Bachelor Thesis

Organizing supplier involvement in NPD: Patterns in the Portuguese automotive parts and components industry

An empirical research on the New Product Manufacturability

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Preface

This research report presents my Bachelor Thesis of the Bachelor study Business Administration of the University of Twente in Enschede. From April until October 2007, I have conducted the described research in The Netherlands and Portugal.

The research is part of the 'Patterns in NPD' project, an emergent European research project, which searches for consistent NPD configurations for sustained innovation. It aims to develop knowledge in the new product development (NPD) area, by describing, exploring, and analyzing the organization of innovation in different industries across Europe and Australia. This report focuses on the Portuguese automotive parts and components industry where the influence of supplier involvement in NPD on the integration between R&D and manufacturing is researched because problems arose in New Product Manufacturability (NPM). This research is made possible thanks to the cooperation of **11** organizations active in the Portuguese automotive parts and components industry.

During this research, I spent time at the 'Capitool' of the Twente University in order to prepare and finalize this research. Therefore, I would like to thank my supervisors Dr. Ir. P.C. De Weerd-Nederhof and Dr. Ir. P. Terlouw for their comments, support, feedback, and help on the aspects of NPD and methodology during this research. In addition, special thanks go to Tiago Ratinho, a Portuguese PhD student who helped me a lot during the preparations of my stay in Portugal.

Of course, the most important period of this research was between April and July 2007, when I spent three months at ISPA University in Lisbon, Portugal. Frankly speaking, I have had one of the most beautiful experiences in my life. This was also due to the hospitality of the Portuguese people who welcomed me warmly. My special thanks go to Dr. Ir. Jorge F.S. Gomes, my supervisor from ISPA who really treated me as a researcher instead of a student, and helped me with lots of aspects, within and outside this research. Moreover, special thanks go to Manuel Correia for the support on translations. And for becoming a real friend, who helped me discover Lisbon and the Portuguese way of life. Still, I have to mention some names of people from ISPA because they really helped me along this period; Ana Margarido, Teresa Oliveira, Miguel Lopes & Patrícia Palma, and of course Margarida Piteira. Muito Obrigado!

Some special gratitude goes to my parents, brother, sister, and my girlfriend, who helped me through this time by 'Skyping' every day, and especially by visiting me in Lisbon! Thank you!

Hengelo, October 2007

Daniël J.E. Giesen

Voorwoord

Dit onderzoeksrapport presenteert mijn Bachelor afstudeerverslag van de studie Bedrijfskunde aan de Universiteit Twente in Enschede. Het onderzoek dat in dit rapport wordt beschreven werd tussen april en oktober 2007 uitgevoerd in Nederland en Portugal.

Dit onderzoek maakt deel uit van het 'Patterns in NPD' onderzoeksproject, een Europees onderzoeksproject gericht op het zoeken naar consistente NPD configuraties voor aanhoudende innovatie. Het doel is om kennis te ontwikkelen in de nieuwe product ontwikkelingsgebieden door het beschrijven, verkennen, en analyseren van de organisatie van innovatie in verschillende industrieën verspreid over Europa en Australië. De focus van dit rapport ligt op de Portugese automotive onderdelen- en componentenindustrie, en de invloed van leverancierbetrokkenheid in NPD op de integratie tussen R&D en fabricage om problemen te boven te komen, die ontstaan zijn in de maakbaarheid van nieuwe producten (NPM). Dankzij de medewerking van **11** organisaties actief in de Portugese automotive onderdelen- en componentenindustrie kon dit onderzoek uitgevoerd worden.

Voor de uitvoering van dit onderzoek heb ik veel tijd gespendeerd op het 'Capitool' van de Universiteit Twente zodat ik het onderzoek kon voorbereiden en afronden. Daarom wil ik mijn begeleiders Dr. Ir. P.C. De Weerd-Nederhof en Dr. Ir. P. Terlouw bedanken voor hun commentaar, ondersteuning, feedback, en hulp tijdens dit onderzoek betreffende nieuwe product ontwikkeling en methodologie. Ook gaat speciale dank uit naar Tiago Ratinho, PhD student op de Universiteit Twente, die mijn veel heeft geholpen tijdens de voorbereidingen van mijn verblijf in Portugal.

Maar de belangrijkste periode in de uitvoering van dit onderzoek was tussen april en juli 2007, toen ik 3 maanden heb mogen verblijven op ISPA in Lissabon, Portugal. Ik moet eerlijk bekennen dat dit één van de meest geweldige ervaringen uit mijn leven is geweest. Dit was dankzij de gastvrijheid en de warme ontvangst van de Portugezen. Mijn speciale dank gaat uit naar Dr. Ir. Jorge F.S. Gomes, mijn begeleider van ISPA die mij echt als een 'onderzoeker' heeft behandeld in plaats van een student, en mij geholpen heeft met heel veel dingen, zowel binnen als buiten mijn onderzoek. Ook gaat mijn speciale dank uit naar Manuel Correia voor zijn ondersteuning tijdens het vertalen van de questionnaires en voor het worden van een echte vriend, die mij heeft geholpen in de ontdekking van Lissabon en de Portugese manier van leven. Naast deze twee personen zijn er nog een aantal mensen van ISPA die mij in deze periode hebben ondersteund; Ana Margarido, Teresa Oliveira, Miguel Lopes & Patrícia Palma, en natuurlijk Margarida Piteira. Muito Obrigado!

Ook gaat mijn speciale dank uit naar mijn ouders, broer, zus en natuurlijk mijn vriendin. Zij hebben mij door deze tijd geholpen door er voor mij te zijn, zeker op Skype elke dag, en door mij te bezoeken waardoor ik een geweldige tijd met ze heb mogen beleven in Lissabon. Echt super bedankt!

Hengelo, oktober 2007

Daniël J.E. Giesen

Management Summary

Rationale

In a pre-analysis, a situation is outlined where difficulties are identified in the integration between R&D and manufacturing in the automotive industry. Due to these difficulties, problems arise in New Product Manufacturability (NPM). These difficulties influence the performance in manufacturing. Manufacturing is an important issue in the automotive industry, because of the dependencies of suppliers in the whole supply chain. Even suppliers can contribute to the NPD process and influence the New Product Manufacturability. This research tries to identify if there are specific relations between the involvement of suppliers in NPD and the R&D/Manufacturing integration. This relationship identification is researched in Portugal. The country is actively involved in the automotive industry. Nonetheless, there are some difficulties due to globalization of markets, delocalization of production, technological innovation, and internal competition.

Objective

The research objective of this Bachelor Thesis is to explore whether organizations involve suppliers in NPD and to what extent this involvement relates to the efficiency in the integration between R&D and manufacturing.

Theoretical recommendations

Based on the conclusions of literature study, it is possible to establish the best practices for supplier involvement in NPD. The involvement of suppliers can be separated in several areas, which all have influence on the role suppliers play in the NPD process: supplier characteristics, supplier performance and competition, degree of supplier involvement in NPD and the organization of supplier involvement in NPD. The best practices are tested in the field to explore whether organizations use them to make improvements in their cooperation with suppliers. Organizations in the Portuguese automotive parts and components industry, which come up to these expectations are recognized as successful organizations. This leads to better development team integration processes (manufacturing involvement in NPD, collaborative team environment, and top management support). According to literature, these processes have a positive influence on the R&D/Manufacturing integration and additionally on the performance in New Product Manufacturing.

Research questions

The main research question of this Bachelor Thesis is:

In what way is the involvement of suppliers in NPD at Portuguese automotive parts and components organizations influencing the integration between R&D and manufacturing?

This main research question can be divided in several sub questions:

1. *What is the R&D/Manufacturing integration of organizations in the Portuguese automotive parts and components industry?*
2. *What are the 'internal' development team integration processes at organizations in the Portuguese automotive parts and components industry?*
3. *To what extent involve organizations in the Portuguese automotive parts and components industry suppliers in NPD?*
4. *What is the relation between the 'internal' development team integration processes and the R&D/Manufacturing integration?*
5. *What is the relation between the supplier involvement in NPD and the 'internal' development team integration processes?*
6. *To what extent is there a (direct) relationship between the supplier involvement in NPD and the R&D/Manufacturing integration?*

Results

A thorough investigation is made in the Portuguese automotive parts and components industry during Spring and Summer 2007. Two sub-businesses are distinguished; stamping and die casting parts.
The empirical results indicated that organizations score diversely on the R&D/Manufacturing integration; organization 1 (plastics), 7 (electrical wiring) and 11 (die casting parts) score very good. Die casting parts organizations (6 & 11) score above average. Organization 2 (textiles), 4 (stamping), 9 (exhaust systems), and 10 (stamping) score below average. Manufacturing problems, which rise in the production start-up phases, are the wrongdoers. In comparing the pre-analysis data and the Portuguese data, we conclude that the R&D/Manufacturing integration is slightly higher at the Portuguese organizations subject to this research compared with the data from the other countries within the 'Patterns in NPD' project.

The empirical results on the development team integration processes indicate that the manufacturing involvement in NPD is very high. Thus, the manufacturing department is involved in NPD and there is a lot of communication between the two departments. The scores on the collaborative team environment are even higher. However, in this environment, organizations not always use cross-functional integration in their NPD processes and roles.
The top management support has the highest scores. Yet this support is not always set clear or fixed in the organization. In the individual organizational results, it is visible that organization 1, 3 (window lifters), and 7 score high on the development team integration processes; organizations 6, 9, and 11 score below average on this variable. The die casting parts organizations have not developed these processes enough, especially the manufacturing involvement in NPD and the collaborative team environment.

The supplier involvement in NPD can be analyzed with several empirical results. It has been proven that to manage suppliers in NPD an organization needs attention for several aspects, such as supplier characteristics, performance and competition of the supplier, and how to organize the supplier involvement in NPD. Despite the fact that scores are above average on the supplier characteristics, performance and competition, the organization of supplier involvement in NPD measures scores below. Organizations in the Portuguese automotive parts and components industry have a lower degree relationship with their suppliers in NPD. Individual organization scores prove this; organizations 8 (metalworking tools), 9 and 11 have problems with managing suppliers. In addition, the die casting parts organizations are not managing suppliers in NPD successfully.
Yet organization 1, 2 and 3 score high in managing suppliers in NPD. In addition, stamping organizations score high on this aspect. These organizations create value with their supplier management.

The explorative data analysis pointed out the following results.
There is an indication given for a positive but weak relation between the development team integration processes and the R&D/Manufacturing integration. Moreover, there is a stronger relation between the processes and the management of supplier involvement in NPD. The individual organization results are varied. Organizations 1, 3, and 7 indicate that they have positive relations between the processes and the R&D/Manufacturing integration, and the management of supplier involvement in NPD.

In addition, an indication is given of a possible relation between the management of supplier involvement in NPD and the R&D/Manufacturing integration. This relation is measured. Organizations 1, 3, and 7 indicate a different pattern compared to the rest of the organizations; they score very good. These organizations operate in the plastics, head linings, and the electrical wiring businesses. Based on these results, an increase of the management of supplier involvement in NPD is suggested to lead to an increase in the R&D/Manufacturing integration.

Referring to the formulated propositions:

- **Proposition 1:** *'At organizations in the Portuguese automotive parts and components industry, there exist a measurable and positive relationship between the level of supplier involvement in NPD and the efficiency of the R&D/Manufacturing integration.'*

- **Proposition 2:** *'At organizations in the Portuguese automotive parts and components industry, the supplier involvement in NPD influences the R&D/Manufacturing integration through the 'internal' development team integration processes.'*

Due to the small difference between the tested relations, both propositions can be accepted, although there is a negligible difference between the tested relations. It is more likely that the development team integration processes influence the relation between the management of supplier involvement in NPD and the integration of R&D and manufacturing. This can be visualized in a research model, which is presented in the figure below.

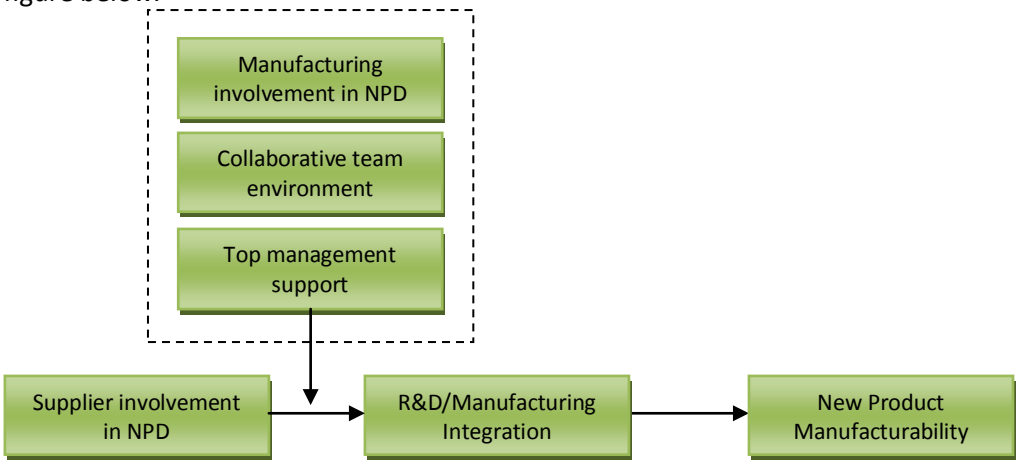

Figure: Model of empirical tested relations

Further research

Because a positive effect of supplier involvement in NPD on R&D/Manufacturing integration is proven, the organizations, which are not following the best practices formulated on the management of supplier involvement in NPD, should reconsider their organization of supplier involvement in NPD to overcome problems in NPM.

This research gave a first insight to manage this cooperation. Literature needs to be developed to continue the research in this area. Moreover, because scales were not available on the supplier involvement in NPD, these were developed specially for this research. These scales need to be tested in different areas to see if they are valid.

Literature was used and combined to define these scales. The result was a specific analysis on the aspects of supplier involvement in NPD and the R&D/Manufacturing integration. These scales and specific analysis have to be used in further research.

More than 230 organizations are already in the dataset of the 'Patterns in NPD' database. However, these organizations have not participated in the research concerning supplier involvement in NPD. Testing such propositions outside the automotive industry and investigate the whole 'Patterns in NPD' dataset on the supplier involvement in NPD will be interesting.

Research limitations

The conducted research described in this report used a dataset of **11** organizations in the Portuguese automotive parts and components industry. All these organizations are originally Portuguese. An implication is that the conclusions are only valid for the Portuguese automotive parts and components industry and not for the entire automotive parts and components industry. For general applicability, further research in this industry needs to be conducted.

Content

Introduction

This report contains the final step of my Bachelor phase of the study Business Administration. I chose to participate in the 'Patterns in New Product Development (NPD)' project due to my interest in innovation management and following the Innovation Management master track.

'The 'Patterns in NPD' project is an emerging European research project based on the assumption that an in-depth, holistic understanding of the relationships between NPD purposes and activities, organization and situational factors, and its impact on performance, will contribute to the identification of consistent configurations in NPD. The project sets out to describe a large number and variety of NPD configurations (organizational forms) in relation to their environment and purposes (functions), and relate these to performance'. (www.patterns-in-npd.com)

It investigates whether different types of consistent NPD configurations might be identified through a quantitative research design. Use is made of the 'Patterns in NPD' questionnaire for the data collection. The selected organizations for this research need to have a R&D/NPD department with a specific amount of New Product Development. Moreover, the organizations must have a Portuguese origin and need to be a first-, second- or lower-tier supplier of the Original Equipment Manufacturer (OEM) in the automotive industry.

My research tries to discover what the difficulties are in the integration between R&D and manufacturing in the automotive industry. Due to these difficulties, problems arise in New Product Manufacturability (NPM). This influences the performance in manufacturing. Manufacturing is an important issue in the automotive industry, because of the dependencies of suppliers in the whole supply chain. Even suppliers can contribute to the NPD process and influence the New Product Manufacturability.

Use is made of a specially developed questionnaire next to the 'Patterns in NPD' questionnaire to gather the right information concerning supplier involvement in NPD. Due to interests in car manufacturing, I will research the automotive parts and components industry, where the focus is on the supply to Original Equipment Manufacturers (OEM's). The country chosen to conduct this research is Portugal. Portugal has plants of international car manufacturers. The automotive sector is developed relatively well with many first- and second-tier suppliers. Moreover, the automotive sector plays an important role in the export of Portugal. Referring to the 'Patterns in NPD' project, Portugal was part of the preliminary analysis, but not yet of the actual data collection. To accomplish my Bachelor Thesis and collect data for the 'Patterns in NPD' project, this research is conducted in Lisbon at ISPA ('Instituto Superior de Psicologia Aplicada').

1. Problem analysis

Preliminary to this research, data is analyzed that is already gathered for the 'Patterns in NPD' project. Some automotive organizations participated in this project. These organizations are established in several countries; the Netherlands, Australia, the Slovak Republic, and Norway (N=20). Paragraph 1.1 describes the results of this data analysis, followed by paragraph 1.2 concerning R&D/Manufacturing integration.

1.1 'Patterns in NPD' in the automotive industry

The gathered data is selected on NPD performance to see if patterns can be identified. The NPD performance is a specific manner to measure innovation performance. Figure A1.1 in Appendix 1 gives an outline of the NPD performance as formulated by De Weerd-Nederhof et al. (2002) According to De Weerd-Nederhof et al. (2002, p.3), the NPD performance has two dimensions; Operational Effectiveness and Strategic Flexibility, reflecting a short and a longer-term view. Operational Effectiveness refers to the effectiveness of today's work: the degree to which NPD processes contribute to realizing the innovation goals set by the organization. Strategic Flexibility refers to the readiness to adapt to, anticipate, or create future NPD performance requirements.

1.1.1 Operational Effectiveness and Strategic Flexibility

The data comes from questions 21-24 of the 'Patterns in NPD' questionnaire (Appendix 3). The overall review of the database points out that in the automotive industry, the Operational Effectiveness is 4.7 on a scale of 7 (Appendix 1). Thus, NPD processes contribute reasonably well to realizing the innovation goals set by the organization. Furthermore, the Strategic Flexibility is 4.6 on a scale of 7. (Appendix 2) Organizations in the automotive industry are reasonably well prepared to adapt to, anticipate, or create future NPD performance requirements.

The Operational (NPD) Effectiveness is measured since the focus is set on the current innovation performance. Yet references are made to the Strategic Flexibility to make a comparison with the Operational Effectiveness in order to investigate whether organizations have the readiness to adapt to future NPD performance requirements.

1.1.2 Product Concept Effectiveness and NPD Process Effectiveness

The Operational Effectiveness is depending on Product Concept Effectiveness and NPD Process Effectiveness. However, which aspect is influencing Operational Effectiveness most? Table A5.1 in Appendix 5 indicates that the Product Concept Effectiveness has a significant effect of 0.689 on the Operational Effectiveness. The Strategic Flexibility confirms this. More important is to point out if specific correlations exist between the constructs of Product Concept Effectiveness (fit with market demands, fit with firm competencies), NPD Process Effectiveness (speed, productivity/costs, NPD process flexibility), and Operational Effectiveness.

Table A5.2 in Appendix 5 indicates that the fit with firm competencies has the highest (significant) correlation with the Operational NPD Effectiveness in the automotive industry. A short analysis on the Strategic Flexibility indicates the same pattern. Therefore, the fit with firm competencies is the most important construct determining the current innovation performance of the organizations in the automotive industry that are in the 'Patterns in NPD' project so far (N=20). The total database of the 'Patterns in NPD' project indicates also that the fit with firm competencies is the most important construct. The lowest correlation is found on the NPD process flexibility. Thus, the costs and time of modifying a (re)design are high.

1.1.3 Fit with firm competencies

The fit with firm competencies is the factor related to intra-organizational fit of the product concept. The need for internal fit is most obvious in the alignment with the marketing and manufacturing functions, the traditional predecessor, and successor of the NPD function. (De Weerd-Nederhof et al., 2002, p.7) The fit with firm competencies consists of R&D/Manufacturing integration and R&D/Marketing integration. The R&D Marketing integration is based on the effectiveness of different mechanisms for integrating the marketing and R&D function. (Leenders & Wierenga, 2002, in De Weerd-Nederhof et al., 2002, p.7) The R&D/Manufacturing integration is based on the relationship between manufacturability and integration processes. (Swink, 1999)

A correlation at item scale gives more intense insight on the fit with firm competencies construct. Table A5.3 in Appendix 5 indicates the correlation of the items with fit with firm competencies. What we can conclude is that questions 21 D-F all have significant correlations with the fit with firm competencies and influence this construct most. These questions are related to the R&D/Marketing integration. Thus, within the fit with firm competencies, the R&D/Marketing integration is causing the high correlation found in table A5.2 in appendix 5. What we can state is that the R&D/Manufacturing integration is not well developed; only one item is significant. The total database of the 'Patterns in NPD' project also indicates that the R&D/Manufacturing integration is very low; these scores are even lower that the ones found in the automotive industry. Why are these organizations scoring high on fit with firm competencies, but low on R&D/Manufacturing integration?

1.2 Problems in R&D/Manufacturing integration

Manufacturing is very important as the next step after the NPD process. According to Griffin (1997, p.11) the NPD process can be divided in five steps.

Phase	Stage	Activity
Phase 1	*Stage 0*	Concept generation / Product idea
	Stage 1	Project evaluation / Strategy and target market are approved, project can continue to develop specifications
	Stage 2	Development
Phase 2	*Stage 3*	Manufacturing development / Documentation of process development
	Stage 4	Commercialization / Manufacturing production trials

Figure 1.1: Stages in the NPD process (Griffin, 1997)

The five stages of Griffin are used in this research. The integration of R&D and manufacturing plays an important role in the automotive industry, where suppliers at all tiers in the value chain influence the final product (e.g. cars). The integration between R&D and manufacturing is taking place after stage 4 of the NPD process as visualized in figure 1.2.

