/developing products.	1	2	3	4	5	6	7
Item 4: In general the NPD team spent a lot of time systematically testing their theoretical knowledge about customer needs.	1	2	3	4	5	6	7

Team structure elements; measured on a seven-point likert scale ranging from strongly agree to strongly disagree.

Team stability

Source: (Akgün & Lynn, 2002)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: The project manager who started this project remained on from pre-prototype through launch.	1	2	3	4	5	6	7
Item 2: Department managers who were on the team remained on it from pre-prototype through launch.	1	2	3	4	5	6	7
Item 3: Team members who were on the team remained on it from pre-prototype through launch.	1	2	3	4	5	6	7

Team member autonomy

Source: (Amabile, Conti, Coon, Lazenby, & Amabile, 1996)

1 = Strongly disagree, 2 = somewhat disagree, 3 =disagree, 4 = neutral, 5 = agree, 6 = somewhat agree, 7 = strongly agree	NPD project						
Item 1: Members of the NPD team had the freedom to decide in their team how they are going to carry out their own projects.	1	2	3	4	5	6	7
Item 2: The members of the NPD team felt considerable pressure in their team to meet someone else's specifications in how they do their work.	1	2	3	4	5	6	7
Item 3: The NPD team members did not have the freedom in their team to decide what projects they were going to do.	1	2	3	4	5	6	7
Item 4: The NPD team members had in their daily work environment, a sense of control over their own work and their own ideas in the team.	1	2	3	4	5	6	7

Team member proximity, measured on a 1-7 scale, Please fill out one option.

Source: (Cabigiosu & Camuffo, 2012)

Where were the NPD team members located?	NPD project
1: NPD team members are located within the same office	1
2: NPD team members are located within the department or on the same floor.	2
3: NPD team members are located within the same organization.	3
4: NPD team members are located in the same region.	4
5: NPD team members are located in the same country.	5
6: NPD team members are located on the same continent.	6
7: NPD team members are located on different continents.	7

13. APPENDIX B: CONTROL VARIABLES

Func_divers – PPPD

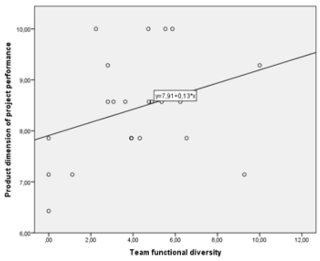

Figure B1: functional diversity and product dimension of project performance

Func_divers- PPMD

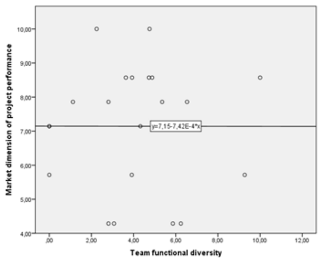

Figure B2: Functional diversity and market dimension of project performance

Func_divers- PPPE

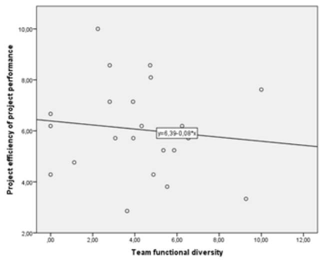

Figure B3: Functional diversity and project efficiency dimension of project performance