Stage	**0**	**1**	**2**	**3**	**4**		
Name	**Concept generation**	**Project evaluation**	**Development**	**Manufacturing development**	**Commercialization**	→ → →	**Manufacturing**
Starting activity	Surfacing of idea	Developing of specs	Spending on physical development	Documentation of process development	Production trials (End: manufacturing for sales)	*R&D/ Manufacturing Integration*	Production
NPD Process	*New Product Development*					→ → →	*New Product Manufacturing*

Figure 1.2: Stages in the NPD process with the position of the R&D/Manufacturing integration (stages derived from Griffin, 1997)

Swink (1999) studied the effects of some suspected threats to New Product Manufacturability, and examined the potential for development team integration processes to moderate these effects. According to Adler (1995, in Swink, 1999, p.691) New Product Manufacturability is an assessment of the degree of fit between specializations of the product design and the capabilities of the production process. Then, the integration between R&D and manufacturing is the step before New Product Manufacturing. Moreover, the R&D/Manufacturing integration affects NPM. The problems described in the pre-analysis are caused by several aspects. According to Swink (1999), threats to New Product Manufacturability are product complexity, product newness, technological uncertainty, design outsourcing, and project acceleration. (Swink, 1999, pp.693-694) Swink also researched the potential of development team integration processes. These aspects have a positive influence on New Product Manufacturability: manufacturing involvement in NPD, supplier influence, collaborative team environment, and top management support.

This is a good starting point for this research. The NPM is a performance indicator and is preceded by the R&D/Manufacturing integration. Thus, the problems in the integration between R&D and manufacturing affect the NPM performance. Aspects mentioned by Swink have a positive influence on the performance of

NPM and on the integration between R&D and manufacturing. These 'development team integration processes consist of four aspects of which one (the supplier influence) is an external related factor. Since the automotive sector relies upon its value chain, this is an interesting aspect to research.

We have now seen the situation at organizations, which are already in the database. My research tries to identify if there are specific relations between the involvement of suppliers in NPD and the R&D/Manufacturing integration. This relationship identification is researched in Portugal. There is already an established relation with a university in this country for the 'Patterns in NPD' project. Yet Portugal has not been part of the data gathering for the 'Patterns in NPD' project. There are good reasons to involve Portugal within this project because the country is actively involved in the automotive industry. There is an established automotive cluster because of establishments of manufacturers, such as Volkswagen. Nonetheless, due to globalization of markets, delocalization of production, technological innovation, and internal competition there are some difficulties in the Portuguese automotive industry. (EU EQUAL, 2004) Several car manufacturers close or will close their establishments, which has negative implications on the continuity of organizations in the automotive parts and components industry.

Concluding this problem analysis, the research objective is:
'To explore in the Portuguese automotive parts and components industry whether organizations involve suppliers in NPD and to what extent this involvement relates to the efficiency in the integration between R&D and manufacturing'.

The research is structured as follows. The following chapter offers a review on the automotive industry in Europe and Portugal and a short outlook on NPD in the automotive industry. Chapter 3 continues with the theoretical framework on NPD firm practices and cooperation. In chapter 4, the methodology of the research is explained, followed by chapter 5, survey results. Finally, in chapters 6 and 7 the conclusions and implications of the thesis are discussed.

2. The automotive industry

This second chapter gives insight in the automotive industry. The focus is set on the parts and components industry. Paragraph 2.1 will describe the automotive parts and components industry in Europe. More specific for this research is paragraph 2.2, which concerns the Portuguese automotive parts and components industry. Furthermore, due to the complexity of the automotive industry, a short explanation is given about the OEM supply chain in paragraph 2.3. Finally, paragraph 2.4 will conclude this chapter with NPD in the automotive industry.

2.1 The automotive parts and components industry in Europe

2.1.1 General

The automotive industry is a very important industry within the European economy. The EU has the world's largest automotive production region with 32% of global output, and is the second most important consumer market. (CBI, 2006a) Vehicle manufacturers (OEM's) like Volkswagen, DaimlerChrysler, PSA (Peugeot, Citroën), and Renault dominate the industry. These multinationals have outsourced up to 75% of production to component manufacturers like Bosch, Valeo, Faurecia, and SiemensVDO. These component manufacturers are often former subsidiaries of the OEM's.

The definition used in this research of the automotive parts and components industry is: '*The automotive parts and components industry covers all the parts, components, and accessories for automotive vehicles, agricultural and horticultural machinery, and mobile equipment*'. (CBI, 2006a)

2.1.2 Growth

In this research, the focus is set on the first group, the automotive vehicles. This group consists of automotive vehicles including cars, light and heavy commercial vehicles, buses, and trailers. This is also the largest group, which has a share of 98%. Consumption of parts and components is calculated at € 260 billion in 2004. Consumption of parts and components indicated a steady rise from 1998 to 2002; the annual growth was 8% on average. The strong growth in the previous years was the result of the increased role of system suppliers in the production of vehicles.

2.1.3 Competition

The automotive industry focuses on product flexibility and product costs. Car manufacturers and global first-tier suppliers try to decrease production costs by sourcing to countries with cheap labor, for example China. China is trying to increase their role on both car market and parts and components market. These (semi-)products are priced lower compared to European, American and other Asian producers. Global OEM's need to be aware of the possibilities in the supply market. Therefore, in order to remain competitive these OEM's need global sourcing systems for the search for suppliers. (CBI, 2006a) They have to be aware of the opportunities in the various countries. One aspect of these opportunities is to develop and secure relations with local suppliers, and binding them to the organization by exchanging design, production and planning expertise.

2.1.4 Customers

The market for parts and components can be divided into two main segments, the supply to the 'Original Equipment Manufacturer', known as the OEM market, and the after-market. Both markets depend on developments in the vehicle market. The OEM market is characterized by its 'relationship' with first- and second-tier suppliers. When these suppliers want to be part of the OE supply chain, they have to be geographically close in order to create a short vehicle assembly line. Thus, automotive clusters arise. The after-market produces spare parts for cars. When for example a part of a car is broken (e.g. the suspension), you will go probably to the dealer and ask to fix it. The choice is between original components, which come from the OEM suppliers or components of other manufacturers. These other manufacturers form the aftermarket. This research is focused on the first segment, the supply to the OEM market, because it gives

more insight in the relationships in the OE supply chain and gives more clear directions to solve problems of integration between R&D and manufacturing.

2.1.5 Sales

The automotive industry increased car production and sales in the late nineties of the last century. Unfortunately, since 2000, sales show a negative growth trend, except the upturn in 2004.
The automotive parts and components industry indicates something different. Where the car sales turned down, the sales of parts and components were rising, especially in 2002. Concerning the sales in the automotive parts and components industry, we could argue that 70% of parts and components sold are used for the manufacturing of the vehicle (OEM market). Unfortunately, segmented data of these different groups do not exist. Therefore, data is given for the whole group of parts, components, accessories, and ancillaries. The data can be found in table 2.1.

	2000	2001	2002	2003	2004	Avg. change	Share
Germany	76,451	75,331	88,482	77,839	74,840	-1%	29%
France	35,737	31,874	37,438	29,389	37,438	+1%	14%
Spain	24,511	30,853	33,304	32,784	35,132	+11%	14%
United Kingdom	25,994	31,434	35,185	31,407	32,656	+6%	13%
Italy	31,708	31,368	32,635	25,657	27,095	-4%	10%
Sweden	10,450	11,862	11,688	10,300	10,690	+1%	4.1%
Belgium	6,182	11,315	10,282	8,994	6,981	+3%	2.7%
Austria	2,938	5,395	4,964	3,988	5,809	+24%	2.2%
Hungary	-	5,671	6,241	5,327	5,655	-0%	2.2%
Netherlands	3,182	4,387	3,985	3,670	3,853	+5%	1.5%
Portugal	3,600	5,875	5,651	3,759	3,767	+1%	1.5%
Total	**224,547**	**254,030**	**281,248**	**246,359**	**259,293**	**+4%**	**100%**

Table 2.1: Apparent consumption of parts and components of countries with 1,5% or more market share, 2000-2004, € million (CBI, 2006a)

What we can conclude is that there are large differences between the countries concerning the average change over the years. This has probably to do with the establishments of automotive clusters in the several countries, for example Spain and Austria, where the parts and components industry increased with 11% and 24%.

2.1.6 Production

Table 2.2 points out the development of the production of parts and components from 2000 to 2004.

	2000	2001	2002	2003	2004	Avg. change	Share 2004
Germany	76,063	80,102	100,775	89,513	90,118	+5%	36%
France	37,518	37,775	42,576	30,240	39,136	+1%	16%
Italy	32,496	35,460	36,640	31,266	34,196	+1%	14%
Spain	23,454	22,698	24,754	26,740	28,825	+6%	11%
United Kingdom	24,708	23,517	24,869	24,405	24,729	+0%	10%
Sweden	11,350	11,757	11,286	9,728	9,914	-3%	3.9%
Hungary	-	5,001	4,510	3,883	4,222	-5%	1.7%
Czech Republic	-	1,156	1,721	1,903	4,114	+85%	1.6%
Portugal	4,279	5,247	5,293	3,735	3,671	-4%	1.5%
Total EU	**219,039**	**232,832**	**264,012**	**235,015**	**251,024**	**+4%**	**100%**

Table 2.2: Production of parts and components for vehicles of countries with 1,5% market share and more, 2000-2004, € million (CBI, 2006a)

Table 2.2 shows that the five important car-producing nations are also the leading countries for the production of parts. The striking aspect is the growth of production in the Czech Republic. The car manufacturer Skoda for example has establishments in this country. Skoda, as a part of the Volkswagen

Group, is becoming a major player in the car market. This has noticeable influences on the automotive industry in the Czech Republic, and first- and second-tier suppliers are experiencing advantages.

2.1.7 Imports

Total imports have been increasing steadily in the past four years: from € 149 billion in 2000 to € 186 billion in 2004, an increase of 35%. (CBI, 2006a) The trend towards globalization and outsourcing stimulates imports strongly.

	2000	2002	2004	Avg. growth	Share	DC° share
Total imports	149,083	164,687	186,367	+6%		5%
Intra EU	125,699	139,857	160,236	+7%	86%	
- of which EU15	112,689	121,696	136,112	+5%	73%	
- of which EU10	13,010	18,161	24,124	+21%	13%	
Extra EU, ex DC°	17,302	17,242	16,943	-1%	9%	
DC° imports	6,082	7,587	9,189	+13%	5%	
DC°: Developing countries						

Table 2.3: Total EU imports of parts and components 2000-2004, € million (CBI, 2006a)

2.1.8 Exports

Most exports from countries within the European Union goes to countries within the European Union. A significant proportion of exports are inter-company exports. (CBI, 2006a) Total exports were calculated in 2004 on almost € 204 billion. Between 2000 and 2004 total exports increased by 28%, an average increase of 7% per year. This follows the trend of continued globalization in the automotive industry.

	2000	2002	2004	Avg. growth	Share	DC° share
Total exports	160,453	174,507	203,548	+7%		11%
Intra EU	123,064	133,002	154,110	+6%	76%	
- of which EU15	110,427	117,940	136,437	+6%	67%	
- of which EU10	12,637	15,062	17,674	+10%	9%	
Extra EU, ex DC°	21,585	24,194	27,848	+7%	14%	
DC° exports	15,802	17,311	21,589	+9%	11%	
DC°: Developing countries						

Table 2.4: Total EU and country exports of parts and components 2000-2004, € million (CBI, 2006a)

The most important countries are Germany and France, covering 44% of all exports within the enlarged European Union. Slovakia has the best growth rates for the period 2000-2004, on average 45% per year. The Czech Republic follows with 28% and Poland with 27% annually. In addition, this data indicates the strong growth of the new EU members.

2.2 The automotive parts and components industry in Portugal

2.2.1 General

The total automotive parts and components industry in Europe produced in 2004 a value of € 250 billion. The largest players are Germany, France, Italy, Spain, and the UK. Portugal counts for 1.5% of the European market. (CBI, 2006a)
Figure 2.5 points out the total number of employees working in the automotive supply industry. In 2005, 40,000 employees worked in the Portuguese automotive parts and components industry.

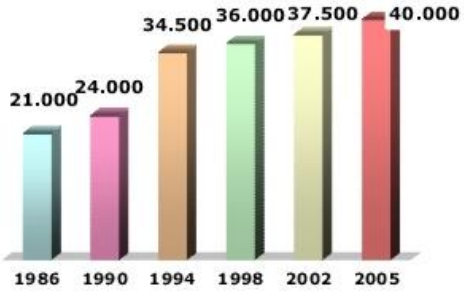

Figure 2.5: Number of employees in the Portuguese automotive supply industry (AFIA, 2006)

Figure 2.6 gives insight in the number of employees per organization; more than 64% of the organizations have < 250 employees. Thus, the sector consists mainly of SME's (Small- and Medium-sized Enterprises).

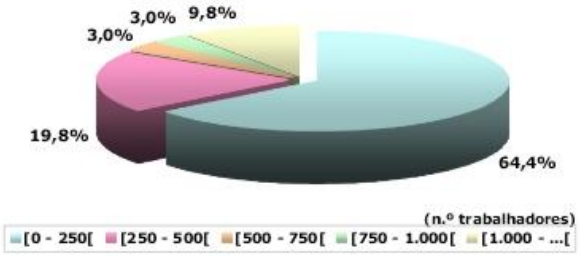

Figure 2.6: Organizations divided by employees - 2005 (AFIA, 2006)

The organizations in the Portuguese automotive parts and components industry, which are used in this research, are members of AFIA, the Association of Portuguese automotive suppliers. The goal in defining the organizations is to get those who are in the OEM supply chain as mentioned before. Using the CAE number 34300 (Classificação das Actividades Económicas) which is for the automotive parts and components industry, gives organizations that are not in the OEM supply chain, and are therefore not useful in this research.

2.2.2 Production

According to the CBI, the average annual change of total consumption between 2000 and 2004, was -4%. Production in Portugal is 1.5% of total EU production. (CBI, 2006b)

Years	National Market	Exports	Turnover
1986	200	224	424
1990	329	798	1.127
1994	434	1.786	2.220
1998	1.352	2.319	3.671
2002	1.495	2.658	4.153
2005	873	3.627	4.500

Table 2.7: Components industry evolution, € million (AFIA, 2006)

However, according to the Portuguese Association of Automotive Suppliers (AFIA), total turnover reached € 4.5 billion in 2005. This would indicate that the CBI data (derived from Prodcom) is slightly underreported. Furthermore, AFIA data indicate a continuous growth trend since 1998. About 200 organizations are active in

automotive production. Several international manufacturers have established operations for the production of car parts and components in Portugal. (AFIA, 2006)

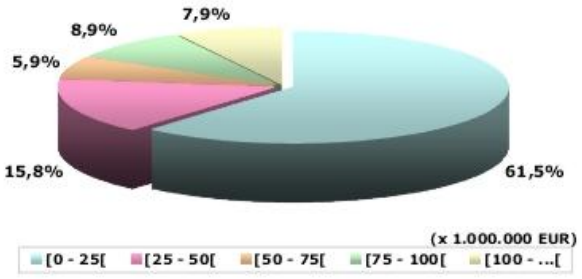

Figure 2.8: Turnover by enterprises – 2005 (AFIA, 2006)

The turnover by organizations is not divided equally under the organizations. As figure 2.8 shows, 61.5% of the organizations have maximum turnovers of € 25 million. This is in line with the size of the organizations, because most of them are SME's.

2.2.3 Suppliers

Regarding the suppliers, we could argue that most of them are OEM suppliers; 62.3% of the organizations are in the first tier of the supply chain. The establishment of many car manufacturers mainly caused this large number of first-tier suppliers. The second largest group, the second-tier suppliers, who also deliver directly to the OEM's, have a share of 23.3%.

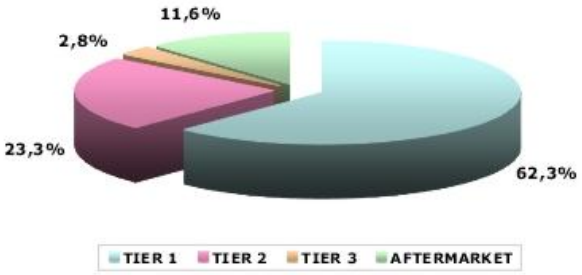

Figure 2.9: AFIA statistics on Supply Chain information – 2005 (AFIA, 2006)

Thus, the Portuguese automotive industry contains a sizeable market for Original Equipment components due to the car assembly operations in Portugal. The demand for OE components is expected to continue to grow because of increased production of vehicles and components. (CBI, 2006b)

2.2.4 Imports

With a share of 1.6% of total imports, Portugal is one of the small countries in the EU. Total imports of parts and components in 2004 were valued at € 2.9 billion. Parts for vehicles constituted € 2.8 billion of this total. € 16 million was realized with parts for agricultural equipment, and € 100 million with parts for other mobile equipment. The largest of the main product categories were other parts and accessories (31%), and engines and engine parts (21%). Brake linings (1.9%) and batteries (1.1%) were the largest of the after-market product groups.

2.2.5 Exports

Also concerning exports, Portugal is one of the small countries in the EU with a total export of € 3.6 billion in 2005 (table 2.7). (AFIA, 2006) 94% of exports went to other EU member states, which is above the EU average. The 2.6% share of exports to developing countries is below the EU average. Electric equipment was the product category with the highest exports (23%), and other parts and accessories followed (15%). (CBI, 2006b)

2.2.6 Sector problems

The Portuguese automotive industry indicates a trend of fewer organizations, and manufacturers are moving their establishments to other countries. What was the second largest export sector is now fragmentally declining due to competitors from Eastern Europe and Asia who can produce with fewer costs. Yet the last five years indicate progress in the Portuguese automotive industry, but the expectations are not quite well. This shift abroad of whole assembly lines affects other smaller and more dependent actors of the supply chain. Most of the Portuguese component suppliers – those who produce small parts such as engine components, moulds, tools, electronics, plastic parts, seats, and climate control systems – are located in the lower levels of the supply chain. These SME's – or 'component manufacturers' or 'manufacturing assemblers' as they are technically called - all have low levels of productivity compared to other European organizations and increasingly have workers with outdated skills. (EU EQUAL, 2006)
Therefore, there is a need to develop and improve their capacity and skills, particularly in the areas of product development and technological innovation. Organizations need to raise the flexibility of their production and adapt to new economic requirements in order to remain competitive in the market. Through better cooperation between suppliers, a product can be build, which is less expensive and has better quality. Despite of the car manufacturers that may leave Portugal, there could be an opportunity for particularly first-tier and low-tier suppliers, because the products they built are low priced and are established with a unique integration with other organizations.

2.3 The OEM supply chain

In order to understand the supply chain in the automotive industry, this part gives a short explanation on this vertical integration. Figure 2.10 visualizes the relations in the supply chain.

Tier-three supplier	→	Tier-two supplier	→	Tier-one/system supplier
Commodity parts and materials	→	*Components*	→	*Integrated systems or modules*

Figure 2.10: The OEM supply chain (CBI, 2006a)

To be accepted in the OEM supply chain, a supplier has to have the status of approved supplier. As car manufacturers want to do business with a limited number of first-tier suppliers (also called systems suppliers), the selection of the second-tier supplier becomes a responsibility of the first-tier supplier. In order to be able to gain access to a first-tier supplier, next to the quality and pricing of the product, reliability, and commitment to the very strict logistics chain is very important. (CBI, 2006a)

2.4 NPD in the automotive parts and components industry

The automotive industry depends on the relations in its value chain in order to build effectively a product, whether this is an automobile or a semi-finished product. Several external parties could play a role in NPD and NPM due to the importance of the value chain in the automotive industry (Clark & Fujimoto, 1991) and the dependencies in the value chain. In addition, because of a growing need for production flexibility, cooperation between buyer and supplier increases. In the automotive industry, the value added by suppliers can contribute significantly to the (semi-) product. Therefore, a part of the competitiveness of the value chain depends upon supplier performance (cost, quality, and on-time delivery). (Clark & Fujimoto, 1991) Studies have shown that supplier involvement in NPD can have a major impact on improving project time (Clark & Fujimoto, 1991), enhancing product quality, and reducing product development costs (Ragatz et al., 1997). The shift of product design work to suppliers causes that supplier performance is increasingly critical to project success and overall Original Equipment Manufacturing (OEM) competitive performance.

3. Theoretical framework

This part formulates the theoretical perspective for the main research question. The literature serves as a body of knowledge in formulating this main research question and is used to analyze the organizations in the Portuguese automotive parts and components industry.
The first variable is described in paragraph 3.1 and implies the NPD performance and the factors affecting this form of innovation performance. Paragraph 3.2 describes one aspect of this NPD performance in detail: the characteristics of the integration between R&D and manufacturing. In addition, several factors that prevent or support the New Product Manufacturability are described. The external aspect, the management of the involvement of suppliers in NPD, is the main theme of this research and is described in paragraph 3.3. Several insight are studied and lead to the best practices of managing the involvement of suppliers in NPD, which are described in paragraph 3.4.