Team size – PPPD

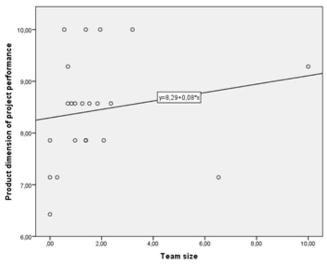

Figure B4: Team size and product dimension of project performance

Team size- PPMD

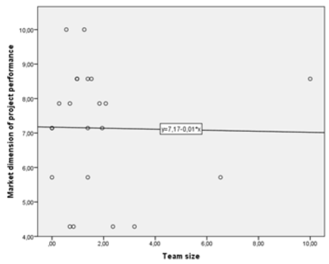

Figure B5: Team size and market dimension of project performance

Team size- PPPE

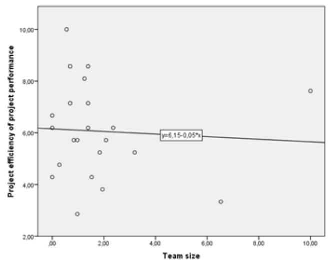

Figure B6: Team size and project efficiency dimension of project performance

Goal clarity – PPPD

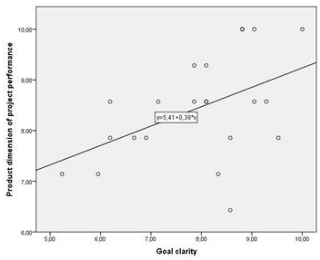

Figure B7: Goal clarity and product dimension of project performance

Goal clarity- PPMD

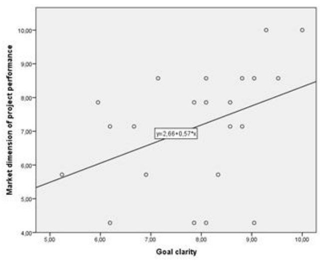

Figure B8: Goal clarity and market dimension of project performance

Goal clarity- PPPE

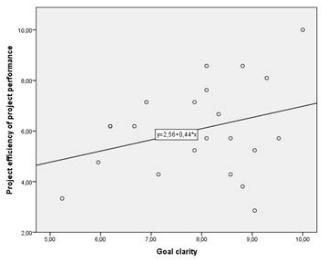

Figure B9: Goal clarity and project efficiency dimension of project performance

Team leadership – PPPD

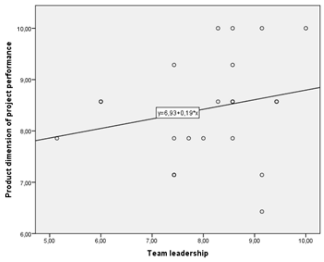

Figure B10: Team leadership and product dimension of project performance

Team leadership- PPMD

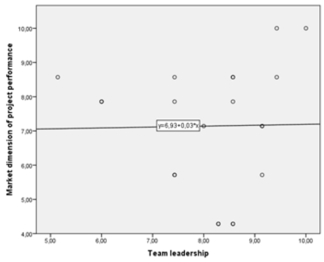

Figure B11: Team leadership and market dimension of project performance

Team leadership- PPPE

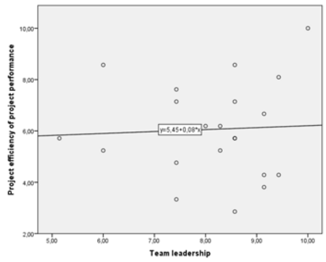

Figure B12: Team leadership and project efficiency dimension of project performance

Team cohesiveness – PPPD

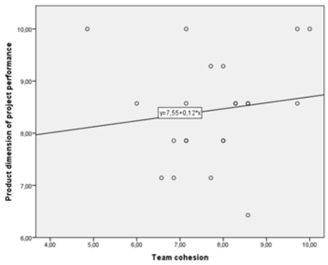

Figure B13: Team cohesiveness and product dimension of project performance

Team cohesiveness- PPMD

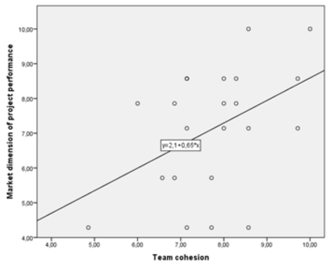

Figure B14: Team cohesiveness and market dimension of project performance

Team cohesiveness- PPPE

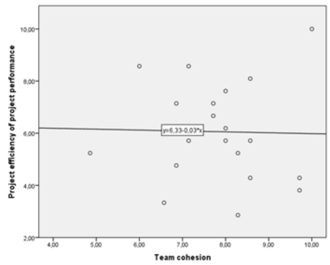

Figure B15: Team cohesiveness and project efficiency dimension of project performance

Team tenure – PPPD

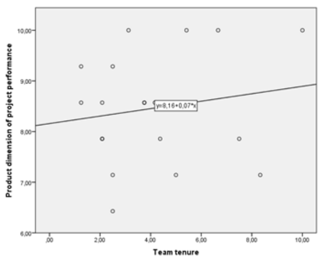

Figure B16: Team tenure and product dimension of project performance

Team tenure- PPMD

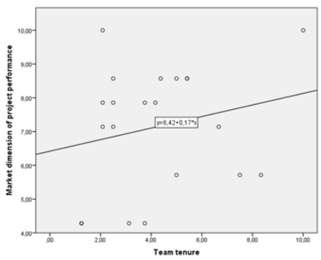

Figure B17: Team tenure and market dimension of project performance

Team tenure- PPPE

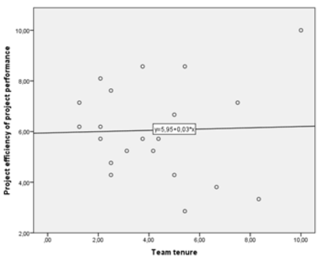

Figure B18: Team tenure and project efficiency dimension of project performance

Innovative climate – PPPD **Innovative climate- PPMD** **Innovative climate- PPPE**

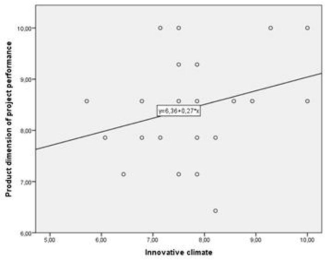

Figure B19: innovative climate and product dimension of project performance

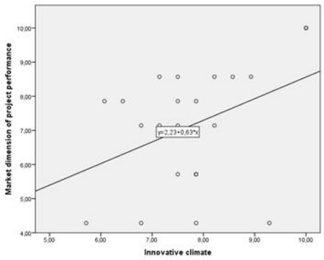

Figure B20: innovative climate and market dimension of project performance

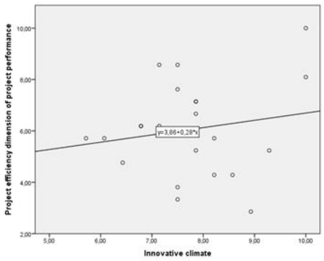

Figure B21: innovative climate and project efficiency dimension of project performance

14. APPENDIX C: SCATTER PLOTS PREDICTING EFFECT OF PRODUCT MODULARITY ON KNOWLEDGE CREATION MODES, TEAM MEMBER AUTONOMY, TEAM MEMBER PROXIMITY, TEAM STABILITY AND INFORMATION TECHNOLOGY USAGE

KCS –PM

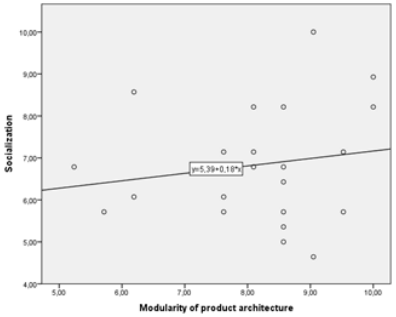

Figure C1: Knowledge creation mode socialization and modularity of product architecture

KCE –PM

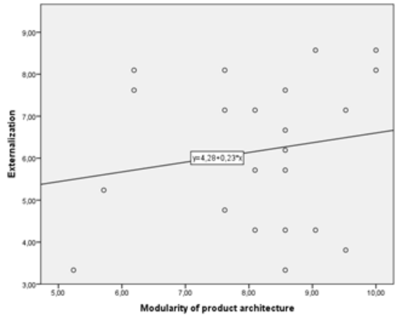

Figure C2: Knowledge creation mode externalization and modularity of product architecture

KCC –PM

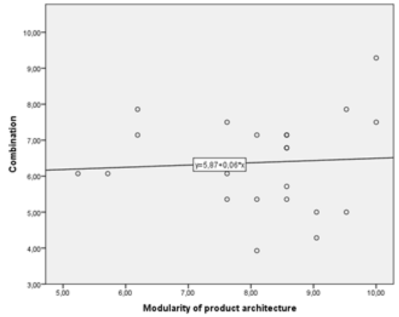

Figure C3: Knowledge creation mode combination and modularity of product architecture

KCI -PM

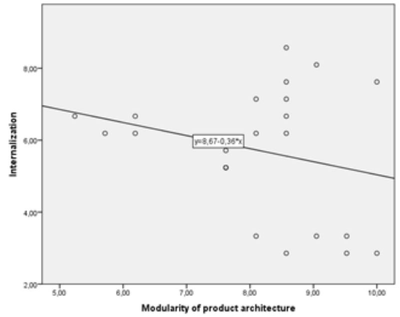

Figure C4: Knowledge creation mode internalization and modularity of product architecture