3.1 NPD Performance

Chapter 1 gave already a brief explanation of the NPD performance. The NPD performance in this part is more detailed. To make clear what the NPD performance is about; figure A1.1 in Appendix 1 gives insight in the measurements of the NPD performance as formulated by De Weerd-Nederhof et al. (2002)

The NPD performance has according to De Weerd-Nederhof et al. (2002, p.3) two dimensions; Operational Effectiveness (OE) and Strategic Flexibility (SF), reflecting a short and a longer-term view. Operational Effectiveness refers to the effectiveness of today's work: the degree to which NPD processes contribute to realizing the innovation goals set by the organization. Strategic Flexibility refers to the readiness to adapt to, anticipate, or create future NPD performance requirements. For this research, the focus is set on Operational Effectiveness because the aim is to measure the current innovation performance.
In the operationalization, De Weerd-Nederhof et al. (2002) used Brown & Eisenhardt's (1995) division of factors affecting NPD success on both performance dimensions. Brown & Eisenhardt spread the performance dimensions OE and SF over Products Concept Effectiveness and NPD Process Effectiveness. Product Concept Effectiveness is measured with the fit with market demands and the fit with firm competencies. The NPD Process Effectiveness is measured with the speed, productivity, and flexibility of the development process.

Organizations in the automotive supply chain are influenced heavily by what others in the supply chain do. The role of suppliers is essential, because without their products and services, the following tier in the chain cannot do anything. Therefore, speed, productivity, and flexibility of the development process are very important. These are all items of the NPD Process Effectiveness. Most of the research concerning the role of the supply chain in NPD is focused on these items.
Although this is very interesting to research, this topic is already saturated. Most research has not discussed important aspects that are also influencing NPD and these aspects are fallen into oblivion. The pre-analysis has indicated that the most important determiner of the NPD performance in the automotive sector is the Product Concept Effectiveness (and not the NPD Process Effectiveness). Furthermore, this pre-analysis indicated that the fit with firm competencies is the most important determiner of the NPD performance.

The fit with firm competencies is the factor related to intra-organizational fit of the product concept. The need for internal fit is most obvious in the alignment with the marketing and manufacturing functions, the traditional predecessor and successor of the NPD function. (De Weerd-Nederhof et al., 2002, p.7) The fit with firm competencies consists of R&D/Manufacturing integration and R&D/Marketing integration. The R&D/Marketing integration is based on the effectiveness of different mechanisms for integrating the marketing and R&D function. (Leenders & Wierenga, 2002, in De Weerd-Nederhof et al., 2002, p.7) The R&D/Manufacturing integration is based on the relationship between manufacturability and integration processes. (Swink, 1999)
Brown and Eisenhardt (1995) entitle one of the research streams New Product Development as communication web. The fact that a whole stream is addressed to communication as driver of New Product Development success, underpins the importance of communication. (Brown and Eisenhardt, 1995, p.354)

Therefore, the 'Patterns in NPD' project focuses on communication for the integration between marketing/manufacturing and NPD.

In the pre-analysis, it became clear that the high correlation of the fit with firm competencies is caused by the R&D/Marketing integration, which scores very good. On the contrary, the R&D/Manufacturing integration scores low. The next paragraph will describe the R&D/Manufacturing integration in detail to make clear what the possible causes could be of these scores.

3.2 R&D/Manufacturing Integration

3.2.1 R&D- and Manufacturing capabilities

The output side of the NPD function is characterized by its integration with the manufacturing function. The R&D/Manufacturing integration influences the manufacturability of the new products. (Swink, 1999) Swink (1999) studied the relationship between manufacturability and integration processes. Yam et al. (2004) studied auditing technological innovation capabilities in Chinese firms. Yam et al. address technological innovation capabilities including R&D capability and manufacturing capability. R&D capability refers to a firm's ability to integrate R&D-strategy, project implementation, project portfolio management, and R&D expenditure. Manufacturing capability refers to a firm's ability to transform R&D results into products, which meet market needs, accord with design request and can be manufactured. (Yam, 2004, p.1126)
The problem found in the pre-analysis is a problem of manufacturing capability. Due to a gap between development and manufacturing, R&D results are not converted correctly into products and therefore do not meet market needs. Referring to Swink (1999), these are threats to New Product Manufacturability (NPM). New Product Manufacturability is an assessment of the degree of fit between specifications of the product design and the capabilities of the production process. (Adler, 1995, in: Swink, 1999, p.691) It is not useful to research the outcomes on NPM, yet how R&D and Manufacturing are integrating in order to overcome the problems that organizations face in this stage of/after the NPD process. Several aspects of the NPM are applicable to the R&D/Manufacturing integration, because the NPM and the R&D/Manufacturing integration are interrelated. The NPM is a kind of performance indicator.

3.2.2 Threats to New Product Manufacturability

According to Swink (1999), several characteristics of NPD projects can have negative effects on the integration between R&D and Manufacturing. First, complexity of the product, which is considered as a fundamental source of difficulty. When the product is complex, more organizational departments and more technical specialists need to be involved in the project team. (Clark & Fujimoto, 1991) Thus within the NPD project, coordination problems arise. Griffin (1997) operationalizes product complexity as 'the number of functions a product performs'. (Griffin, 1997, p.13)
The second threat, product newness, is a matter of how much of the product needs to be redesigned. (Swink, 1999, p. 694) It has nothing to do with technological uncertainty, which relates to how much technical invention must take place. (Griffin, 1997) Product newness can be of negative effect on the integration between R&D and Manufacturing due to the development of unique designs. These designs need alternatives, thus there are more ways to produce the product. Instead of declining uncertainty by making alternative designs, more uncertainty arises concerning the manufacturing of the product.
The third threat is technological uncertainty. More technical invention creates more doubts concerning the final product, because there are no previous results of outcomes. This leads to problems in the later stages of the NPD process. Primo and Amundson (2002) found further evidence from Swink's study that the technical difficulty of a project is an important variable affecting the relationship between supplier influence and NPD outcomes.

The fourth threat is the threat of design outsourcing. In a NPD project, it is very important to determine the project scope. According to Clark (1989), project scope is the extent to which a new product is based on unique parts developed by a firm's internal resources. (Clark, 1989, p.1248) The project scope can be divided in two aspects: the choice of unique versus off-the-shelf parts (product newness) and the amount of design outsourcing. A higher amount of design outsourcing results in more organizational barriers, and therefore the

NPD team has not the complete capability to perform successfully in the NPD process, which results in problems at the manufacturing stage. It must be noted that design outsourcing is something different from supplier influence or supplier involvement. The latter refers to how suppliers are managed. (Swink, 1999, p.695)
Finally, the threat of project acceleration. When the product development time is shortened, this has consequences for manufacturing, because steps in the NPD process are skipped and several goals are not achieved, so performance decreases. (Clark & Fujimoto, 1991) When performance decreases, this has consequences for the next stage in the NPD process, which is manufacturing. Thus, the integration between R&D and Manufacturing is not sufficient, and the performance of manufacturability decreases. On the other hand, the acceleration of the product development time can have positive influences on the integration between R&D and Manufacturing. According to Swink (1999), designers are likely to attach greater importance and greater attention to the tasks they perform, because there is less time to correct mistakes. (Swink, 1999, p.695)

3.2.3 New Product Manufacturability support

The study of Swink (1999) examines supporting effects on NPM. Swinks calls these effects the development team integration processes. According to the research of Swink (1999), these processes influence NPM performance positively and thus can solve the problems in the R&D/Manufacturing integration. In this paragraph, a short description of the aspects is given. A thorough analysis on the supplier involvement in NPD can be found in paragraph 3.3.

The development team integration processes Swink (1999) mentioned are divided in four areas. The first area is the manufacturing involvement in NPD. This implies that people from manufacturing are involved in the stages of the NPD process, which are concerned with the design of the product. In this way, problems can be solved early, because manufacturing engineers now have insight and influences on the design. The involvement of manufacturing could only work when project teams are set up as cross-functional teams. According to Sánchez & Pérez (2003), cross-functional design (e.g. multifunctional teams) should ultimately lead to minimization of time and costs of NPD. (Sánchez & Pérez, 2003, p.65) Moreover, the design-manufacturing interface (design for manufacturability) has the same results. (Sánchez & Pérez, 2003, p.65) The manufacturing involvement in NPD is part of the NPD process.

The second area is the collaborative team environment. Here, cross-functional integration of personnel in product development is the starting point. To integrate successfully, barriers of communication must be removed. With respect to NPD, numerous terms and phrases have been used analogously, such as interfunctional integration, collaboration, and teamwork. According to Song et al. (1997), cross-functional cooperation refers to the interdependency and information sharing between the various organizational units. (Song et al., 1997, p.37) Although past research generally has suggested a positive relationship between cross-functional integration and NPD success, in recent years, a contingency perspective is gaining attention in the research on cross-functional integration. The contingency approach suggests that, under some conditions, personnel within departments may perform NPD activities more effectively and efficiently without requiring cross-functional involvement. Therefore, one important task in managing the cross-functional interface is to identify the conditions under which the benefits of cross-functional integration outweigh the costs. (Song et al., 1998, p.290) The benefits could be achieved by a flexible organization where the organization is open; employees have autonomy and have a broad job description. This leads to minimization of time and costs of NPD. (Sánchez & Pérez, 2003, p.65) The collaborative team environment is part of the NPD process and the NPD structure.

The third area is the support of top management. Development team integration processes often require project personnel to behave in non-traditional ways. (Swink, 1999, p.697) It is of most importance to encourage team members to overcome barriers formed by the corporate culture and functional norms. More management commitment and priority causes interest at the team members in the project. This role within the NPD function resembles with the ‘champion’ role Roberts & Fusfeld (1982) defined. The ‘champion’ sells new ideas to others in the organization and gets resources. The person recognizes, proposes, and pushes a

new technical idea for formal management approval. (Roberts & Fusfeld, 1982 in Katz, 2004) Thus top management support is part of the NPD roles.

Finally, the fourth area is supplier influence. Faems et al. (2005) found that collaborations with suppliers differ from collaborations with for example research institutes. (Faems et al., 2005, p.243) Collaborations with suppliers are exploitation-oriented. According to different authors, suppliers often have an interest in the status quo and tend to preserve the dominant role of existing technologies and competencies by developing them further. (Faems et al., 2005, p.242) Suppliers play important roles in NPD, because of outsourcing in product design and manufacturing activities. (Clark & Fujimoto, 1991; Ragatz et al., 1997) They provide additional ideas and sources of technical knowledge. The role of suppliers in the NPD process is called supplier influence or supplier involvement. It is indicated by the direct involvement and communication suppliers have within the project team. (Swink, 1999, p.696) To indicate how suppliers are concerned with the NPD process, use is made of 'supplier involvement'.

Case studies suggest that increased supplier involvement in NPD produces greater consistency among product tolerances and process capabilities, increased refinement of process designs and better availability of detailed process data. (Bonaccorsi & Lipparini, 1994) When suppliers have greater influences over the product design parameters, this increases opportunities in identifying the most reliable manufacturing methods and for designing product specifications that meet process capabilities. This final area is not pointed out in a NPD function.

Swink states in his research that all the measured aspects of development team integration are associated with higher performances in NPM. (Swink, 1999, p.691) The next paragraph will discuss the supplier involvement in NPD in detail.

3.3 Management of supplier involvement in NPD

Environmental forces may have significant consequences for processes in the organization, and may affect organizational performance. (Tidd et al., 2001, p. 174) Some researchers suggest that suppliers should be treated as full partners in NPD. (Ragatz et al., 1997) The results of the study of Swink (1999) are consistent with that argument.
This paragraph discusses the role suppliers play in NPD, and how this can be managed. First, the characteristics of the supplier are presented, followed by the supplier performance and competition. Furthermore, the degree of supplier involvement and the organization of supplier involvement in NPD are discussed.

3.3.1 Supplier characteristics

An organization has to be aware of several characteristics of its supplier. Petersen et al. (2003) found that increased knowledge of a supplier is more likely to result in greater information sharing and involvement of the supplier in the product development process. (Petersen et al., 2003, p.284) Wasti & Liker (1999) use several factors as control variables in their research in order to define characteristics. A first important characteristic is the size of the supplier organization. According to Wasti & Liker (1999), size can have an influence on the collaboration between buyer and supplier. (Wasti & Liker, 1999, p. 452) This can be measured by the number of employees in an organization, expressed in the number of Full Time Employees (FTE's). The size of the organization has influences on the relation between buyer and supplier in a way that one is subordinate to the other. The authority usually is at the largest organization.
A second characteristic is the position in the value chain. (Wasti & Liker, 1999, p. 451) The tier levels in the OEM value chain are important in defining specific levels. These levels can convey if an organization is in the first-tier or in a lower-tier of the value chain. Moreover, it conveys if an organization is really part of the OEM value chain. Cooperative efforts from the car manufacturer (first-tier supplier) towards the low-tier supplier (supplier development) are sometimes a prerequisite to establish a partnership relationship between suppliers and customers. With these criteria, it is easy to define if an organization is delivering directly to a car manufacturer (first- and/or second-tier supplier) or if it is a supplier of the first-tier level (low-tier supplier). In

this research, the 'organizations' are the first- and second-tier organizations in the OEM value chain, and the 'suppliers' are the low-tier organizations in the OEM value chain. Data is gathered at the first- and second-tier suppliers.
A third characteristic is the product, which the supplier delivers. Considering suppliers, we could also think of suppliers that are important for the administrative part of the organization. However, these suppliers are not interesting for this research and have no role in the NPD process. Thus, the search is for suppliers that are involved in the NPD process. Wasti & Liker (1999) make a categorization in components that suppliers deliver. This is not applicable, because there are first- and second-tier suppliers involved, which deliver for example complete car seats. The typology used by Wasti & Liker (1999) is based on technical parts only. Because an organization that makes car seats is extremely depending on its leather supplier, this is the most important supplier in its NPD process. Therefore, a study is made of the key component the supplier delivers in NPD.

3.3.2 Supplier performance & competition

The supplier performance is another important aspect in defining the role suppliers play in NPD. NPD literature associates supplier quality, cost and on-time delivery performance with early supplier involvement with the Original Equipment Manufacturer. (Hartley et al., 1997) In addition, Quesada et al. (2006) defined supplier performance as a second-order construct with three first-order factors. These factors are:

- Supplier quality
- Supplier cost
- Supplier on-time performance

Another option is to measure supplier capabilities with in-house technical capabilities of the supplier and the supplier performance history. (Wasti & Liker, 1999, p.451) However, this gives no insight in the quality, costs, and on-time performance of the current situation. Thus, use is made of the definition of Quesada et al. (2006). In addition, we could argue that early supplier involvement in the NPD process leads to more supplier performance; organization and supplier are integrating on a higher level due to earlier involvement. This leads to the best performance of the supplier in the eyes of the organization.

The position in the value chain is an important characteristic to define a supplier as mentioned in paragraph 3.3.1. An organization can have advantages over suppliers with the position in the value chain. This relates to the authority the organization has over its suppliers. When there is competition among suppliers, this gives more authority to the organization. In addition, more competition among suppliers probably causes increased quality, decreased costs, and on-time delivery. However, is this always the case?

Bonaccorsi & Lipparini (1994) discuss partnering models in NPD. One of their measurements is the degree of competition among suppliers. According to Bonaccorsi & Lipparini (1994), referring to the degree of competition among suppliers at the time of their involvement in the NPD process, several situations can be distinguished. First, because the probability to be selected is the same, an open competition among suppliers exists. The number of suppliers involved may vary from all the potential vendors to a small number of approved suppliers. Second, a certain degree of competition exists, but a small number of suppliers have a greater probability to be selected. Third, a selected supplier already exists, and consequently, it becomes a firm's partner in the innovative project. (Bonaccorsi & Lipparini, 1994, p.135) Thus, it is important to consider whether an organization can switch easily from one supplier to another. Wasti & Liker's (1999) research indicates that a lower level of competition and length of the buyer-supplier relationship seems to result in a higher level of supplier involvement. (Wasti & Liker, 1999, p.454) This should ultimately lead to the second or third configuration Bonaccorsi & Lipparini (1994) mentioned. Thus, we could argue that lower competition among suppliers results in a higher level of supplier involvement.

3.3.3 Degree of supplier involvement in NPD

According to Eisenhardt and Tabrizi (1995), the degree of supplier involvement in NPD is defined as whether suppliers are involved in each of the stages of the NPD process. (Eisenhardt & Tabrizi, 1995, p.98) Urban & Hauser (1993) present the new-product development decision process as a sequential set of activities. (Urban & Hauser, 1993, p. 37) The stages of the NPD process are adapted from Griffin (1997) as mentioned before

under paragraph 1.2. These stages are similar to the stages used by Urban & Hauser (1993). Ernst (2002) distinguishes in his article five broad categories in NPD. One of the main success factors, which are found in this review of the empirical literature on NPD, is a clear definition of the product before development. This means a clear definition of the product before development begins, including the product concept, target market need, and purpose of the NPD process. Ragatz et al. (1997) argue that 'supplier integration into NPD suggests that suppliers are providing information and directly participating in decision-making for purchases used in the new product. This integration can occur at any point in the NPD process.' (Ragatz et al., 1997, p.193)

Handfield et al. (1999) tried to visualize the supplier involvement in the NPD process. Figure 3.1 gives a view on the degree of supplier involvement in NPD.

NPD Process	New Product Development					→ → →	New Product Manufacturing
Stage	0	1	2	3	4		
Name	Concept generation	Project evaluation	Development	Manufacturing development	Commercialization		Manufacturing
Supplier Involvement	↑ Supplier	↑ Supplier	↑ Supplier	↑ Supplier	↑ Supplier	*R&D/ Manufacturing Integration*	Production

Figure 3.1: Stages in the NPD process with the position of the R&D/Manufacturing integration and the possibilities of supplier involvement (stages derived from Griffin, 1997; timing of supplier derived from Handfield, 1999)

As figure 3.1 indicates, there are five different phases where suppliers could be involved. Handfield et al. (1999) argue that early supplier involvement has important characteristics. (Handfield et al., 1999, p. 62) When suppliers are involved early, they will deliver systems or subsystems, which are complex items. These items are critical and contain new technologies. Therefore, a strategic alliance is necessary with these suppliers. This relation with suppliers is also called 'black box'. (Handfield et al., 1999, p.78) Thus, when suppliers participate more and early in stages of the NPD process, the involvement of the suppliers in NPD is high. This early involvement has its consequences on the Product Concept Effectiveness. When suppliers are involved early, this has influences on the product concept. Therefore, the organization of suppliers should be arranged perfectly when they are involved early in the process. The next paragraph will discuss this in detail.

3.3.4 Organization of supplier involvement in NPD

According to Clark (1989), not only suppliers have valuable capability. The organization manages the process so that capability plays an important role. Moreover, the organizations cultivate capability in their suppliers. This involves investment, sharing of knowledge, providing space and facilities for 'guest engineers', and helping suppliers to solve problems. On the suppliers' side, there is a commitment to build capability and a willingness to assume a critical role in the development process. (Clark, 1989, p.1261)

Hartley et al. (1997), define the buyer-supplier interface in a NPD project as 'the extent of frequent communications with suppliers, timing of supplier involvement and supplier's responsibility for design'. (Hartley et al., 1997) According to Quesada, Syamil & Doll (2006) should organizations involve suppliers earlier in design and manufacturing in order to ensure improved performance. Involving suppliers earlier in the development process decreases uncertainties on the suppliers' side. (Quesada, Syamil & Doll, 2006, p.37) Bidault et al. (1998) define early supplier involvement as 'the vertical cooperation where manufacturers involve suppliers at an early stage in the NPD process, generally at the level of concept and design. (Bidault et al., 1998, p. 719) Thus, supplier influence in the design of NPD (which means they are part of the internal NPD and are early involved) should lead to increased NPD performance.

Bidault et al. (1998) defined three groups that influence early supplier involvement, based on Lamming (1993). They argue that early supplier involvement is influenced by three areas; environmental pressures, social and industry norms, and organizational choice. The latter is the area that influences early supplier involvement most. The organizational choice consists of level of integration, purchasing ratio, initiatives towards supplier base and scope of suppliers' activity. (Bidault et al., 1998, p.724)

As mentioned before, one view of NPD is that of a 'communication web'. (Brown & Eisenhardt, 1995) Information is gathered from multiple sources, analyzed, interpreted, and acted upon. High levels of communication both within the project team and externally with stakeholders are related to R&D project success. (Brown & Eisenhardt, 1995, p.354) Brown & Eisenhardt (1995) concluded that frequent and appropriately structured task communication (both internal and external) leads to more comprehensive and varied information flow to the team members and thus to higher performing development processes. (Brown & Eisenhardt, 1995, p.358) Therefore, more communication with the supplier is associated with earlier involvement in the NPD process.

It is clear that suppliers have to be early involved in the NPD process and that communication plays an important role. Yet the extent of supplier involvement is underexposed. Brown and Eisenhardt (1995) discuss the extent and timing of supplier involvement, and confirm the general view that the greater supplier involvement, the better. Clark & Fujimoto (1991) provide one of the first scales for measuring the extent and timing of supplier involvement as including joint engineering problem solving, early involvement, and strong communication. Suppliers could participate in the design and development of a product in a variety of ways. First, 'supplier proprietary parts', where standard products are taken from concept to manufacturing by the supplier and are sold to organizations through a catalogue. Second, 'black box parts' where developmental work is split between organization and supplier. Third, 'detail-controlled parts' of functional parts and fourth 'detail-controlled parts' of body parts. In the latter two extents of supplier involvement, the supplier takes responsibility for process engineering and production based on blueprints provided by organizations. (Clark & Fujimoto, 1991, p.140)
Ragatz et al. (1997) and Swink (1999) also identified this aspect. Ragatz et al. (1997) identify supplier membership on the NPD project team as the greatest differentiator between most and least successful integration efforts. As mentioned before, Swink (1999) defines supplier influence as the direct involvement and communication suppliers have with the project team. Thus, the extent of supplier involvement should be organized as 'black box parts', because this divides the developmental work between supplier and organization. Then, the supplier is early involved and this increases the NPD performance.