TS-PM

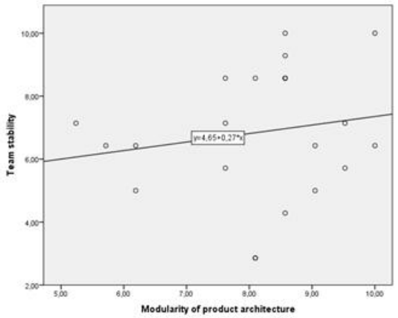

Figure C5: team stability and modularity of product architecture

TMA-PM

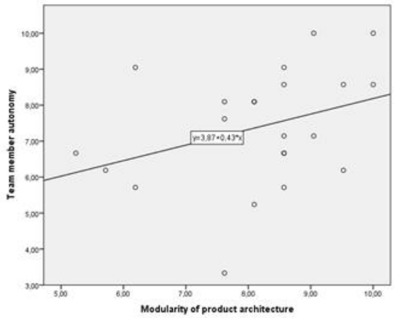

Figure C6: team member autonomy and modularity of product architecture

TM_prox-PM

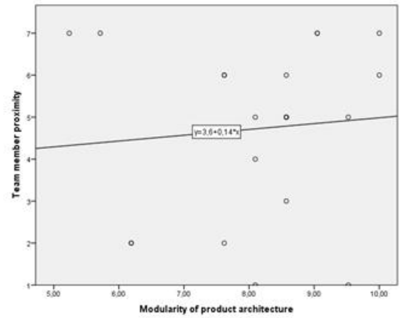

Figure C7: team member proximity and modularity of product architecture

ITU-PM

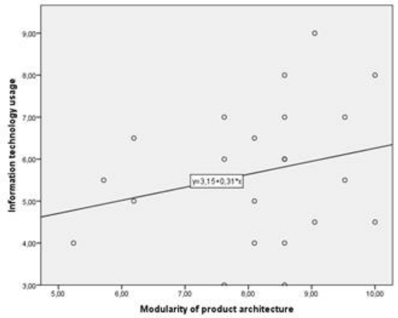

Figure C8: Information technology usage and modularity of product architecture

APPENDIX D: SCATTER PLOTS PREDICTING PROJECT PERFORMANCE

PPPD –KCS

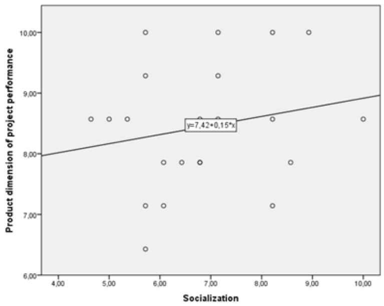

Figure D1: Knowledge creation mode socialization and Product dimension of project performance

PPMD-KCS

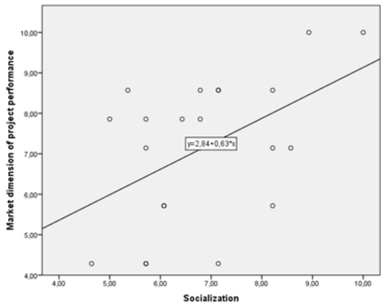

Figure D2: Knowledge creation mode socialization and market dimension of project performance

PPPE-KCS

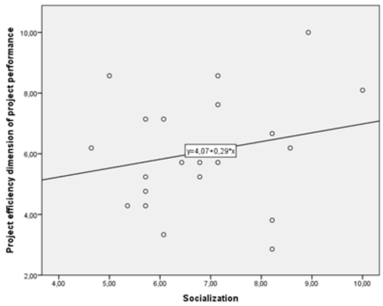

Figure D3: Knowledge creation mode socialization and project efficiency dimension of project performance

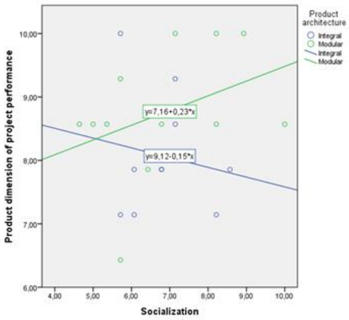

Figure D4: Knowledge creation mode socialization and Product dimension of project performance with subgroups relating to modularity of product architecture

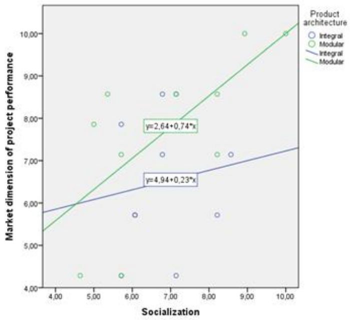

Figure D5: Knowledge creation mode socialization and market dimension of project performance with subgroups relating to modularity of product architecture

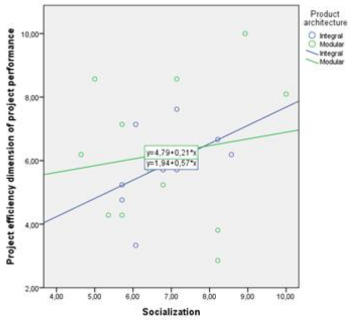

Figure D6: Knowledge creation mode socialization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –KCE **PPMD-KCE** **PPPE-KCE**

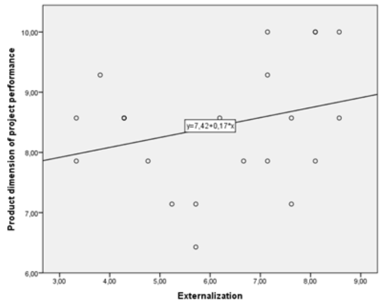

Figure D7: Knowledge creation mode externalization and Product dimension of project performance

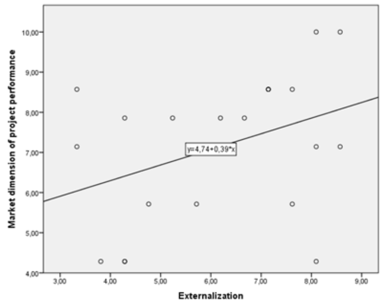

Figure D8: Knowledge creation mode externalization and market dimension of project performance

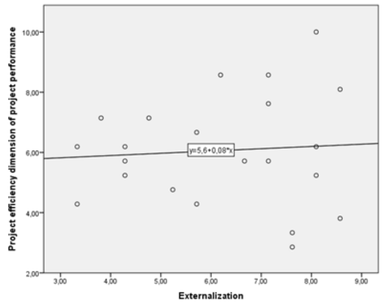

Figure D9: Knowledge creation mode externalization and project efficiency dimension of project performance

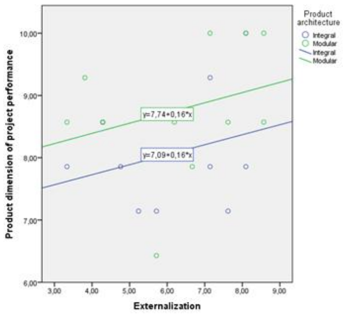

Figure D10: Knowledge creation mode externalization and Product dimension of project performance with subgroups relating to modularity of product architecture

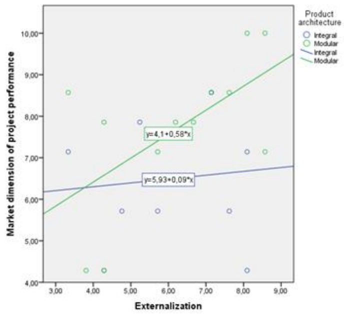

Figure D11: Knowledge creation mode externalization and market dimension of project performance with subgroups relating to modularity of product architecture

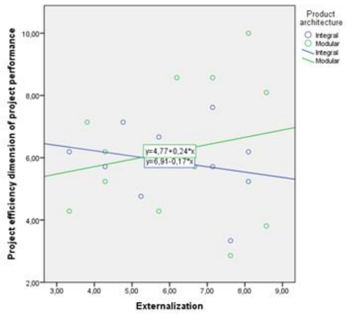

Figure D12: Knowledge creation mode externalization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –KCC **PPMD-KCC** **PPPE-KCC**

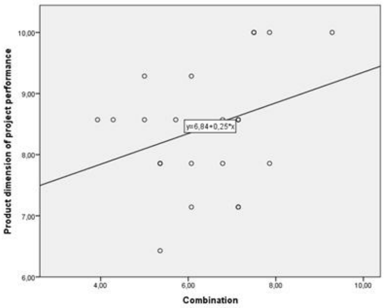

Figure D13: Knowledge creation mode combination and Product dimension of project performance

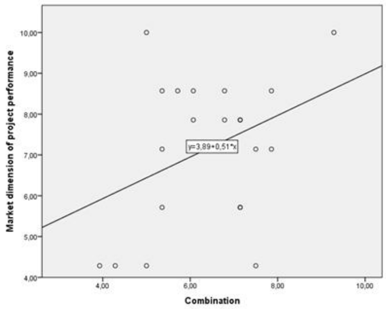

Figure D14: Knowledge creation mode combination and market dimension of project performance

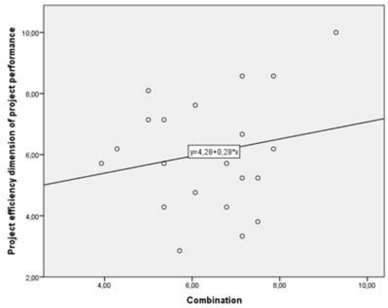

Figure D15: Knowledge creation mode combination and project efficiency dimension of project performance

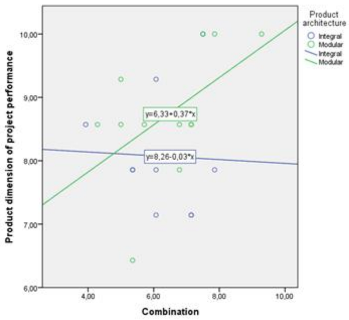

Figure D16: Knowledge creation mode combination and Product dimension of project performance with subgroups relating to modularity of product architecture

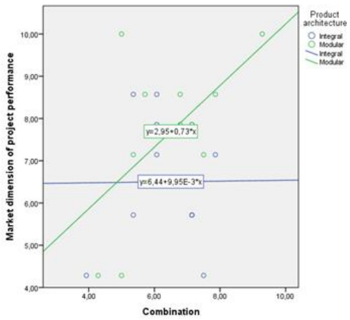

Figure D17: Knowledge creation mode combination and market dimension of project performance with subgroups relating to modularity of product architecture

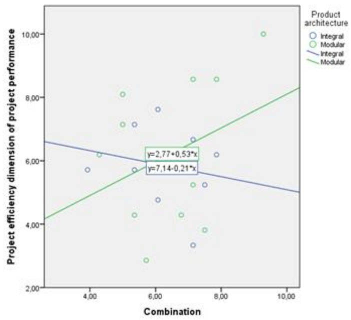

Figure D18: Knowledge creation mode combination and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –KCI **PPMD-KCI** **PPPE-KCI**

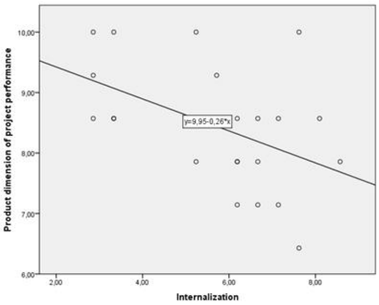

Figure D19: Knowledge creation mode internalization and Product dimension of project performance