In order to create an efficient integration between R&D and manufacturing, suppliers must not only be involved in the NPD process, but also in manufacturing. The model presented in figure 3.1 must be adapted to this issue. Figure 3.2 below indicates that suppliers also have to be involved in manufacturing.

NPD Process	New Product Development					→→→	New Product Manufacturing
Stage	0	1	2	3	4		
Name	Concept generation	Project evaluation	Development	Manufacturing development	Commercialization		Manufacturing
Supplier Involvement	↑ Supplier	↑ Supplier	↑ Supplier	↑ Supplier	↑ Supplier	*R&D/ Manufacturing Integration*	↑ Supplier

Figure 3.2: Stages in the NPD process with the position of the R&D/Manufacturing integration and the possibilities of supplier involvement including SI in manufacturing (stages derived from Griffin, 1997; timing of supplier derived from Handfield, 1999)

Results of Swink's (1999) research points out that greater supplier influence is generally positively associated with NPM, and especially so when there is a high degree of outsourcing. Increasingly, firms are outsourcing more NPD activities. (Ragatz, 1997) While this strategy has been shown to reduce development lead-time and to improve productivity (Clark, 1989), there appear to be negative consequences for NPM unless suppliers are given equal influence over the product design. (Swink, 1999, p.706) Then, these suppliers can solve manufacturing problems during start-up phases.
In defining the extent of supplier involvement in NPD, it is useful to consider the amount of assets that are shared with the supplier. According to Ragatz et al. (1997), a variety of internal and external barriers must be overcome to make such integration work well. (Ragatz et al., 1997, p.199) Barriers include resistance of a number of levels within the organization to sharing proprietary information with suppliers and the 'not

invented here' culture. Second, there can be resistance in the supplier's organization as well: the reveal of proprietary information. Petersen et al. (2003) conclude that sharing of technology information results in higher levels of supplier involvement and improved outcomes and in cases when technology uncertainty is present, suppliers and buyers are more likely to share information on NPD teams. (Petersen et al., 2003, p.284) Third, the supplier's organization may worry about inequitable treatment with a more-powerful buyer. (Ragatz et al., 1997, p.199)
To overcome these barriers, Ragatz et al. (1997) defined two differentiators; relationship structuring and asset allocation. Relationship structuring practices facilitate integration and sharing of assets, but do not directly affect the speed, cost, and quality of NPD. (Ragatz et al., 1997, p. 200) The second differentiator is asset allocation, where its practices more directly influence the results of the NPD process. This research uses the asset allocation practices. These practices can be divided in intellectual assets, human assets and physical assets and in return lead to supplier integration and new product success.

Finally, after discussing the early involvement of suppliers, communication with these suppliers, extent of supplier involvement (also in the manufacturing process), and the asset sharing with suppliers, an overview is given of the cooperation of suppliers in NPD. This cooperation can be related to the different areas mentioned before in this paragraph. Fliess & Becker (2006) presented in their research several possible cooperation designs, which can be distinguished by the type and intensity of the contractual relationship. Figure 3.3 shows these cooperation designs.

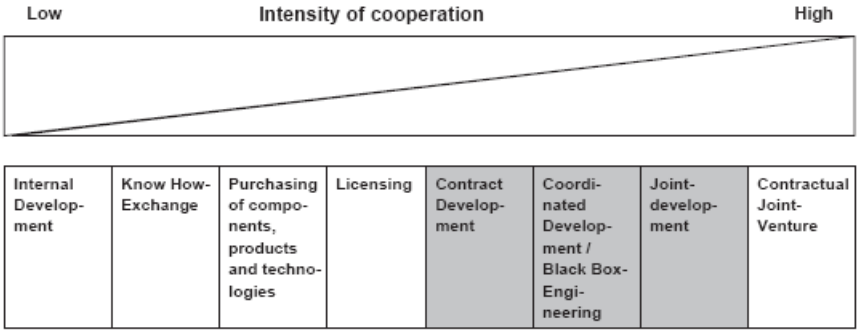

Figure 3.3: Cooperation designs in NPD (Fliess & Becker, 2006)

According to Fliess & Becker (2006), the most important forms of cooperation are contract-, coordinated-, and joint development. (Fliess & Becker, 2006, p.29) Contract development is based on contracts with organizations or institutions. Coordinated development is based on a separation of tasks for the company involved. Joint development is based on a regular cooperation in teams with members of the supplier's and customer's organization. (Fliess & Becker, 2006, p.29) Thus, when suppliers are involved in NPD, organizations use the cooperation forms of contract-, coordinated-, or joint development.

3.5 Best practices of supplier involvement in NPD

Based on the conclusions of the four preceding paragraphs, it is possible to establish the best practices for supplier involvement in NPD in the Portuguese automotive parts and components industry. A first image of the management of supplier involvement is visualized in figure 3.4. The involvement of suppliers can be separated in several areas, which all have influence on the role suppliers play in the NPD process. These areas are supplier characteristics, supplier performance and competition, degree of supplier involvement in NPD and the organization of supplier involvement in NPD.

Figure 3.4: The Management of Supplier involvement in NPD (based on the theoretical framework)

The best practices of supplier involvement in NPD that are derived from literature are presented in table 3.5. Obviously, the ultimate goal is to increase the R&D/Manufacturing integration by the involvement of suppliers in NPD. In addition, this leads to an increase in NPM performance. Most interesting is to investigate if there is a direct relationship between the R&D/Manufacturing integration and the involvement of suppliers in NPD, or that other variables influence this relationship.

	Theory
Supplier characteristics	
Size of the supplier	➢ Equivalent to organization in order to prevent inequitable treatment ➢ Balance of power
Position in the OEM supply chain	➢ First- or second-tier of the OEM supply chain (organization delivers to OEM – supplier delivers to first- or second-tier level)
Product of the supplier	➢ Supplier must deliver a key component in order to be involved in the NPD process
Supplier performance and competition	
Supplier performance / Performance measurements	➢ Supplier must deliver conform quality, cost and time
Position in the value chain / Nr. of other possible suppliers	➢ Degree of competition between suppliers must be medium to low for more supplier involvement ➢ Degree of competition between suppliers must be high to increase supplier quality, cost and on-time performance
Degree of supplier involvement	
Stages in the NPD process	➢ Supplier involvement in every stage of the NPD process

Organization of supplier involvement	
Supplier is part of internal NPD / influence on the design	➢ Supplier involvement already in early stages of the NPD process ('Black box integration')
Supplier communication	➢ Frequent and appropriately structured task communication (both internal and external)
Participation of suppliers in NPD	➢ 'Black box parts' participation where developmental work is split between organization and supplier
Participation of suppliers outside NPD	➢ Involve suppliers also in New Product Manufacturability
Asset allocation	➢ Share intellectual, human and physical assets with supplier
Cooperation of suppliers in NPD	➢ Cooperate with suppliers by contract development, coordinated development and joint development with a medium to high intensity of cooperation

Table 3.5: Configuration of the management of supplier involvement in NPD

The best practices are tested in the field to explore whether organizations use these practices to make improvements in their supplier involvement in NPD. Organizations in the Portuguese automotive parts and components industry, which come up to these expectations are recognized as successful organizations that involve suppliers in NPD. When suppliers are involved successfully, this leads to better development team integration processes. These processes have according to literature, a positive influence on the integration between R&D and manufacturing and in addition on the performance in New Product Manufacturing.

Provided the three internal areas (manufacturing involvement in NPD, collaborative team environment, and top management support) are satisfactory, and the supplier involvement in NPD is on a high level, this leads to an efficient integration between R&D and Manufacturing. Thus, the performance in the manufacturing of new products, also known as NPM, is higher.

4. Methodology

This Bachelor Thesis is part of the research project 'Patterns in New Product Development' where consistent NPD configurations for sustained innovation are studied. The R&D/Manufacturing integration in the NPD process is the focus of this research. This chapter discusses the methodology that is used to answer the main research question. The research question is presented in paragraph 4.1. It gives a visual representation of the research in a research model and describes the research questions that are used to come to a well-defined answer on the main research question. Furthermore, this chapter outlines the research perspective (paragraph 4.2), the design strategy (paragraph 4.3), and the research methods (paragraph 4.4). The chapter concludes with paragraph 4.5 concerning the measurements used in this research.

4.1 Research model and Research Questions

As already discussed in the theoretical framework in chapter 3, the problem of the low R&D/Manufacturing integration is caused by several factors. The solutions for this low score are available; the focus is set on the supplier involvement in NPD. A study is made of the relationship between the involvement of suppliers in NPD and the scores on the R&D/Manufacturing integration.

4.1.1 Research objective

With this research, I would like to explore to what extent the involvement of suppliers in NPD (X) and the R&D/Manufacturing integration (Y) are related at organizations in the Portuguese automotive parts and components industry. The research object is the R&D/Manufacturing integration.

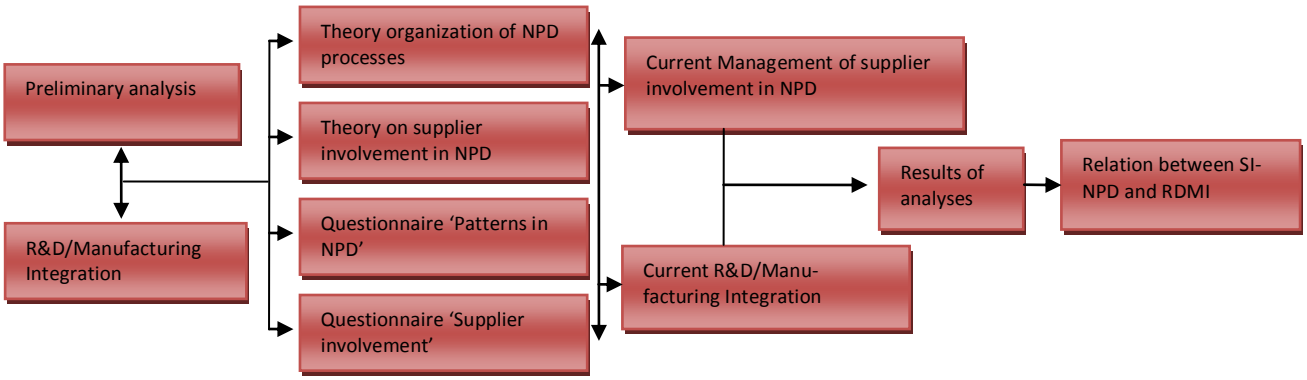

Figure 4.1: Research Framework

This framework points out the way the research is conducted. This is explained thoroughly in paragraph 4.2. The relations between the variables, as presented in chapter 3, are visualized in the following research model (figure 4.2). The definitions of the variables can be found in paragraph 4.4.

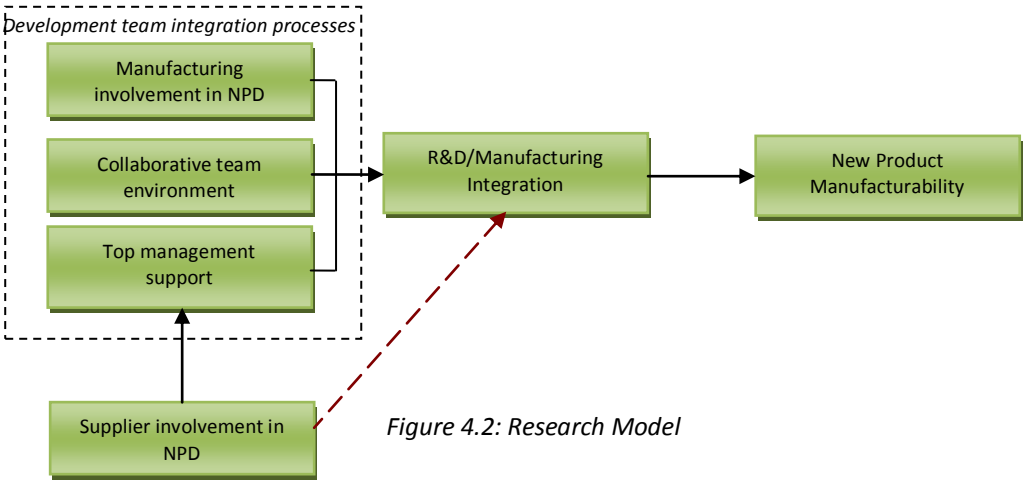

Figure 4.2: Research Model

This model shows the development team integration processes on the left side. The supplier involvement in NPD is the focus of this research; this construct is taken apart from the other 'internally focused' processes. These processes also contribute to the R&D/Manufacturing integration, and are used as moderator variables. Moderator variables are according to Shadish et al. (2002) variables that influences the nature of the relationship between two other variables (an independent variable and a dependent variable). (Shadish et al., 2002, p. 509) The independent (X) variable is the supplier involvement in NPD and the dependent (Y) variable is the R&D/Manufacturing integration.
The question arises if there is a direct connection or relationship between the supplier involvement in NPD and the R&D/Manufacturing integration or that the supplier involvement in NPD contributes to the 'internal' development team integration processes, which on its turn influence the integration between R&D and manufacturing. Therefore, two propositions are formulated to test whether the moderator variables play an important role.

Proposition 1 is:
'At organizations in the Portuguese automotive parts and components industry, there exists a measurable and positive relationship between the level of supplier involvement in NPD and the efficiency of the R&D/Manufacturing integration.'

When there is a direct relationship between the supplier involvement in NPD and the R&D/Manufacturing integration, proposition 1 can be accepted.

Proposition 2 is:
'At organizations in the Portuguese automotive parts and components industry, the supplier involvement in NPD influences the R&D/Manufacturing integration through the 'internal' development team integration processes.'

When there is no direct (positive) relationship between the supplier involvement in NPD and the integration between R&D and manufacturing, proposition 2 can be accepted.
Finally, when the processes (both internal and supplier involvement in NPD) contribute effectively to the integration between R&D and manufacturing, this leads to a better performance in New Product Manufacturability. Thus, R&D results are converted correctly into products, which are feasible and therefore meet market needs.

4.1.2 Research questions

The main research question of this Bachelor Thesis is:

In what way is the involvement of suppliers in NPD at Portuguese automotive parts and components organizations influencing the integration between R&D and manufacturing?

This main research question can be divided in several sub questions:

1. *What is the R&D/Manufacturing integration of organizations in the Portuguese automotive parts and components industry?*

2. *What are the 'internal' development team integration processes at organizations in the Portuguese automotive parts and components industry?*

3. *To what extent involve organizations in the Portuguese automotive parts and components industry suppliers in NPD?*

4. *What is the relation between the 'internal' development team integration processes and the R&D/Manufacturing integration?*

5. *What is the relation between the supplier involvement in NPD and the 'internal' development team integration processes?*

6. *To what extent is there a (direct) relationship between the supplier involvement in NPD and the R&D/Manufacturing integration?*

4.2 Research perspective

A preliminary analysis, pointed out that the R&D/Manufacturing Integration of organizations in the automotive industry in comparison to the R&D/Marketing Integration was low. The background for these problems is found in New Product Manufacturability (NPM). R&D results are not converted correctly into products, and thus are not feasible and do not meet market needs. Possible threats to manufacturability are the complexity of the product, product newness, technological uncertainty, design outsourcing, and project acceleration. The study of literature in chapter 3 showed that ways to improve the NPM are manufacturing involvement in NPD, collaborative team environment, top management support, and supplier involvement. Regarding the three internal aspects that determine the organization of the NPD process, we could argue that these circumstances are quite the same for organizations. The supplier involvement in NPD could be different for every organization and for every supplier. Supplier involvement is especially interesting because of the dependencies in the automotive OEM supply chain.
As figure 4.2 indicated, both the 'internal' development team integration processes and the supplier involvement in NPD have their effects on the integration between R&D and manufacturing, but probably each in a different way. This is tested throughout this research. The R&D/Manufacturing integration is a performance indicator for the manufacturability of new products. The three aspects of the development team integration processes are used as moderator variables in measuring the NPM.
This Bachelor Thesis uses two questionnaires, which are filled in by R&D/NPD managers; one from the 'Patterns in NPD' project, and one developed specially for this research providing answers on the construct of supplier involvement in NPD. The study of literature led to 'best-practices' of supplier involvement in NPD. The data provided by the questionnaires gives an overview of the current R&D/Manufacturing integration. An exploratory data analysis on the data from the questionnaires leads to the identification of a relationship between the effectiveness of the R&D/Manufacturing integration and the involvement of suppliers in NPD.

4.3 Design strategy

The design strategy consists of a number of aspects and is based on the 'Bow net of Miller'. (Geurts, 1999) This formal research has an explanatory goal and uses the knowledge gathered for evaluation. More than one type of research is of application, because this research is part of the larger 'Patterns in NPD' project. This research has elements of a field research; it uses questionnaires to explore the 'field'. Moreover, this research has elements of comparative research; several organizations are compared in order to define patterns in the involvement of suppliers in NPD and in the R&D/Manufacturing integration.
Due to the choice for a specific design strategy - field research and comparative research - I can use the 'Bow net of Miller', which gives important aspects for analyzing the outcomes. The expected results are:

- The outcomes will contain patterns in the supplier involvement in NPD and the R&D/Manufacturing integration.
- The results need to be intense, so the terms need an intense measurement (quantitative). Use is made of two questionnaires.
- The results are descriptions of processes used in supplier involvement and patterns in the relationship with the performance in NPM.
- Precise identification of causal factors (is the R&D/Manufacturing integration really influenced by supplier involvement in NPD?) is necessary for conditioning relations and causal factors.
- Socialization processes need to be identified.
- Terms (R&D/Manufacturing integration, supplier involvement in NPD) have the possibility to develop and need to be tested on validity and reliability.
- The cases can be coded; classifications and their mutual consistency are submitted to statistical tests.

4.4 Research methods

Empirical research is conducted in the Portuguese automotive parts and components industry to answer the research questions mentioned in paragraph 4.1.2 and to explore the R&D/Manufacturing integration and supplier involvement in NPD. To identify the organizations that operate in the Portuguese automotive parts and components industry, use is made of the database of the AFIA (Associação de Fabricantes para a Indústria Automóvel). The AFIA is the Portuguese Association of Automotive Suppliers that links and represents the automotive suppliers at the national and international level. (AFIA, 2006) This database contains 57 organizations that deliver parts and components to car manufacturers or to suppliers of these car manufacturers. Use is made of this database, and not from e.g. a CAE code (Classificação das Actividades Económicas), because using the CAE code gives organizations that are not in the OEM supply chain but are delivering to the aftermarket, or are making parts and components for the agricultural or horticultural vehicles. Probably, the organizations that only produce for e.g. the aftermarket have different relationships with their suppliers. Using those organizations within the research leads to biased effects on the results.

Two questionnaires are sent to the NPD/R&D managers of the organizations to gather quantitative data. These organizations are identified inside the AFIA database as valuable for this research. The first questionnaire is the 'Patterns in NPD' questionnaire and is developed as part of the international 'Patterns in NPD' project established by the University of Twente, The Netherlands. How the questions of the 'Patterns in NPD' Questionnaire are defined can be found in the master thesis from Altena. (Altena, 2005) The questions used from this questionnaire will focus on the R&D/Manufacturing integration, and performance, process, structure, and roles of the NPD function. The questions used are presented in tables 4.3-4.5. The 'Patterns in NPD' questionnaire can be found in Appendix 3.

Variable	Question(s) PNPD	Definition
R&D/Manufacturing integration	21 A-C	Based on the relationship between manufacturability and integration processes

Table 4.3: Data analysis on the R&D/Manufacturing integration from the 'Patterns in NPD' questionnaire

Construct	Definition	Sub-constructs	Question(s) PNPD	Variable(s)	Definition
NPD performance (OE)	Operational Effectiveness refers to the effectiveness of today's work: the degree to which NPD processes contribute to realizing the innovation goals set by the organization	Product Concept Effectiveness	20	Fit with market demands	Strongly influenced by four characteristics of a product: unique benefits, quality, cost, and a clear product concept. Captures the more short term fit with extra-organizational context
			21	Fit with firm competencies	Factor related to intra-organizational fit of the product concept in the alignment with the marketing and manufacturing functions
		NPD Process Effectiveness	22	Speed of the NPD process	Refers to the lead time, which is related to time to market
			23	Productivity of the NPD function	Refers to the use and costs of resources in the NPD process
			24	Flexibility of the NPD process	The incremental cost and time of modifying a design

Table 4.4: Data analysis on the NPD performance from 'Patterns in NPD' questionnaire

Construct	Question(s) PNPD	Question(s) SI NPD	Variable(s)	Definition
(Internal) Development team integration processes that influence NPM	21H, 27	8A	Manufacturing involvement in NPD	Implies that people from manufacturing are involved in the stages of the NPD process, which are concerned with the design of the product
	25-26, 35-36	8B	Collaborative team environment	Refers to the interdependency and information sharing between the various organizational units
	28	8C	Top management support	Encourage team members to overcome barriers formed by the corporate culture and functional norms. More management commitment and priority causes interest at the team members in the project

Table 4.5: Data analysis on the processes that influence NPM from both questionnaires

The second questionnaire is the 'Supplier involvement in NPD' questionnaire and is developed exclusively for this research. The questions used will concentrate on the characteristics, performance and competition of suppliers, and the degree and organization of supplier involvement in NPD. The 'Supplier involvement in NPD' questionnaire can be found in Appendix 4. The questions used are presented in table 4.6.