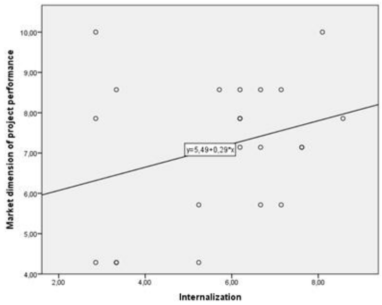

Figure D20: Knowledge creation mode combination and market dimension of project performance

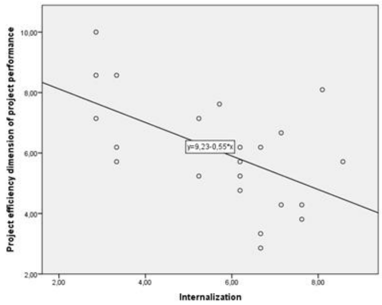

Figure D21: Knowledge creation mode combination and project efficiency dimension of project performance

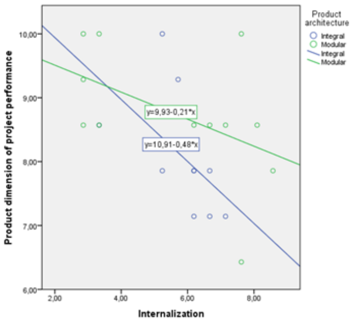

Figure D22: Knowledge creation mode internalization and Product dimension of project performance with subgroups relating to modularity of product architecture

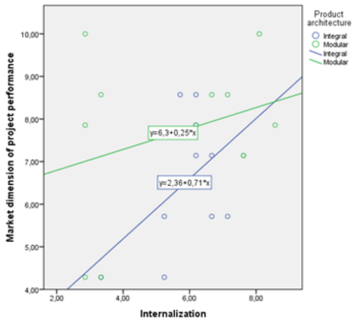

Figure D23: Knowledge creation mode internalization and market dimension of project performance with subgroups relating to modularity of product architecture

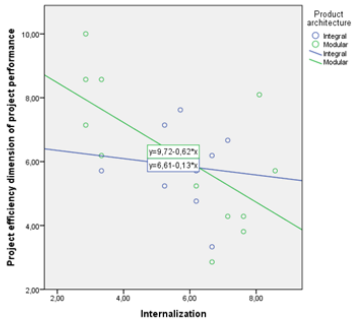

Figure D24: Knowledge creation mode internalization and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –TS **PPMD-TS** **PPPE-TS**

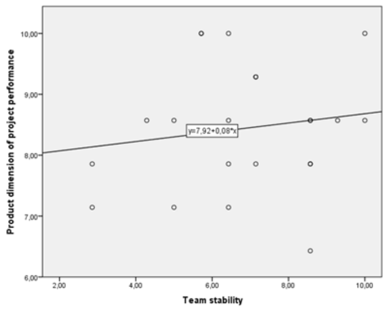

Figure D25: Team stability and Product dimension of project performance

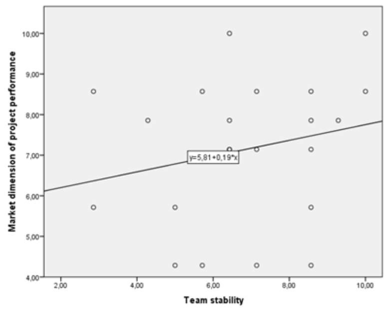

Figure D26: Team stability and market dimension of project performance

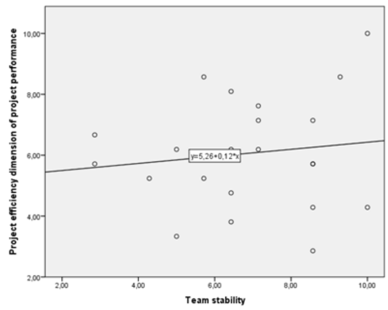

Figure D27: Team stability and project efficiency dimension of project performance

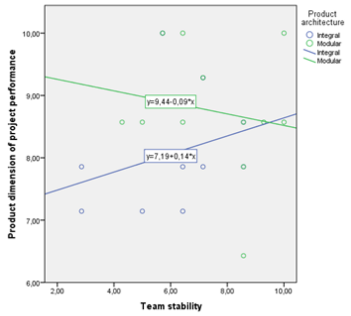

Figure D28: Team stability and Product dimension of project performance with subgroups relating to modularity of product architecture

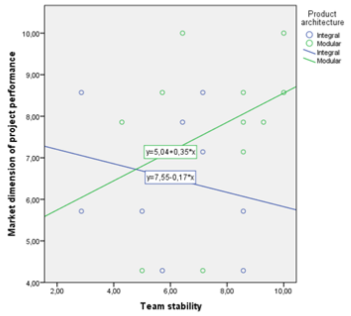

Figure D29: Team stability and market dimension of project performance with subgroups relating to modularity of product architecture