Construct	Question(s) SI NPD	Variable(s)	Definition
Management of supplier involvement in NPD	1	Supplier characteristics	The characteristics of the supplier which are valuable in the relationship between the organization and the supplier (size of the supplier, position OEM supply chain, product of supplier)
	2	Supplier performance and competition	Measurements for and performance of supplier combined with the degree of competition a supplier faces in its market
	3	Degree of supplier involvement	Whether suppliers are involved in each of the stages of the NPD process
	4-7	Organization of supplier involvement	Combining of valuable capability of suppliers and managing the process by the organization so that capability plays an important role. Moreover, organizations cultivate capabilities in their suppliers. This involves participation in NPD, communication, asset allocation and cooperation

Table 4.6: Data analysis on the management of supplier involvement in NPD from the 'Supplier involvement in NPD' questionnaire

4.5 Measurements

The theoretical framework established in chapter 3 is used for defining the constructs and variables concerning the NPD function and supplier involvement in NPD. These constructs and variables are used in the questionnaires to measure the R&D/Manufacturing integration, NPD performance, (internal) development team integration processes, and the management of supplier involvement in NPD. The data gathered is analyzed by comparing the empirical data with the theoretical framework. The SPSS program is used for the exploratory data analysis. The different tables to explain the measurements can be found in figures A6.1-A6.14 appendix 6.

First, it is important to determine the scores of the R&D/Manufacturing Integration (RDMI). Question 21 A-C from the 'Patterns in NPD' questionnaire are used for measuring this construct on a 7-point Likert scale (1-7) and are analyzed by using the SPSS program.

Second, the Operational Effectiveness (OE), Product Concept Effectiveness (PCE) and NPD Process Effectiveness (NPD PE) are analyzed with the SPSS program. This is done additionally to the model described in figure 4.2. Because this Bachelor Thesis is part of the 'Patterns in NPD' project, a reference is made to the current NPD performance, measured by the Operational Effectiveness. The results can be found in appendix 9. For questions 20-24 of the 'Patterns in NPD' questionnaire, the scores are measured on a 7-point Likert scale (1-7). The Product Concept Effectiveness can be measured by taking the averages of the fit with market demand and the fit with firm competencies together and divide them by two. The NPD Process Effectiveness can be measured by taking the averages of the speed of the NPD process, productivity of the NPD function and the flexibility of the NPD process together and divide them by three. The Operational Effectiveness can be measured by taking the Product Concept Effectiveness together with the NPD Process Effectiveness and divide them by two.

Third, the development team integration processes in measuring the effect on NPM (also analyzed with the SPSS program). The manufacturing involvement in NPD (MI-NPD) is measured by question 8A from the 'Supplier involvement in NPD' questionnaire and additionally by questions 21H and 27 from the 'Patterns in NPD' questionnaire. For the questions 8A and 21H, scores are measured on a 7-point Likert scale (1-7). The average of these two questions is used to measure the Manufacturing involvement in NPD. Question 27 cannot be calculate quantitative, but it gives insight in the stages used in the NPD process and if manufacturing is involved in incremental and radical innovation. To make the outcomes quantitative, a 0 or 1 is used to clarify the use of the specific stage in the NPD process.
The collaborative team environment (CTE) is measured by question 8B from the 'Supplier involvement in NPD' questionnaire and additionally by questions 25-26 from the 'Patterns in NPD' questionnaire. Question 8B

scores are measured on a 7-point Likert scale (1-7). Questions 25-26 (not quantitative) are used in order to give insight in whether an organization uses cross-functional teams (questions 25-26).
The top management support (TMS) is measured by question 8C from the 'Supplier involvement in NPD' questionnaire and additionally by question 28 of the 'Patterns in NPD' questionnaire. Question 8C scores are measured on a 7-point Likert scale (1-7). Question 28 (not quantitative) is used to give insight in the specific roles within the NPD function.

Finally, the management of the supplier involvement in NPD (MSI-NPD) is analyzed with the SPSS program. The supplier characteristics (SC) are measured by question 1 from the 'Supplier involvement in NPD' questionnaire. Scores are measured on a 7-point Likert scale (1-7). The supplier performance and competition (SPC) are measured by question 2 from the 'Supplier involvement in NPD' questionnaire. In addition, these scores are measured on a 7-point Likert scale (1-7). The degree of supplier involvement in NPD (DSI-NPD) is measured by question 3 of the 'Supplier involvement in NPD' questionnaire and scores are measured on a 7-point Likert scale (1-7). The organization of supplier involvement in NPD (OSI-NPD) is measured by questions 4 and 6 of the 'Supplier involvement in NPD' questionnaire and additionally by questions 5 and 7. A 7-point Likert scale (1-7) measures the scores of questions 4 and 6. Questions 5 and 7 are not quantitative and are used to give insight in the participation of suppliers in NPD and the asset sharing with suppliers. The management of supplier involvement in NPD is measured by the averages of the scores on supplier characteristics, supplier performance and competition, degree of supplier involvement in NPD, and the organization of supplier involvement in NPD, and divided by 4.

These scores and use of exploratory data analysis lead to conclusions concerning the relation between supplier involvement in NPD and R&D/Manufacturing integration.

5. Empirical Results

In order to answer the research questions outlined in paragraph 4.1.2, empirical research has been performed in the Portuguese automotive parts and components industry, focused on the OEM supply chain. Data gathering took place during Spring and Summer of 2007 at ISPA University in Lisbon, Portugal.

5.1 Dataset

The definition used of the automotive parts and components industry is: '*The automotive parts and components industry covers all the parts, components, and accessories for automotive vehicles, agricultural and horticultural machinery, and mobile equipment*'. (CBI, 2006a) The industry is further reduced by choosing for the parts and components for automotive vehicles, which are produced within the OE supply chain.

5.1.1 AFIA Database

The organizations in the Portuguese automotive parts and components industry, which are used in this research, are members of AFIA, the Association of Portuguese automotive suppliers. Organizations are selected on their presence in the OEM supply chain. Using the CAE (Classificação das Actividades Económicas) number 34300, which is for the automotive parts and components industry, gives organizations that are not in the OEM supply chain, and are therefore not useful in this research. Within the AFIA database, 57 organizations were identified.

5.1.2 Sample

The AFIA database (57 organizations) has been investigated on origin, employees in NPD/R&D and business activity. Eight Organizations were not selected due to wrong business activities. Therefore, 49 organizations were left after the first selection. These 49 organizations were contacted mainly in English (the first three weeks in Portuguese). First, questions were asked if the organization was useful for this research by referring to the NPD function of the organization and if the person in the organization was willing to participate in this research. Table 5.1 below gives an outline of the sample of this research.

AFIA Database		
Total		**57**
First selection		*8*
No Portuguese origin	0	
No employees in NPD/R&D	0	
Wrong business activity	8	
Organizations left after first selection		49
Contacted organizations		**49**
Second selection		*17*
No NPD in Portugal	9	
No response	3	
Not interested	1	
Not existing	2	
No time	2	
Send Questionnaires		**32**
Received Questionnaires		**11**
Not received Questionnaires		*21*
Response rate in %		***34.38***

Table 5.1: Research sample

From these 49 organizations, 17 organizations were not usable for this research, from which 9 organizations had no NPD in Portugal, 3 organizations did not respond, 1 organization was not interested to participate, 2

organizations did not exist, and 2 organizations had no time. Therefore, 32 organizations received both the 'Patterns in NPD' questionnaire and the 'Supplier involvement in NPD' questionnaire by email. To compensate the effort made with filling in two questionnaires, the managers received a gift cheque of €10,- (FNAC) when they returned filled-in questionnaires before the 19th of July. In total, 11 managers within these organizations have filled in both questionnaires. Therefore, the response rate was **34.38%**. The filled-in questionnaires are used for the empirical results, which are described in this chapter.

5.2 Results description

Table 5.2 below gives an outline of general data and research method information of the 11 organizations, which participated in this research. The calculations made in this paragraph are done in accordance to the measurements explained in paragraph 4.5.

Company	Company code	Automotive	Products	First contact date	Date Q filled in	Sales in mln	FTE's	FTE's in NPD
1	h5fad9	Plastics	Plastics	12-6-2007	25-6-2007	9	40	2
2	cctc8m	Textiles	Upholstery for the automotive and others industries	29-5-2007	4-7-2007	14	110	2
3	m6yvay	Head linings	Window lifters	19-6-2007	10-7-2007	50	270	7
4	b5a2vt	Stamping	Parts for the automotive industry	5-6-2007	11-7-2007	16	190	3
5	bwx57v	Stamping	Stamped and welding metallic parts: Luggage components, Clamps, Wheel net wrenches	29-5-2007	11-7-2007	6	140	10
6	xwv2fv	Die casting parts	Die casting parts: Oil pump bodies, Oil pump covers, Oil filter bodies, Inlet air bodies, Heat sink, Pedals, Pedal supports	5-6-2007	11-7-2007	22	250	6
7	s2ahcc	Electrical	Electrical wiring	29-5-2007	12-7-2007	62	182	4
8	5dmfv2	Tooling	Metalworking tools, Woodworking tools	29-5-2007	16-7-2007	9	90	4
9	mm8xsy	Exhaust systems	Exhaust systems	4-6-2007	16-7-2007	11	152	7
10	xwv2fv	Stamping	Stamping, welding, prototypes, laser cutting	29-5-2007	19-7-2007	22	250	6
11	5xq6xa	Die casting parts	Die casting parts: Alternators brackets, Several brackets, Oil pumps bodies and covers, Cylinder heads, Air-conditioning holders, Water pump bodies and covers, Engine mountings	19-6-2007	20-7-2007	27	215	6

Table 5.2: General data and research method information of the 11 participating organizations

There are organizations in the dataset, which can be categorized in sub-groups. Three organizations are in the automotive stamping business. These organizations are marked in red. Two organizations are in the die casting parts business and are marked in green. Comparisons will be made between these sub-businesses.

5.2.1 R&D/Manufacturing integration

The R&D/Manufacturing scored very low in the pre-analysis data. Table 5.3 shows the scores on the R&D/Manufacturing integration from the organizations in the Portuguese automotive industry.

The results indicate that the scores on R&D/Manufacturing integration are on average 4.5. The individual results lie between 3.3 and 5.7. Referring to the automotive data used in the pre-analysis, that dataset had a R&D/Manufacturing integration of 4.0, and the results lie between 1.0 and 6.3. Tables on descriptive statistics can be found in appendix 7 (tables A7.1 & A7.2). Thus, there is more variation in the data used in the pre-analysis. In comparing the pre-analysis data and the Portuguese data, we could argue that the R&D/Manufacturing integration is slightly higher at the Portuguese organizations subject to this research.

		NPD	OE FC (Q21)		
Firm	**Company code**	21	a	b	c
1	h5fad9	**5,7**	5	7	5
2	cctc8m	**3,3**	4	2	4
3	m6yvay	**5,0**	6	4	
4	b5a2vt	**3,7**	5	2	4
5	bwx57v	**4,0**	5	3	
6	xwv2fv	**5,0**	6	3	6
7	s2ahcc	**5,3**	6	5	5
8	5dmfv2	**4,7**	5	4	5
9	mm8xsy	**3,7**	4	5	2
10	sjwrxu	**3,3**	3	3	4
11	5xq6xa	**5,3**	6	4	6
		4,5	**5,0**	**3,8**	**4,6**
		RDMI			

Table 5.3: R&D/Manufacturing integration in the Portuguese automotive parts and components industry

The stamping organizations score lower that the average R&D/Manufacturing integration. These organizations face problems in manufacturing due to the design activities in the NPD process. The die casting parts organizations face fewer problems in the integration between R&D and manufacturing and score above average. The highest score is 5.7 from organization 1, which operates in plastics. Figure 5.4 gives a detailed view on the R&D/Manufacturing integration per organization.

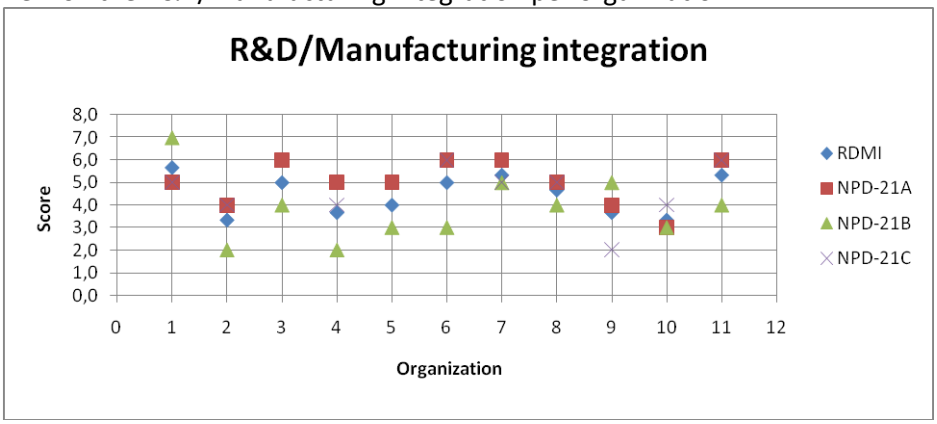

Figure 5.4: Graphical view on the R&D/Manufacturing integration

Figure 5.4 indicates that question 21B scores are very low, and is the cause of the low scores on the R&D/Manufacturing integration. This question concerns the **small number** of manufacturing problems that occur during production start-up phases. Organizations score low on this question. These organizations have **many** problems in manufacturing that occur during production start-up phases.

5.2.2 Operational Effectiveness

As mentioned in paragraph 4.5, the Operational Effectiveness still is part of this research despite the fact that it is not in the research model. The analysis, which is interesting for the 'Patterns in NPD' project can be found in appendix 9.

5.2.4 Development team integration processes

The development team integration processes, which play an important role in defining the influence on NPM, are also subject to analysis. Since some of these measurements are tested through the 'Supplier involvement in NPD' questionnaire, no comparisons can be made with the automotive data that is already gathered in the

'Patterns in NPD' project. Only Portuguese organizations have filled in this special questionnaire. First, the Manufacturing involvement in NPD is analyzed, and data is visualized in table 5.5.

		SI NPD	MI-NPD	NPD	MI-NPD	MI-NPD
Firm	**Company code**	8	a	21	h	
1	h5fad9	**6,0**	6	**5,0**	5	**5,5**
2	cctc8m	**5,0**	5	**5,0**	5	**5,0**
3	m6yvay	**4,0**	4	**5,0**	5	**4,5**
4	b5a2vt	**5,0**	5	**6,0**	6	**5,5**
5	bwx57v	**6,0**	6	**7,0**	7	**6,5**
6	xwv2fv	**3,0**	3	**6,0**	6	**4,5**
7	s2ahcc	**7,0**	7	**6,0**	6	**6,5**
8	5dmfv2	**6,0**	6	**2,0**	2	**4,0**
9	mm8xsy	**2,0**	2	**5,0**	5	**3,5**
10	sjwrxu	**4,0**	4	**6,0**	6	**5,0**
11	5xq6xa	**5,0**	5	**6,0**	6	**5,5**
		4,8		**5,4**		**5,1**
		SI NPD		NPD		MI NPD

Table 5.5: Manufacturing involvement in NPD in the Portuguese automotive parts and components industry

Use is made of two questions, which are in different questionnaires. Question 8A from the 'Supplier involvement in NPD' questionnaire (*'the manufacturing department is early and intense involved in NPD'*) indicates different scores compared to Question 21H from the 'Patterns in NPD' questionnaire (*'we built upon manufacturing competences for the exploration of new technological developments*). Both questions are based on the involvement of the manufacturing department in NPD. However, the way of questioning is completely different and this is visible in the results. For example, organization 6 scores low (3) on question 8A but high on 21H (6), and organization 8 scores high (6) on question 8A but low on question 21H (2). Figure 5.6 visualizes this best.

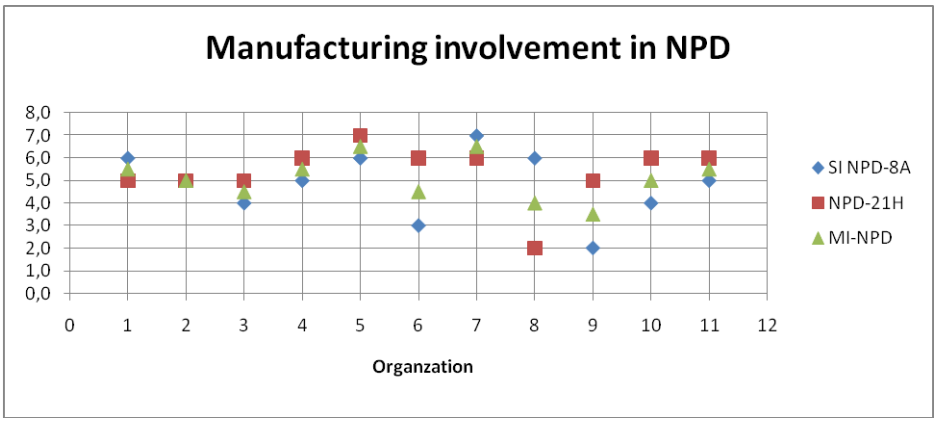

Figure 5.6: The items of MI-NPD plus the Manufacturing involvement in NPD

The average score on question 8A is 4.8 and on question 21H 5.4. Thus, there is a visible difference. Due to differences in questioning and differences in scores, the two questions are taken together in defining the manufacturing involvement in NPD. Then, the scores indicate small variances and lie between 3.5 and 6.5. This is visible in table A7.3 in appendix 7 (descriptive statistics of the Manufacturing involvement in NPD). The overall score on the manufacturing integration in NPD is quite high. Thus, the manufacturing department is involved in NPD and there is a lot of communication between the two departments. The sub-businesses, the stamping organizations, and the die casting parts organizations score very high.
Important is to consider the stages of the NPD process. Several development activities are present in the NPD process. Here, the Manufacturing Development stage is of importance. This stage entails the development

and pilot of manufacturing processes. Tables 5.7 and 5.8 points out the stages of the NPD process divided by incremental and radical innovation.

		NPD	Stages NPD Process (Incremental)							
Firm	**Company code**	27	PrStrDev	Id/CpGen	IdScr	BusAn	Dev	Test/Val	**ManDev**	Com
1	h5fad9		0	0	0	0	1	1	**1**	1
2	cctc8m		1	0	1	1	1	1	**1**	1
3	m6yvay		0	0	1	1	0	1	**1**	1
4	b5a2vt		0	0	1	1	1	1	**1**	1
5	bwx57v		0	0	0	0	0	1	**1**	1
6	xwv2fv		0	0	0	0	1	1	**1**	1
7	s2ahcc		1	1	1	1	1	1	**1**	1
8	5dmfv2		0	0	0	0	0	0	**0**	0
9	mm8xsy		1	1	0	1	0	1	**1**	1
10	sjwrxu		1	1	1	1	1	1	**1**	1
11	5xq6xa		0	0	1	0	1	0	**1**	0

Table 5.7: Stages of the incremental NPD process per individual organization

Table 5.20 points out the importance of the Manufacturing Development stage in the NPD process. Ten organizations use this stage in their NPD process, and it is the stage, which is used most. Only organization 8 has no Manufacturing Development stage, but this organization has no stages in the NPD process. It is obvious that regarding the use of the different stages per organization, the Manufacturing Development stage is the most important stage.

		NPD	Stages NPD Process (Radical)							
Firm	**Company code**	27	PrStrDev	Id/CpGen	IdScr	BusAn	Dev	Test/Val	**ManDev**	Com
1	h5fad9		1	1	1	1	0	0	**0**	0
2	cctc8m		0	1	0	0	0	0	**0**	0
3	m6yvay		1	1	1	1	1	1	**1**	1
4	b5a2vt		0	1	0	1	1	1	**1**	1
5	bwx57v		0	0	0	0	0	1	**1**	1
6	xwv2fv		0	0	0	0	0	0	**0**	0
7	s2ahcc		1	1	1	0	1	1	**1**	1
8	5dmfv2		0	0	0	0	0	0	**0**	0
9	mm8xsy		1	1	0	0	0	1	**1**	1
10	sjwrxu		0	1	0	0	0	0	**0**	0
11	5xq6xa		0	0	0	0	0	0	**0**	0

Table 5.8: Stages of the radical NPD process per individual organization

The radical NPD process shows a different pattern on the stages in the NPD process. The Idea/Concept Generation stage is the most used stage in the radical NPD process. This is obvious, because radical innovation is focused on the identification of opportunities and initial generation of possible solutions. The Manufacturing development stage is the second most important stage. Comparing the incremental and radical NPD processes, the Portuguese organizations in the automotive parts and components industry are focused on incremental innovation.

In the stamping business, the organizations start very divers. Organization 10 begins at stage 1 and organizations 4 and 5 start far later. The die casting parts organizations start in the incremental NPD process in the Development stage. In the radical NPD process, the die casting parts organizations have no stages in the radical NPD process. On the contrary, the stamping organizations do have stages in the radical NPD process.

The second development team integration process is the collaborative team environment. Table 5.9 points out the scores on the collaborative team environment as measured by question 8B of the 'Supplier involvement in NPD' questionnaire.

		SI NPD	CTE (Q8)	NPD	NPD process & roles (Q25 & 26)	
Firm	**Company code**	8	b	25 & 26	25 Incr	26 Rad
1	h5fad9	**7,0**	7	**Cross-functional team**	4	4
2	cctc8m	**6,0**	6	**No formally documented process**	2	2
3	m6yvay	**7,0**	7	**Formally documented process and/or cross-functional team with facilitating process owner**	3	5
4	b5a2vt	**6,0**	6	**No formally documented process**	2	2
5	bwx57v	**5,0**	5	**No formally documented process**	2	2
6	xwv2fv	**3,0**	3	**Formally documented process with facilitating 'process owner'**	5	5
7	s2ahcc	**7,0**	7	**Cross-functional team**	4	4
8	5dmfv2	**6,0**	6	**Formally documented process**	3	3
9	mm8xsy	**4,0**	4	**Formally documented process and/or cross-functional team with management reviews**	3	4
10	sjwrxu	**6,0**	6	**Cross-functional team with facilitating process owner**	5	5
11	5xq6xa	**3,0**	3	**Cross-functional team with no standard approach to NPD**	4	1
		5,5				

Table 5.9: Collaborative team environment per individual organization

The data in table 5.9 indicate some variance in the scores. Table A7.4 in appendix 7 confirms this. Organizations' scores lie between 3.0 and 7.0. The average on collaborative team environment is 5.5, which is very high. The organizations in the die casting parts business score both very low on the collaborative team environment. Possibly, it is common in this sub-business. On the other hand, the stamping organizations score very well on the collaborative team environment. Overall, the results indicate that Portuguese organizations in the automotive industry have a collaborative team environment. This implies that the organizations make use of cross-functional integration of personnel in product development. For example, organization 1 scores 7 out of 7 with their collaborative team environment, and this can be found again in the NPD processes and roles, where the organization makes use of cross-functional teams. Yet this cannot be stated for all the organizations. Organization 4 scores 6 out of 7 on collaborative team environment, but it has no formally documented process in their NPD processes and roles. Thus, Portuguese organizations in the automotive parts and components industry score very good on collaborative team environment, but several organizations make no use of cross-functional integration in their NPD processes and roles.

The third development team integration process is the top management support. Table 5.10 gives an overview of the scores on top management support as measured by question 8C (SI NPD) and 28 (NPD).

The scores on question 8C indicate a strong focus on top management support. All organizations score 6 or 7 on top management support and the average score is 6.5. Table A7.5 in appendix 7 confirms this. Thus, top managers within these organizations encourage team members to overcome barriers formed by the corporate culture and functional norms. When the scores of question 8C are compared to question 27, where the 'Champion' role resembles the role of top managers, a striking difference become known. Figure 5.11 shows the NPD roles from the organizations in the dataset.

		SI NPD	TMS	NPD	NPD Roles (Q28)									
Firm	**Company code**	8	c	28	IdGen		**Champ**		PrLdr		Gtkpr		Sp	
1	h5fad9	**6,0**	6		YES	2	**YES**	**2**	YES	5	YES	5	YES	5
2	cctc8m	**6,0**	6		YES	1	**NO**	**3**	YES	5	NO	3	NO	2
3	m6yvay	**7,0**	7		NO	0	**YES**	**3**	YES	6	YES	5	YES	5
4	b5a2vt	**6,0**	6		YES	5	**YES**	**5**	YES	5	YES	5	YES	4
5	bwx57v	**6,0**	6		NO	0	**YES**	**4**	YES	4	NO	0	YES	4
6	xwv2fv	**7,0**	7		YES	2	**YES**	**5**	YES	6	YES	5	YES	6
7	s2ahcc	**7,0**	7		NO	0	**YES**	**2**	YES	6	YES	5	YES	5
8	5dmfv2	**6,0**	6		NO	0	**NO**	**0**	YES	6	NO	0	YES	3
9	mm8xsy	**6,0**	6		YES	3	**YES**	**0**	YES	1	NO	0	NO	0
10	sjwrxu	**7,0**	7		YES	4	**YES**	**6**	YES	3	YES	3	YES	4
11	5xq6xa	**7,0**	7		NO	0	**NO**	**0**	YES	6	YES	5	NO	0
		6,5												
		TMS												

Table 5.10: Top management support per individual organization

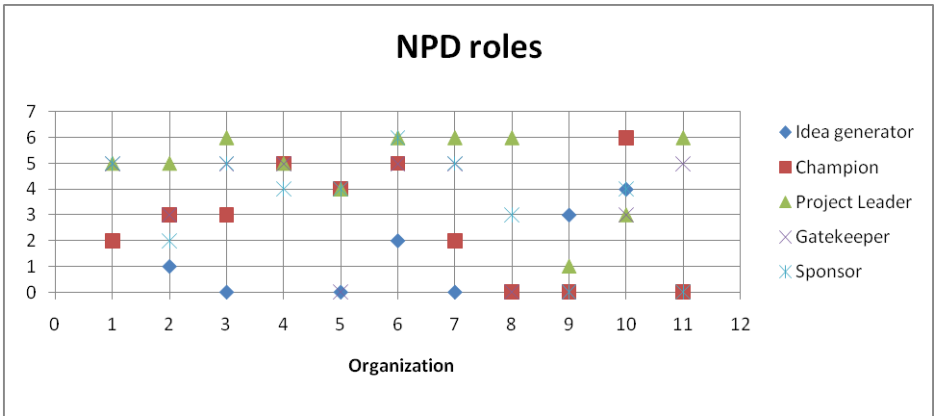

Figure 5.11: NPD roles

The most important role in the NPD process is according to these 11 organizations the role of the project leader. The second most important role is the champion. The scores of the champion role are not as high as the scores of the top management support. Possibly, the supporting role of top managers is not fixed in the NPD process at several organizations. Using these two questions gives a good view on the interpretation of top management support: this support occurs also when this role is not fixed in the NPD process.

Finally, figure 5.12 gives an overview of the scores on the three development team integration processes.

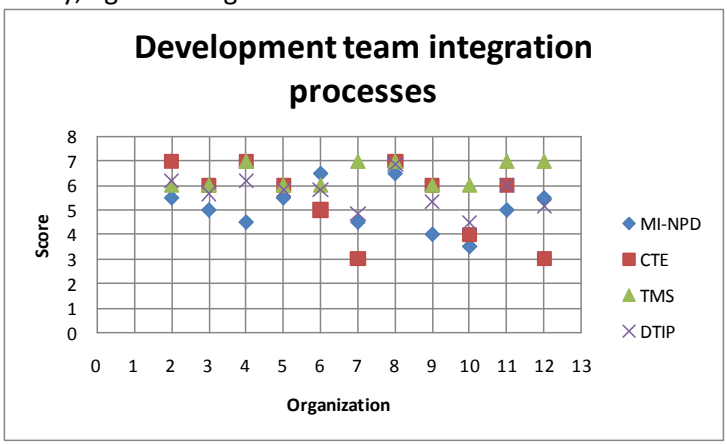

Figure 5.12: The development team integration processes

These scores point out that the organizations in the stamping business score better on development team integration processes compared to the organizations in the die casting parts business. They score higher on the manufacturing involvement in NPD and the collaborative team environment.

5.2.4 Management of supplier involvement in NPD

This research also examines the supplier involvement in NPD. Therefore, specific questions have been constructed to gather data on the management of supplier involvement in NPD. First, the supplier characteristics are described. Question 1 of the 'Supplier involvement in NPD' questionnaire is used, and data is visualized in table 5.13.

		SI NPD	SC (Q1)		
Firm	**Company code**	1	a	b	c
1	h5fad9	**5,3**	7	2	7
2	cctc8m	**3,3**	2	2	6
3	m6yvay	**4,7**	4	5	5
4	b5a2vt	**4,7**	3	6	5
5	bwx57v	**6,0**	5	6	7
6	xwv2fv	**3,0**	1	1	7
7	s2ahcc	**3,3**	3	3	4
8	5dmfv2	**3,3**	5	2	3
9	mm8xsy	**3,0**	1	6	2
10	sjwrxu	**5,7**	7	3	7
11	5xq6xa	**3,3**	1	7	2
		4,2	**3,5**	**3,9**	**5,0**
		SC			

Table 5.13: Individual organization results on supplier characteristics

Table 5.13 indicates several remarkable results. Organizations score on question 1A very divers. It contains the largeness of the organization compared to their most important supplier. Therefore, the variance is high; scores lie between 1 and 7. The die casting parts organizations score very low on this question and are smaller organizations compared to their suppliers. This has influences on the relationship with suppliers.
Another remarkable result is the low score on question 1B, which measures if the organizations are the link between low-tier suppliers and car manufacturers. The average score is 3.9. This score is low, especially considering the goal of this research, which was to get organizations in the OEM supply chain. However, the organizations that scored beneath 4 are low-tier suppliers and are in the start of the OEM-supply chain. **Extra information has been gathered at the organizations to identify if the organizations really were in the OEM-supply chain.**
Question 1C points out that most organizations have a supplier that delivers a key component in NPD. The average score on question 1C is 5.0. The three stamping organizations score very high (5-7) on this question. Possibly, the stamping business really needs key components (metals) from suppliers in order to make their products.

The second aspect of the management of supplier involvement in NPD is the supplier performance and competition. Table 5.14 gives an overview of the scores on question 2 from the 'Supplier involvement in NPD' questionnaire, which is used for the performance of suppliers and the competition between suppliers.

Question 2A-C of the 'Supplier involvement in NPD' questionnaire is focused on the quality, costs, on-time delivery of suppliers. As can be seen from table 5.14, the scores on question 2A are very high; between 6 and 7. The average is 6.5. Therefore, the quality of supplier's products is very good. On the contrary, the costs of supplier's products and the on-time delivery are lower; the average on costs is 4.3 and the average on on-time delivery is 5.5.

		SI NPD	SPC (Q2)					
Firm	**Company code**	2	a	b	c	d	e	f
1	h5fad9	**5,5**	7	6	7	7	2	4
2	cctc8m	**6,0**	6	5	7	7	6	5
3	m6yvay	**5,2**	6	6	6	6	4	3
4	b5a2vt	**5,0**	6	4	4	6	5	5
5	bwx57v	**3,4**	7	2	6		1	1
6	xwv2fv	**5,5**	6	6	6	6	6	3
7	s2ahcc	**4,7**	6	3	5	6	5	3
8	5dmfv2	**5,3**	7	4	4	5	6	6
9	mm8xsy	**4,7**	6	4	3	5	5	5
10	sjwrxu	**4,3**	7	4	6	3	2	4
11	5xq6xa	**5,5**	7	3	6	5	5	7
		5,0	**6,5**	**4,3**	**5,5**	**5,6**	**4,3**	**4,2**
		SPC						

Table 5.14: Individual organization results on supplier performance & competition

Most organizations use measurements in their NPD department for supplier performance; the average score is 5.6 (Question 2D). Questions 2E and 2F, which concern the advantage in the value chain position and the easiness of switching from supplier, are 4.3 and 4.2 respectively. Thus, organizations have not easily an advantage over their supplier concerning the position in the value chain, and cannot switch very fast from one supplier to another. Only organization 11 scores 7 on this question.
The stamping organizations score on or below average. The die casting parts organizations score very high. Therefore, supplier performance and competition is high at organizations in the die casting parts business. The highest score is at organization 2 operating in the automotive textiles.

The third aspect of the management of supplier involvement in NPD is the degree of supplier involvement in NPD. This question is very important for this research, because it gives insight in the cooperation with suppliers. Table 5.15 shows the results of the 11 organizations on the degree of supplier involvement in NPD.

		SI NPD	DSI-NPD (Q3)				
Firm	**Company code**	3	a	b	c	d	e
1	h5fad9	**5,0**	5	6	5	5	4
2	cctc8m	**4,4**	4	5	6	5	2
3	m6yvay	**4,4**	3	5	5	6	3
4	b5a2vt	**3,8**	5	5	5	2	2
5	bwx57v	**3,0**	1	3	4	6	1
6	xwv2fv	**3,0**	2	5	5	2	1
7	s2ahcc	**5,4**	5	5	5	6	6
8	5dmfv2	**1,0**	1	1	1	1	1
9	mm8xsy	**2,2**	2	5	2	1	1
10	sjwrxu	**3,0**	1	1	7	2	4
11	5xq6xa	**1,2**	2	1	1	1	1
		3,3	**2,8**	**3,8**	**4,2**	**3,4**	**2,4**
		DSI-NPD					
	Remarkable low score variable						
	Remarkable high score variable						

Table 5.15: Individual company result on the degree of supplier involvement in NPD

The results per organization show large differences. Organization 8 is involving suppliers as less as possible in NPD, and scores 1. Organization 8 operates in the automotive tooling. The scores are best visible in figure 5.16.

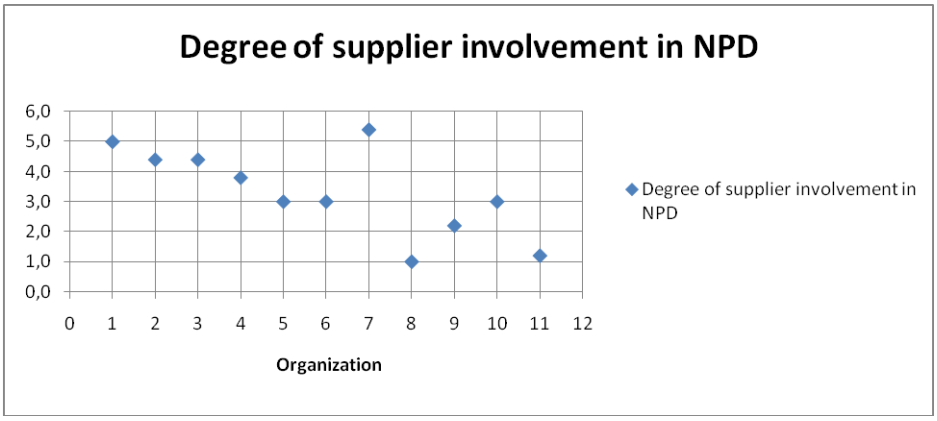

Figure 5.16: The degree of supplier involvement in NPD

On the contrary, organization 7, operating in the electrical wiring, is involving suppliers in all stages of the NPD process, and scores 5.4. The results also show variance in which stage suppliers are involved. Suppliers are least involved in the commercialization stage (question 3E with an average of 2.4), where production trials are manufactured. Suppliers are most involved in the development stage (question 3C with an average of 4.2). Overall, considering the average score of 3.3, the degree of supplier involvement in NPD is very low. Therefore, organizations in the Portuguese automotive parts and components industry are less involving their suppliers in NPD. This is also visible at the organizations in the die casting parts business.

The fourth aspect of the management of supplier involvement in NPD is the organization of supplier involvement in NPD. The organization of suppliers in NPD is measured by question 4 and 6 from the 'Supplier involvement in NPD' questionnaire. Question 4 indicates how the relation with the most important supplier is organized within the NPD and NPM function. Question 6 indicates the level of cooperation in NPD regarding supplier involvement. Table 5.17 gives organization results for these two questions.

		SI NPD	OSI-NPD (Q4)					SI NPD	OSI-NPD (Q6)								OSI-NPD
Firm	**Company code**	4	a	b	c	d	e	6	a	b	c	d	e	f	g	h	
1	h5fad9	**4,4**	4	5	5	5	3	**3,4**	5	6	4	4	1	1	1	5	**3,9**
2	cctc8m	**6,0**	6	6	6	5	7	**4,3**	1	5	4	4	5	5	6	4	**5,1**
3	m6yvay	**5,8**	6	5	6	6	6	**4,1**	4	5	3	4	5	5	6	1	**5,0**
4	b5a2vt	**4,2**	5	3	5	4	4	**3,7**	4	3	3	4	5	4		3	**4,0**
5	bwx57v	**4,8**	7	3	5	4		**3,0**	7	4	6	1	1	2	2	1	**3,9**
6	xwv2fv	**3,0**	1	1	6	5	2	**3,4**	2	6	1	5	4	4	4	1	**3,2**
7	s2ahcc	**5,6**	6	6	6	5	5	**3,3**	3	5	5	3	2	3	3	2	**4,4**
8	5dmfv2	**1,0**	1	1	1	1	1	**1,8**	7	1	1	1	1	1	1	1	**1,4**
9	mm8xsy	**3,6**	5	2	6	3	2	**3,5**	6	5	2	4	6	2	2	1	**3,6**
10	sjwrxu	**4,4**	4	5	4	5	4	**3,6**	7	7	7	1	3	2	1	1	**4,0**
11	5xq6xa	**1,0**	1	1	1	1	1	**2,0**	7	2	2	1	1	1	1	1	**1,5**
		4,0	**4,2**	**3,5**	**4,6**	**4,0**	**3,5**	**3,3**	**4,8**	**4,5**	**3,5**	**2,9**	**3,1**	**2,7**	**2,7**	**1,9**	**3,6**
		NPD-NPM						LevCoNPD									OSI-NPD

Table 5.17: Individual organization result on the organization of supplier involvement in NPD

Variance in the results is also visible in the organization of supplier involvement in NPD. Again, organization 8 (tooling) scores very low (1.4), on both the NPD-NPM (1.0) as well as the level of cooperation in NPD (1.8).

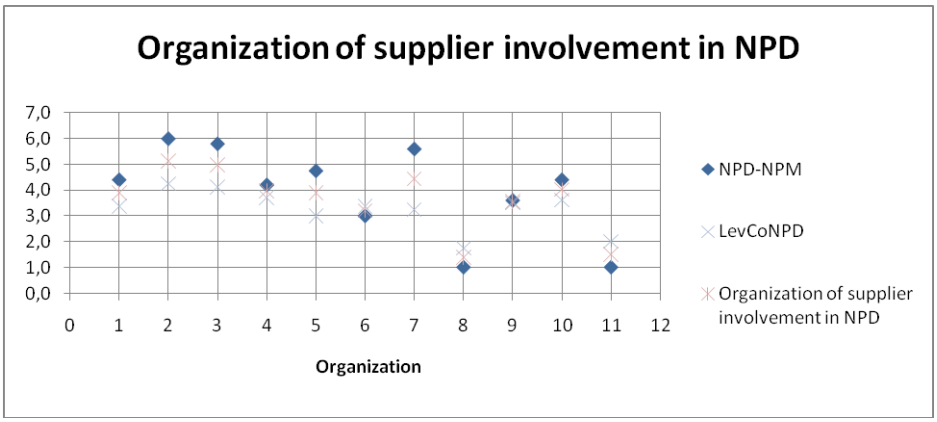

Figure 5.18: Organization of supplier involvement in NPD

In addition, low scores are achieved from organization 11 with an overall score of 1.5. The scores on question 4 concerning the role suppliers play in the NPD process are on average. Question 4C (*'our organization has frequent communication with these suppliers in the early stages of the development process'*) scores best (4.6). The scores on question 6 are considerable lower, with an average of 3.3. A pattern is visible in the separate parts of question 6. This question is built out of different levels of cooperation in NPD. Question 6A entails the lowest level of cooperation (*'these suppliers are not involved; we develop products internally'*) and question 6H the highest (*'the NPD department has a contractual joint venture with these suppliers'*). The averages per part indicate that the organizations have a low level of cooperation in NPD, because the score on question 6A is high (4.8), and the score on question 6H is very low (1.9). Overall, it is not very well organized in the Portuguese automotive parts and components industry. The average score is 3.6 and the highest score is 5.1, which is not very high. The stamping organizations score very good on the organization of supplier involvement in NPD compared to the die casting parts organizations.

Important is to consider question 5 and 7 of the 'Supplier involvement in NPD questionnaire. Question 5 gives insight in the way suppliers participate in NPD and question 7 investigates which assets from the NPD department are shared with suppliers. Table 5.19 gives an overview of the results.

		SI NPD	OSI-NPD (Q5)	SI NPD	OSI-NPD (Q7)
Firm	**Company code**	5	PartSupNPD	7	SupAssNPD
1	h5fad9	**Supplier proprietary parts**	1	**Intellectual assets**	1
2	cctc8m	**Functional parts (detail-controlled)**	3	**Intellectual assets**	1
3	m6yvay	**Functional & body parts (detail-controlled)**	3 & 4	**Intellectual & human assets**	1 & 2
4	b5a2vt	**Body parts (detail-controlled)**	4	**Intellectual assets**	1
5	bwx57v	**None of these options**	0	**Intellectual assets**	1
6	xwv2fv	**Functional parts (detail-controlled)**	3	**Intellectual assets**	1
7	s2ahcc	**None of these options**	0	**None of these options**	0
8	5dmfv2	**None of these options**	0	**None of these options**	0
9	mm8xsy	**Functional parts (detail-controlled)**	3	**Intellectual assets**	1
10	sjwrxu	**Black box parts**	2	**Intellectual assets**	1
11	5xq6xa	**Functional parts (detail-controlled)**	3	**None of these options**	0

Table 5.19: Individual organization result on supplier participation in NPD and supplier asset sharing

Most organizations have organized the participation of suppliers in a way that the suppliers take responsibility for process engineering and production based on blueprints provided by buyers on functional parts (detail-controlled parts). Only organization 10 is working in a way in NPD where developmental work is split between buyer and supplier (black-box parts). Thus, suppliers do not participate in NPD in an extensive way.

The results of question 7 concerning the asset sharing from the NPD department with suppliers, indicates that most organizations share intellectual assets, such as technology information, customer requirements, and direct cross-functional inter-company communication. Several organizations are not sharing assets with suppliers and only organization 3 shares human assets in NPD with suppliers, such as co-location, and supplier participation on the project team. None of the organizations shares physical assets.