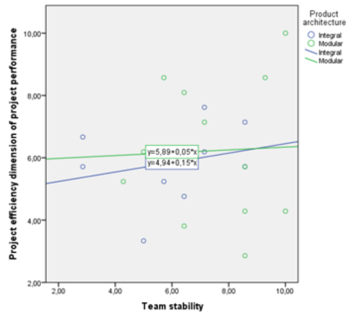

Figure D30: Team stability and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –TMA **PPMD-TMA** **PPPE-TMA**

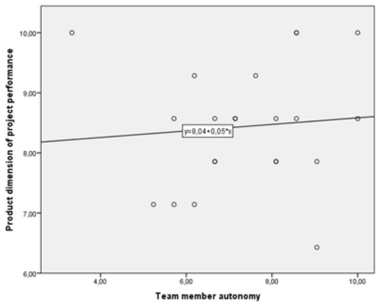

Figure D31: Team member autonomy and Product dimension of project performance

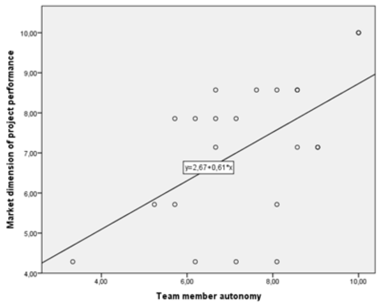

Figure D32: Team member autonomy and market dimension of project performance

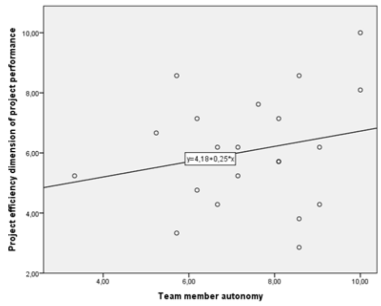

Figure D33: Team member autonomy and project efficiency dimension of project performance

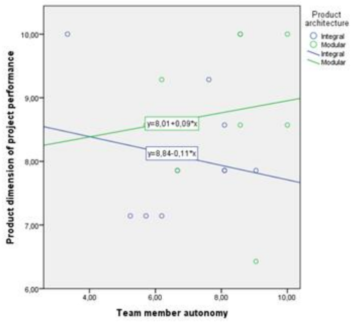

Figure D34: Team member autonomy and Product dimension of project performance with subgroups relating to modularity of product architecture

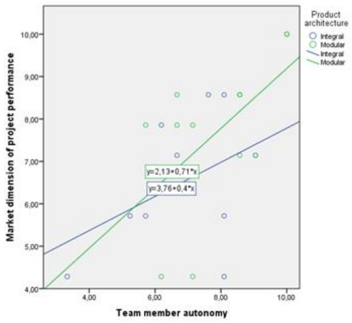

Figure D35: Team member autonomy and market dimension of project performance with subgroups relating to modularity of product architecture

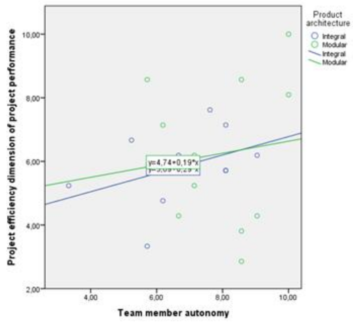

Figure D36: Team member autonomy and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –TM_prox

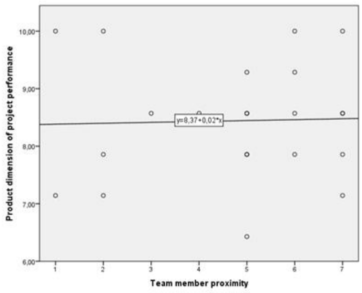

Figure D37: Team member proximity and Product dimension of project performance

PPMD-TM_prox

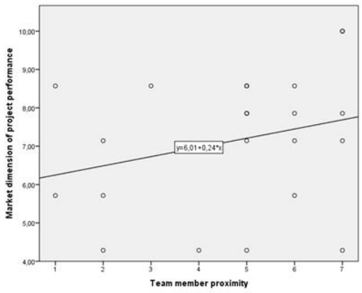

Figure D38: Team member proximity and market dimension of project performance

PPPE-TM_prox

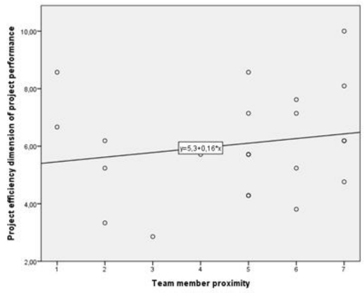

Figure D39: Team member autonomy and project efficiency dimension of project performance

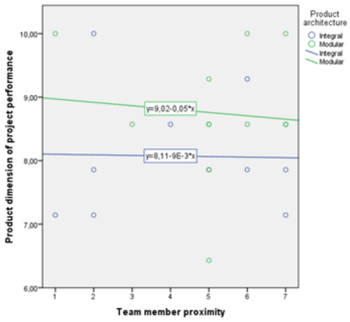

Figure D40: Team member proximity and product dimension of project performance with subgroups relating to modularity of product architecture

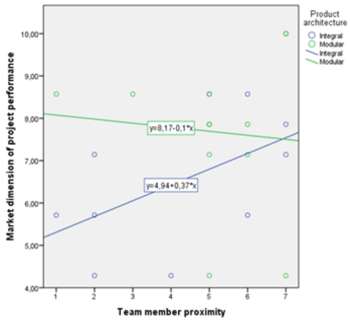

Figure D41: Team member proximity and marker dimension of project performance with subgroups relating to modularity of product architecture

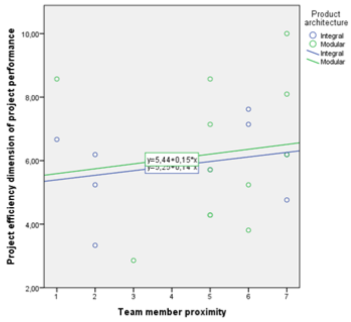

Figure D42: Team member proximity and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

PPPD –ITU **PPMD-ITU** **PPPE-ITU**

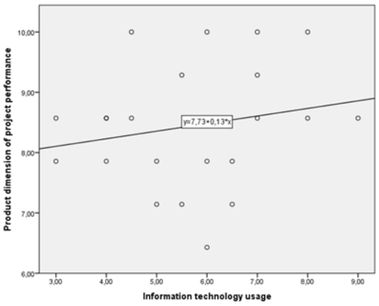

Figure D43: Information technology usage and Product dimension of project performance

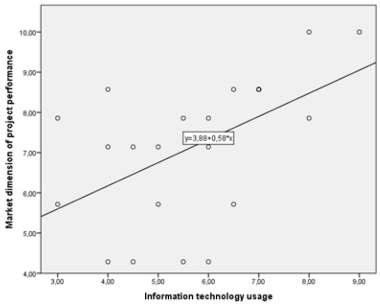

Figure D44: Information technology usage and market dimension of project performance

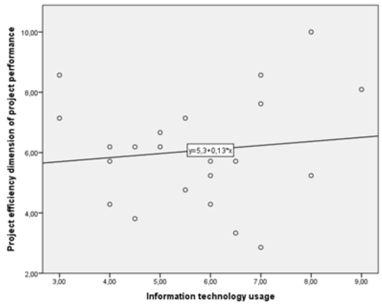

Figure D45: Information technology usage and project efficiency dimension of project performance

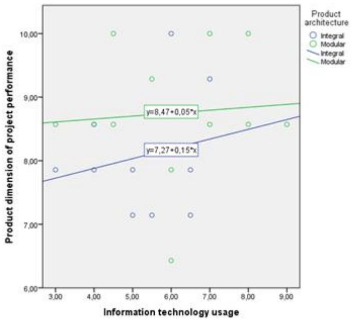

Figure D46: Information technology usage and Product dimension of project performance with subgroups relating to modularity of product architecture

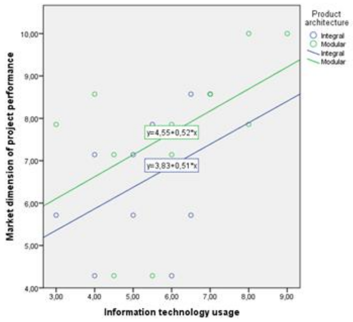

Figure D47: Information technology usage and market dimension of project performance with subgroups relating to modularity of product architecture

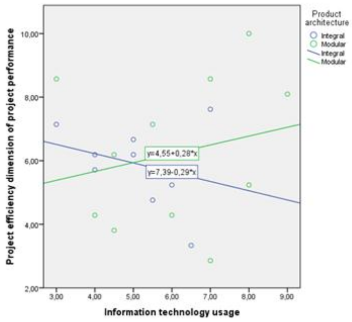

Figure D48: Information technology usage and project efficiency dimension of project performance with subgroups relating to modularity of product architecture

15. APPENDIX E: ADDITIONAL TESTING

KCS - ITU

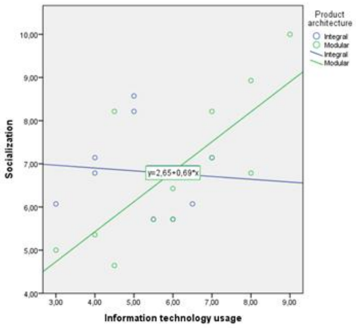

Figure E1: Knowledge creation mode socialization and information technology usage with subgroups relating to modularity of product architecture