Finally, taking all the average scores of the supplier characteristics, supplier performance & competition, degree of supplier involvement in NPD, and the organization of supplier involvement in NPD together, the average score of the management of supplier involvement in NPD can be calculated. Table 5.20 contains the overall view of the management of supplier involvement in NPD.

		SC (Q1)	SPC (Q2)	DSI-NPD (Q3)	OSI-NPD (Q4 & 6)	MSI-NPD (Q1-4 & 6)
Firm	**Company code**	SupChar	SupPerfComp	DgrSupInvNPD	OrgSupInvNPD	ManSupInvNPD
1	h5fad9	**5,3**	**5,5**	**5,0**	**3,9**	**4,9**
2	cctc8m	**3,3**	**6,0**	**4,4**	**5,1**	**4,7**
3	m6yvay	**4,7**	**5,2**	**4,4**	**5,0**	**4,8**
4	b5a2vt	**4,7**	**5,0**	**3,8**	**4,0**	**4,4**
5	bwx57v	**6,0**	**3,4**	**3,0**	**3,9**	**4,1**
6	xwv2fv	**3,0**	**5,5**	**3,0**	**3,2**	**3,7**
7	s2ahcc	**3,3**	**4,7**	**5,4**	**4,4**	**4,5**
8	5dmfv2	**3,3**	**5,3**	**1,0**	**1,4**	**2,8**
9	mm8xsy	**3,0**	**4,7**	**2,2**	**3,6**	**3,4**
10	sjwrxu	**5,7**	**4,3**	**3,0**	**4,0**	**4,3**
11	5xq6xa	**3,3**	**5,5**	**1,2**	**1,5**	**2,9**
		4,2	**5,0**	**3,3**	**3,6**	**4,0**
		SC	SPC	DSI-NPD	OSI-NPD	**MSI-NPD**

Table 5.20: Individual organization result on the management of supplier involvement in NPD

The constructs of the management of supplier involvement in NPD are also visualized in figure 5.21.

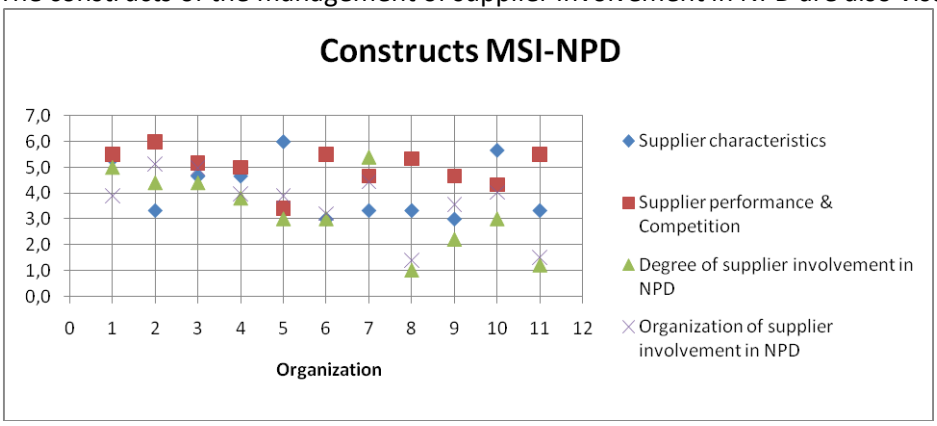

Figure 5.21: The constructs of the management of supplier involvement in NPD

Organizations score between 2.8 and 4.9 on the management of supplier involvement in NPD. The lowest score is again for organization 8, and thus this is the organization, which involves its suppliers the least in NPD. The highest score is achieved by organization 1. The overall score of the organizations in the Portuguese automotive parts and components industry on the management of supplier involvement in NPD is 4.0. Descriptive statistics of the management of supplier involvement in NPD and its constructs can be found in appendix 7 (table A7.6). The overall scores are above average, but not very high. They are influenced by the supplier performance & competition, which is relatively high. The lowest score is achieved by the degree of supplier involvement in NPD, which is the indicator for the relation between organization and supplier.

Concluding, organizations in the Portuguese automotive parts and components industry have a relationship with their suppliers in NPD, but this relationship is not extensive. The organizations in the stamping business scored low on the NPD performance, but high on the management of supplier involvement in NPD. The die casting parts organizations scored high on the NPD performance, but low on the management of supplier involvement in NPD. Figure 5.22 again highlights the scores on the management of supplier involvement in NPD. To research several relationships between variables, the following paragraph discusses the correlations made.

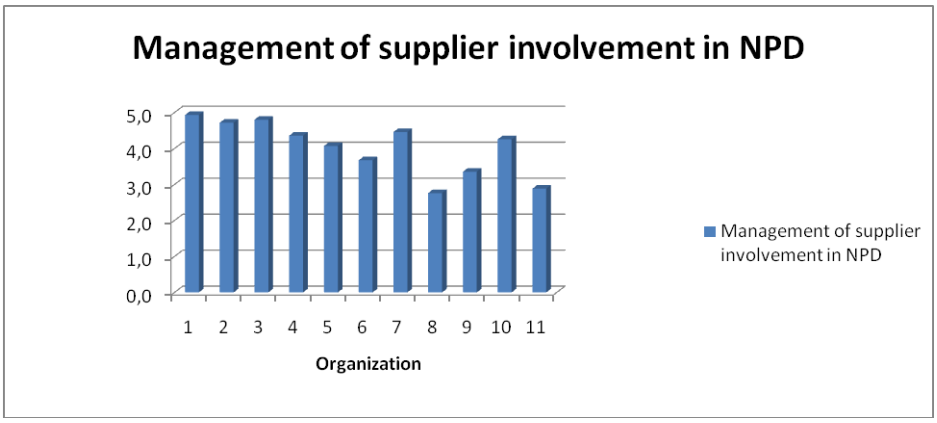

Figure 5.22: Management of supplier involvement in NPD

5.3 Exploratory analysis of results

In this paragraph, the data is analyzed exploratory with the use of SPSS. First, the R&D/Manufacturing integration is submitted to correlation analysis. References are made to the pre-analysis. However, the extensive part concerning the Operational Effectiveness is not described, because it is not in line with the model used in this research. Yet some analyses are made for the 'Patterns in NPD' project. Therefore, the exploratory analysis on the Operational Effectiveness can be found in appendix 9. Second, a correlation analysis is done on the development team integration processes together with the R&D/Manufacturing integration to study if these processes have a positive effect on this integration. Third, the management of supplier involvement in NPD is subject to correlation analysis to define which construct is influencing the management of supplier involvement most. In addition, an analysis is made to research the relation between the supplier involvement in NPD and the development team integration processes. Finally, an insight is given in the relations between the management of supplier involvement in NPD and the R&D/Manufacturing integration.

Several analyses will be made. First, a correlation analysis is made by using SPSS. This correlation analysis gives insight in the linear relation between the tested variables. It is possible that the tested relations between variables are not linear but quadratic for example. Therefore, a scatter plot is made to acquire insight in the relation between the variables. **Thus, an impression, or indication is given of the possible relation.** 'We have to sit on the fence', and thus be cautious with making statements (no signification possible!), because only an impression is given.
In the scatter plots, an impression of a relation can go further until X^{10} for example. Yet this is not possible with the SPSS program, and it would not give a useful indication for the relation found. Appendix 10 gives some extra insight in the possible relations between the variables, whether they are linear, quadratic, or cubic.

5.3.1 R&D/Manufacturing integration

The R&D/Manufacturing integration is, together with the R&D/Marketing integration, part of the fit with firm competencies. Table A8.1 in appendix 8 shows the correlation of the items with the fit with firm competencies. Similar to the pre-analysis, questions 21D-F all give an impression of a relation with the fit with firm competencies and influence this construct most. These questions are related to the R&D/Marketing integration. The R&D/Manufacturing integration is extremely lower; only one item (*'the degree of manufacturing cost advantage that NPD provides is satisfactory'*) gives the impression that it is significant. To infer from the R&D/Manufacturing integration, we might state that at these organizations, many manufacturing problems occur during production start-up phases and that more product design changes are needed to solve manufacturing performance.

5.3.1 Development team integration processes

The second part of this exploratory data analysis concerns the development team integration processes. The relationships between the processes and the R&D/Manufacturing integration, and the management of supplier involvement in NPD are studied.

Table A8.2 in appendix 8 shows the correlations between the processes and the R&D/Manufacturing integration. The reason for this correlation is that through the R&D/Manufacturing integration, there is a positive relationship between the processes and the performance of the New Product Manufacturability. Table A8.2 confirms this, and the correlation scores 0.214. There might be a positive relation between the processes and the R&D/Manufacturing integration. However, this possible relation is not strong. An indication is given by figure 5.23.
Figure 5.23 indicates that the R square cubic is 0.252. This is close to the correlation found. Other scatter plots (linear and quadratic) can be found in appendix 10 (figures A10.1 & A10.2). Therefore, there is a positive, but weak cubic relation between the development team integration processes and the R&D/Manufacturing integration.

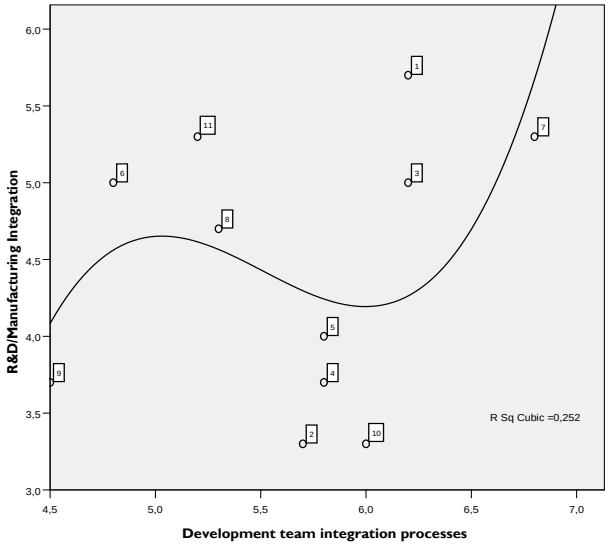

Figure 5.23: Scatter plot of the development team integration processes and the R&D/Manufacturing integration

As visible in figure 5.23, organizations 1, 3 and 7 score above average on both aspects. The other organizations score very divers.

The scatter of the organizations may also indicate a linear relation. Especially in the upper region of the field, a straight line can be drawn from point 9 to point 1 or 7 for example. Figure A10.1 in appendix 10 shows a linear relation. Yet this line, which is drawn automatically in SPSS, is not high enough (and indicates a low R Square). The kind of possible relation described is or can be the outcome of a regression analysis for example. Yet the cubic relation found, is used in the exploratory data analysis.

The development team integration processes are also correlated to the management of supplier involvement in NPD. According to the literature, the supplier involvement in NPD is part of the development team integration processes. As a result, there has to be a strong relation between the processes and the supplier involvement in NPD. Table A8.3 confirms this. The possible correlation indicates a relationship of 0.720. In the scatter plot, the relation is a little bit higher with a cubic R square of 0.754. This is pointed out in figure 5.24. The other scatter plots can be found in appendix 10 (figure A10.4-5).

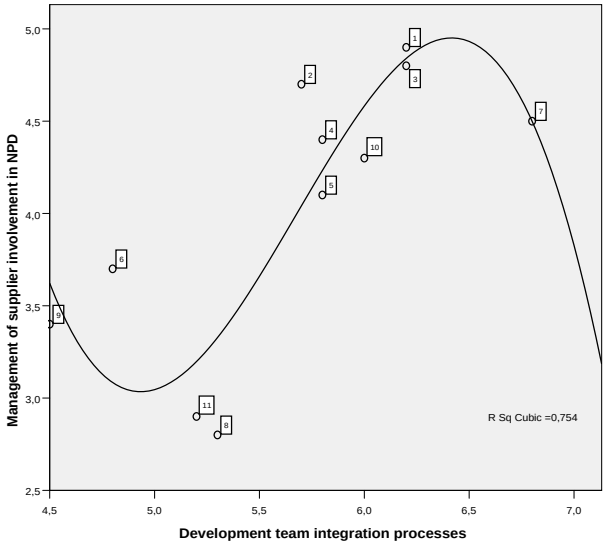

Figure 5.24: Scatter plot of the development team integration processes and the management of supplier involvement in NPD

It is visible that organization 7 is exactly on the cubic line. This organization might have a possible cubic relationship between the processes of development team integration and the management of supplier involvement in NPD. Many organizations are close to the line drawn. For example, organizations 4, 5 and 10 operate in the stamping business. These organizations might have a possible relation between the variables. The die casting parts organizations, 6 and 11, score lower in this analysis and these organizations might not have a possible relation between the variables.

5.3.2 Management of supplier involvement in NPD

The following correlation analysis is made on the management of supplier involvement in NPD. A definition is made which construct is influencing the management of supplier involvement most.

Table A8.4 in appendix 8 points out that not all constructs indicate a positively correlation with the management of supplier involvement in NPD. The supplier performance and competition indicate a negative correlation to almost every construct (-0.18). In addition, an indication is given that the supplier characteristics construct is not highly correlated to the management of supplier involvement in NPD (0.504). The degree of supplier involvement in NPD (0.937), and the organization of supplier involvement in NPD (0.909) might be highly correlated to the management of supplier involvement in NPD. They affect this construct most. Then, an indication is given that the higher the degree and the better the organization of supplier involvement in NPD, the better the management of supplier involvement in NPD. Besides, an indication for a high correlation is found between the degree and the organization of supplier involvement in NPD. Therefore, it might be that the higher the degree of supplier involvement in NPD, the better the organization of supplier involvement in NPD.

Finally, correlations are made on the R&D/Manufacturing integration with the management of supplier involvement in NPD. This correlation analysis provides an insight in the relationship between the management of supplier involvement in NPD and the R&D/Manufacturing integration. Table A8.5 in appendix 8 visualizes the correlations. The possible correlation between R&D/Manufacturing integration and the management of suppliers in NPD is negative (-0.70). Possibly, an increase of the management of supplier involvement in NPD is not causing an increase in the R&D/Manufacturing integration. Consequently, there might be no positive correlation between these two variables. However, a correlation expects a linear relation. Perhaps this relation is different. A scatter plot helps to identify the real relationship. Figure 5.25 points out the scatter plot of the management of supplier involvement in NPD and the R&D/Manufacturing integration. The other scatter plots can be found in appendix 10 (figures A10.7 & A10.9).

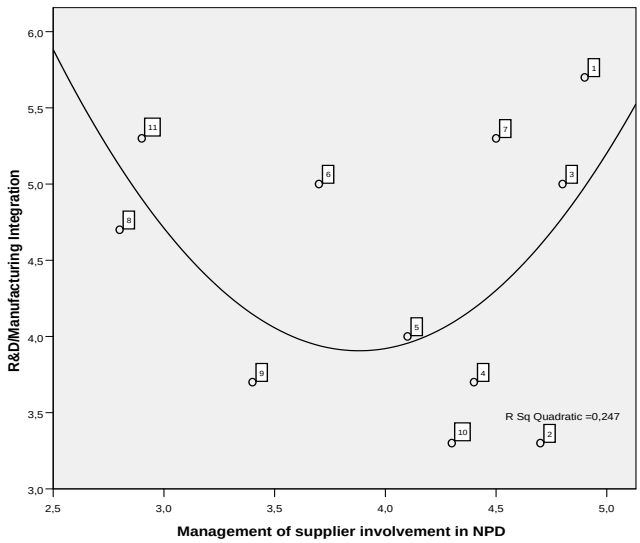

Figure 5.25: Scatter plot of the management of supplier involvement in NPD and the R&D/Manufacturing integration

As figure 5.25 indicates, there is not an indication given for a linear relationship between the management of supplier involvement in NPD. The R square quadratic is 0.247, which might indicate a positive (quadratic)

relationship between the two variables. Organizations 1, 3, and 7 are close to the quadratic up going line. Especially at these organizations, an indication is given that the better the management of supplier involvement in NPD, the higher the R&D/Manufacturing integration. These organizations all have different businesses.
The stamping organizations (4, 5, 10) score high on the management of supplier involvement in NPD, but low on the integration between R&D and manufacturing. The die casting parts organizations (6 and 11) score high on the R&D/Manufacturing integration, but low on the management of supplier involvement in NPD. However, both sub-businesses do not indicate a possible existing relation between these variables. On the contrary, organizations 1, 3, and 7 certainly indicate that this possible relation exists.

A study is made also on the degree of supplier involvement in NPD, because this is an important element of the management of supplier involvement in NPD. Much literature focuses on the degree of supplier involvement in NPD. Therefore, a short analysis is made. Table A8.6 in appendix 8 shows the correlation of the degree of supplier involvement in NPD and the R&D/Manufacturing integration. The correlation indicates a score of 0.130, which is a positive, but weak correlation. The scatter plot probably points out a different relation. The scatter plots made can be found in appendix 10 (figures A10.10-11).

For a second time, the scatter plot indicates no linear relationship between the two variables. Figure 5.26 gives an indication that there is a possible cubic relation between the degree of supplier involvement in NPD and the R&D/Manufacturing integration. This relation scores 0.438, which is good. Especially at organization 1, 3, and 7 there is an indication given of a possible relation. Then, a higher degree of supplier involvement in NPD causes a more efficient R&D/Manufacturing integration.

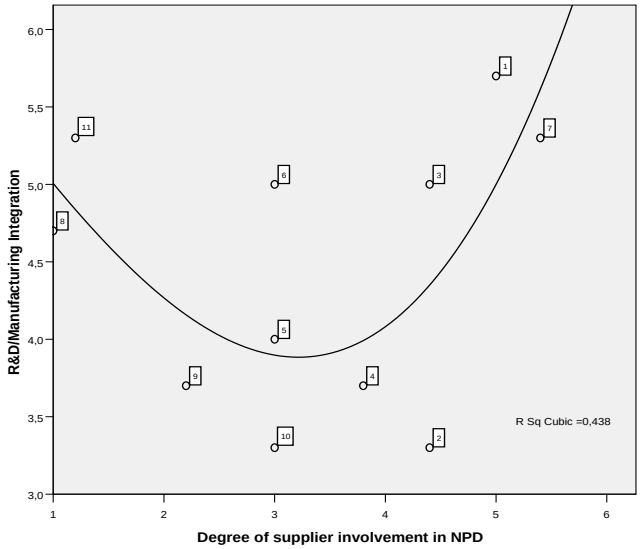

Figure 5.26: Scatter plot of the degree of supplier involvement in NPD and the R&D/Manufacturing integration

The organizations 1, 3, and 7 indicate a different pattern compared to the rest of the organizations; they score very good on all the analyses. These organizations operate in the plastics, head linings, and the electrical wiring businesses. The three organizations score good on degree-, management of supplier involvement in NPD, and the R&D/Manufacturing integration. This is visualized in figure 5.27.

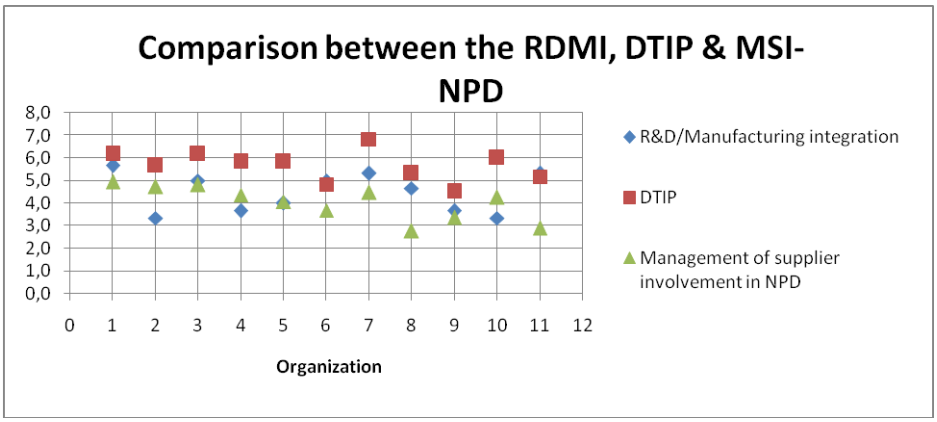

Figure 5.27: Comparison between the R&D/Manufacturing integration, Operational Effectiveness, degree-, and management of supplier involvement in NPD

As figure 5.27 indicates, at these three organizations it is possible that efficient development team integration processes, better management of supplier involvement in NPD, and an efficient integration between R&D and manufacturing, ultimately leads to a high performance in New Product Manufacturability.

5.4 Overall results

Finally, the overall results are discussed by comparing the best practices of the supplier involvement in NPD to the empirical results.

	Theory	Empirical Results
Supplier characteristics		
Size of the supplier	➢ Equivalent to organization in order to prevent inequitable treatment ➢ Balance of power	➢ Organizations are sometimes smaller than suppliers ➢ No balance of power
Position in the OEM supply chain	➢ First- or second-tier of the OEM supply chain (organization delivers to OEM – supplier delivers to first- or second-tier level)	➢ Also low-tier OEM supply chain
Product of the supplier	➢ Supplier must deliver a key component in order to be involved in the NPD process	➢ According to literature
Supplier performance and competition		
Supplier performance / Performance measurements	➢ Supplier must deliver conform quality, cost and time	➢ According to literature
Position in the value chain / Nr. of other possible suppliers	➢ Degree of competition between suppliers must be medium to low for more supplier involvement ➢ Degree of competition between suppliers must be high to increase supplier quality, cost and on-time performance	➢ Different degrees of competition, mostly high competition
Degree of supplier involvement		
Stages in the NPD process	➢ Supplier involvement in every stage of the NPD process	➢ Suppliers are not always involved in every stage
Organization of supplier involvement		
Supplier is part of internal NPD / influence on the design	➢ Supplier involvement already in early stages of the NPD process ('Black box integration')	➢ Suppliers are not always early involved
Supplier communication	➢ Frequent and appropriately structured task communication (both internal and external)	➢ According to literature
Participation of suppliers in NPD	➢ 'Black box parts' participation where developmental work is split between organization and supplier	➢ Only one organization works with black box integration
Participation of suppliers outside NPD	➢ Involve suppliers also in New Product Manufacturability	➢ According to literature

Asset allocation	➢ Share intellectual, human and physical assets with supplier	➢ Mostly intellectual asset sharing
Cooperation of suppliers in NPD	➢ Cooperate with suppliers by contract development, coordinated development and joint development with a medium to high intensity of cooperation	➢ Cooperation is of low intensity

Table 5.28: Best practices and empirical results of the supplier involvement in NPD

The results indicate, especially in table 5.28, that the Portuguese automotive parts and components industry not always has the ingredients needed according to literature to cooperate with suppliers. It was clearly visible in the scores of the 11 organizations that the supplier involvement in NPD is not perfectly managed.

Finally, the results indicate a possible quadratic relationship of 0.247 between the management of supplier involvement in NPD and the R&D/Manufacturing integration. In addition, the results point out a possible cubic relation of 0.252 between the development team integration processes and the R&D/Manufacturing integration. This is only a minimal difference. Comparing these results with the two propositions;

- **Proposition 1:** *'At organizations in the Portuguese automotive parts and components industry, there exist a measurable and positive relationship between the level of supplier involvement in NPD and the efficiency of the R&D/Manufacturing integration.'*
- **Proposition 2:** *'At organizations in the Portuguese automotive parts and components industry, the supplier involvement in NPD influences the R&D/Manufacturing integration through the 'internal' development team integration processes.'*

There is an indication given that the empirical results point in the right direction. Both propositions can be accepted. However, the relation between the processes and the R&D/Manufacturing integration is slightly higher compared to the relation between the management of supplier involvement in NPD and the R&D/Manufacturing integration. Moreover, the relation between the management of supplier involvement in NPD and the processes is higher compared to the relation of the management of supplier involvement in NPD and the R&D/Manufacturing integration. As a result, it is more likely that the development team integration processes influence the relation between the management of supplier involvement in NPD and the integration of R&D and manufacturing. This can be visualized in an adjusted research model, which is presented in figure 5.29.

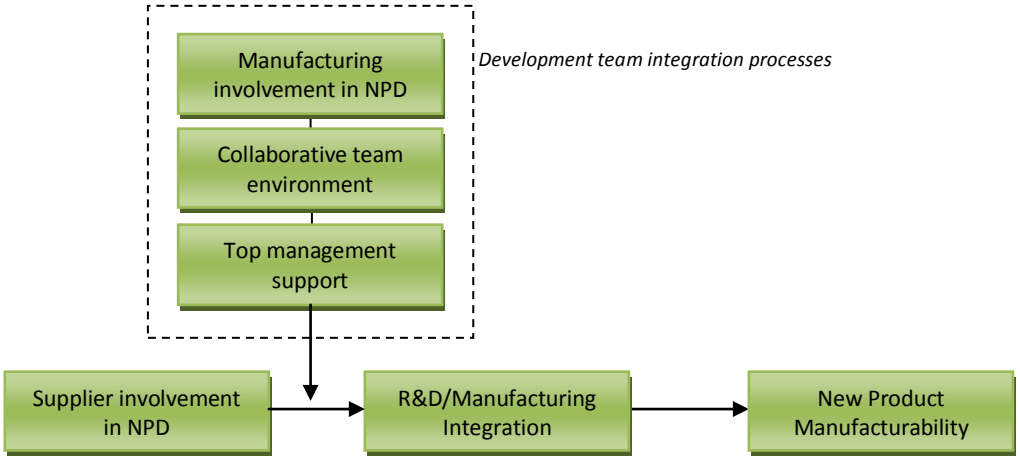

Figure 5.29: Model of empirical tested relations

Yet some remarks have to be made. As paragraph 5.3.2 indicated, there exists also a possible positive relation between the degree of supplier involvement in NPD and the R&D/Manufacturing integration. This relation is probably cubic and indicates a score of 0.438! This is higher compared to the analysis made on the development team integration processes and the management of supplier involvement in NPD. Therefore, an indication is given that the R&D/Manufacturing integration possibly has the best relation with the degree of supplier involvement in NPD. To increase the efficiency of the integration between R&D and manufacturing,

suppliers have to be involved in NPD. The development team integration processes might indeed influence the relations described. Thus, these processes are moderator variables.

Finally, an overview is presented of the constructs, which have been measured. Figure 5.30 visualizes this overview.

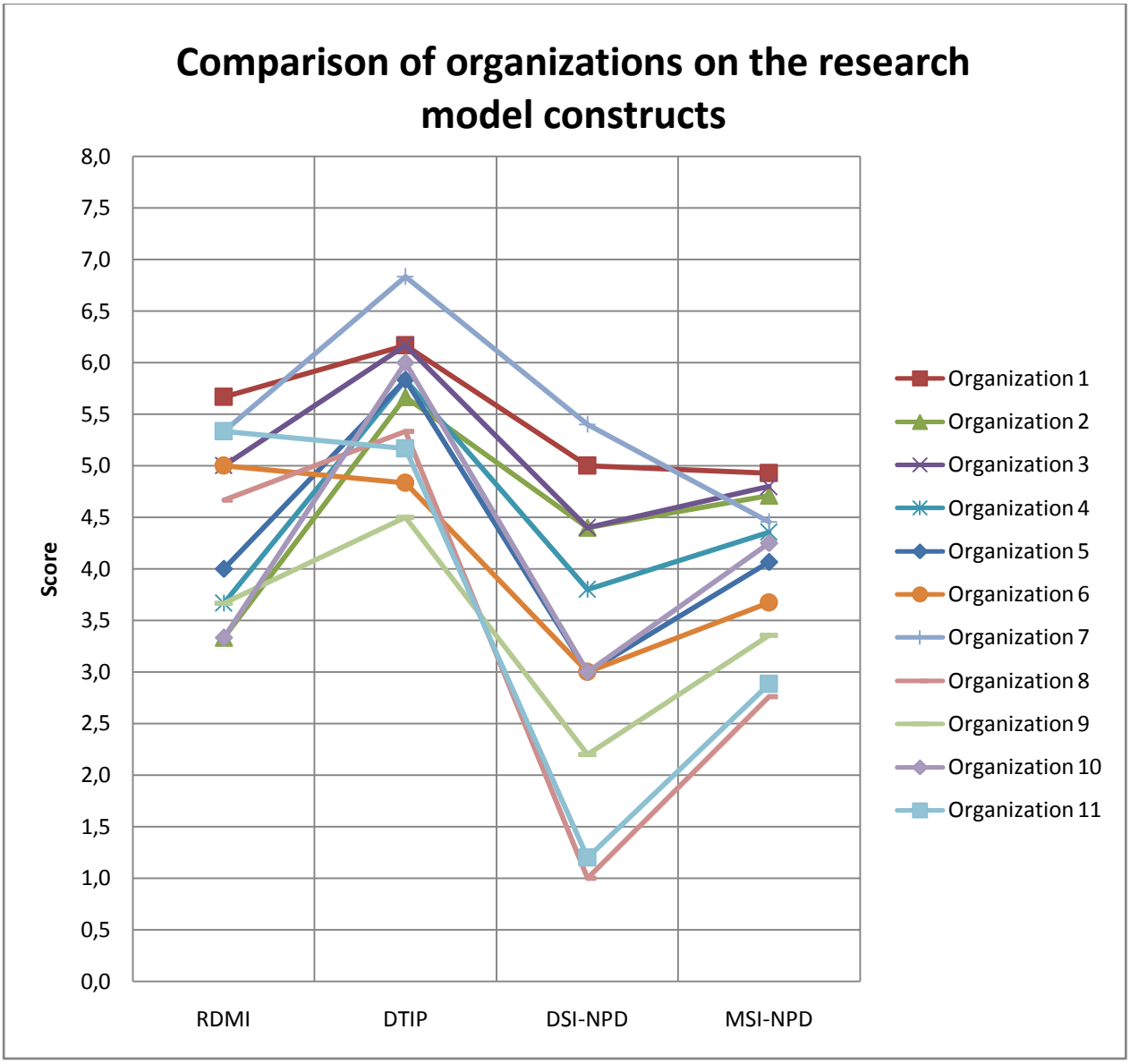

Figure 5.30: Comparison of organizations on the research model constructs

This overview once more points out that organizations 1, 3 and 7 have high scores on all the constructs. The scores of the other organizations are also presented. A comparison can be made between the good and bad performers.

6. Conclusion

Concluding and summarizing the findings of this research, we could state the following important aspects.

Based on the conclusions of literature study, it is possible to establish the best practices for supplier involvement in NPD. The involvement of suppliers can be separated in several areas, which all have influence on the role suppliers play in the NPD process: supplier characteristics, supplier performance and competition, degree of supplier involvement in NPD and the organization of supplier involvement in NPD. The best practices are tested in the field to explore whether organizations use them to make improvements in their cooperation with suppliers. Organizations in the Portuguese automotive parts and components industry, which come up to these expectations are recognized as successful organizations. This leads to better development team integration processes (manufacturing involvement in NPD, collaborative team environment, and top management support). According to literature, these processes have a positive influence on the R&D/Manufacturing integration and additionally on the performance in New Product Manufacturing.

For question 1, the empirical results indicated that organizations score diversely on the R&D/Manufacturing integration; organization 1 (plastics), 7 (electrical wiring) and 11 (die casting parts) score very good. Die casting parts organizations (6 & 11) score above average. Organization 2 (textiles), 4 (stamping), 9 (exhaust systems), and 10 (stamping) score below average. Manufacturing problems, which rise in the production start-up phases, are the wrongdoers. In comparing the pre-analysis data and the Portuguese data, we conclude that the R&D/Manufacturing integration is slightly higher at the Portuguese organizations subject to this research compared with the data from the other countries within the 'Patterns in NPD' project.

For question 2, the empirical results on the development team integration processes indicate that the manufacturing involvement in NPD is very high. Thus, the manufacturing department is involved in NPD and there is a lot of communication between the two departments. The scores on the collaborative team environment are even higher. However, in this environment, organizations not always use cross-functional integration in their NPD processes and roles.
The top management support has the highest scores. Yet this support is not always set clear or fixed in the organization. In the individual organizational results, it is visible that organization 1, 3 (window lifters), and 7 score high on the development team integration processes; organizations 6, 9, and 11 score below average on this variable. The die casting parts organizations have not developed these processes enough, especially the manufacturing involvement in NPD and the collaborative team environment.

For question 3, the supplier involvement in NPD can be analyzed with several empirical results. It has been proven that to manage suppliers in NPD an organization needs attention for several aspects, such as supplier characteristics, performance and competition of the supplier, and how to organize the supplier involvement in NPD. Despite the fact that scores are above average on the supplier characteristics, performance and competition, the organization of supplier involvement in NPD measures scores below. Organizations in the Portuguese automotive parts and components industry have a lower degree relationship with their suppliers in NPD. Individual organization scores prove this; organizations 8 (metalworking tools), 9 and 11 have problems with managing suppliers. In addition, the die casting parts organizations are not managing suppliers in NPD successfully.
Yet organization 1, 2 and 3 score high in managing suppliers in NPD. In addition, stamping organizations score high on this aspect. These organizations create value with their supplier management.

The explorative data analysis pointed out the following results for questions 4-6.
There is an indication given for a positive but weak relation between the development team integration processes and the R&D/Manufacturing integration. Moreover, there is a stronger relation between the processes and the management of supplier involvement in NPD. The individual organization results are varied. Organizations 1, 3, and 7 indicate that they have positive relations between the processes and the R&D/Manufacturing integration, and the management of supplier involvement in NPD.

In addition, an indication is given of a possible relation between the management of supplier involvement in NPD and the R&D/Manufacturing integration. This relation is measured. Organizations 1, 3, and 7 indicate a different pattern compared to the rest of the organizations; they score very good. These organizations operate in the plastics, head linings, and the electrical wiring businesses. Based on these results, an increase of the management of supplier involvement in NPD is suggested to lead to an increase in the R&D/Manufacturing integration.

Referring to the formulated propositions:

- **Proposition 1:** *'At organizations in the Portuguese automotive parts and components industry, there exist a measurable and positive relationship between the level of supplier involvement in NPD and the efficiency of the R&D/Manufacturing integration.'*

- **Proposition 2:** *'At organizations in the Portuguese automotive parts and components industry, the supplier involvement in NPD influences the R&D/Manufacturing integration through the 'internal' development team integration processes.'*

Due to the small difference between the tested relations, both propositions can be accepted, although there is a negligible difference between the tested relations. It is more likely that the development team integration processes influence the relation between the management of supplier involvement in NPD and the integration of R&D and manufacturing. This can be visualized in an adjusted research model, which is presented in figure 6.1.

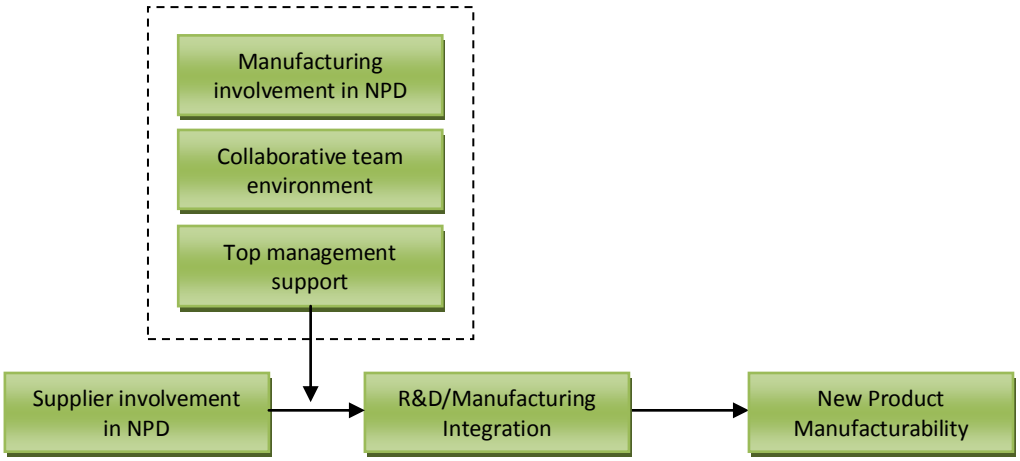

Figure 6.1: Model of empirical tested relations

The main research question of this Bachelor Thesis was:

In what way is the involvement of suppliers in NPD at Portuguese automotive parts and components organizations influencing the integration between R&D and manufacturing?

These conclusions give a clear answer on the main research question. The extent of involving suppliers in the NPD of organizations is standard. At several organizations, supplier involvement in NPD is **indeed** increasing or influencing the integration between R&D and Manufacturing. Three organizations (1, 3, and 7) score high on the degree, and management of supplier involvement in NPD, and the R&D/Manufacturing integration. Here, this possibly leads to a higher performance in New Product Manufacturability. The exploratory data analysis found an indication for a relation. Then, supplier involvement in NPD **might increase** the integration between R&D and Manufacturing at some organizations from the Portuguese automotive industry. The degree of supplier involvement in NPD indicates a very good relation with the integration of R&D and manufacturing. Consequently, for the achievement of a more efficient R&D/Manufacturing integration, probably suppliers must be involved in NPD.

7. Suggestions for further research

Because a positive effect of supplier involvement in NPD on R&D/Manufacturing integration is proven, the organizations, which are not following the best practices formulated on the management of supplier involvement in NPD, should reconsider their organization of supplier involvement in NPD to overcome problems in NPM.

This research gave a first insight to manage this cooperation. Literature needs to be developed to continue the research in this area. Moreover, because scales were not available on the supplier involvement in NPD, these were developed specially for this research. These scales need to be tested in different areas to see if they are valid.

Literature was used and combined to define these scales. The result was a specific analysis on the aspects of supplier involvement in NPD and the R&D/Manufacturing integration. These scales and specific analysis have to be used in further research.

More than 230 organizations are already in the dataset of the 'Patterns in NPD' database. However, these organizations have not participated in the research concerning supplier involvement in NPD. Testing such propositions outside the automotive industry and investigate the whole 'Patterns in NPD' dataset on the supplier involvement in NPD will be interesting.

The conducted research described in this report used a dataset of **11** organizations in the Portuguese automotive parts and components industry. All these organizations are originally Portuguese. An implication is that the conclusions are only valid for the Portuguese automotive parts and components industry and not for the entire automotive parts and components industry. For general applicability, further research in this industry needs to be conducted.

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Internet

ACEA: www.acea.be
AFIA: www.afia-afia.pt
CBI: www.cbi.nl
CLEPA: www.clepa.be
ICEP: www.investinportugal.pt
Patterns in NPD: www.patterns-in-npd.com

List of Tables & Figures

Appendices

Appendix 1: NPD performance measurements

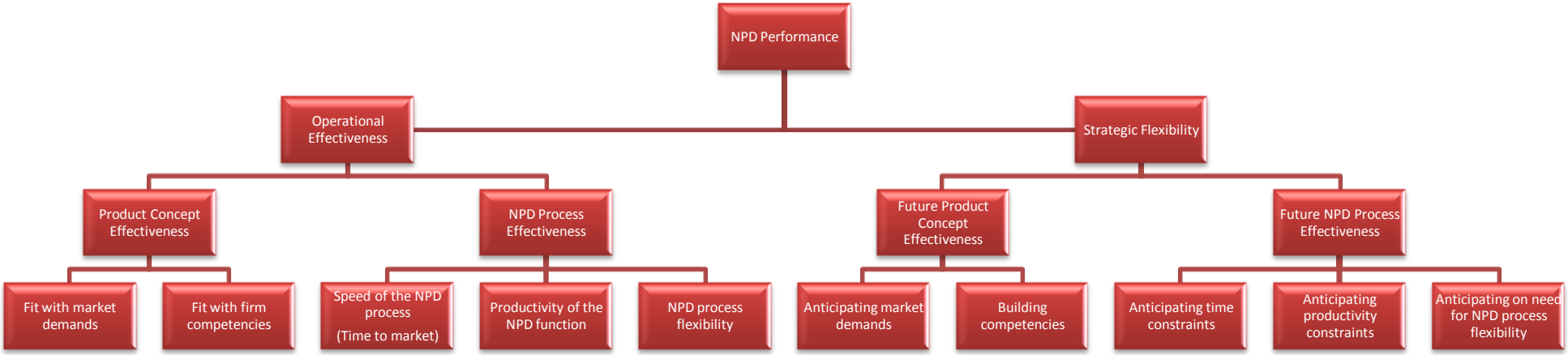


Figure A1.1: The dimensions of NPD performance (De Weerd-Nederhof et al., 2002)

Appendix 2: Patterns in NPD Automotive Data

The 'Patterns in NPD' project data on innovation performance in the automotive sector divided in Operational NPD Effectiveness and Strategic Flexibility.

		OE FMD (Q20)							OE FC (Q21)							OE SDP (Q22)							OE PR (Q23)							OE FL (Q24)							PCE	NPD PE	OE
Firm	20	a	b	c	d	e	f	21	a	b	c	d	e	f	22	a	b	c	d	e	f	23	a	b	c	d	e	24	a	b	c	d	e	f			
1	**5,5**	6	6	5	6	5	5	**4,7**	6	4	3	6	5	4	**6,2**	7	7	5	5	7	6	**5,4**	5	6	6	5	5	**5,7**	6	5	4	6	7	6	**5,1**	**5,7**	**5,4**
2	**6,0**	6	7	6	7	3	7	**2,0**	6	1	2	1	1	1	**3,0**	7	7	1	1	1	1	**2,6**	2	2	2	6	1	**4,5**	5	2	6	2	6	6	**4,0**	**3,4**	**3,7**
3	**5,5**	7	6	6	7	5	3	**4,8**	5	4	4	6	4	6	**5,3**	6	3	5	7	5	6	**3,8**	5	3	2	6	3	**4,2**	6	4	4	4	2	5	**5,2**	**4,4**	**4,8**
4	**5,1**	6	6	4	6	6	3	**4,8**	4	3	4	6	6	6	**4,5**	6	4	6	5	3	3	**4,6**	5	5	5	3	5	**3,7**	3	3	3	3	4	6	**5,0**	**4,3**	**4,6**
5	**5,3**	6	5	6	6	5	4	**4,5**	3	3	3	6	6	6	**3,7**	5	3	4	4	4	2	**4,0**	3	3	5	6	3	**4,8**	4	4	5	5	5	6	**4,9**	**4,2**	**4,5**
6	**7,0**	7	7	7	7	7	7	**6,0**	6	6	6	6	6	6	**6,0**	6	6	6	6	6	6	**4,0**	4	4	4	4	4	**4,7**	5	5	5	5	5	3	**6,5**	**4,9**	**5,7**
7	**4,6**	5	5	4	5	5	4	**3,8**	4	4	4	3			**5,3**	6	5	4	6	6	5	**5,0**	5	5	5	5	5	**5,0**	5	5	5	5	5	5	**4,2**	**5,1**	**4,7**
8	**1,0**	1	1	1	1	1	1	**1,5**	1	1	1	1	4	1	**7,0**	7	7	7	7	7	7	**7,0**	7	7	7	7	7	**7,0**	7	7	7	7	7	7	**1,3**	**7,0**	**4,1**
9	**5,4**	5	6	5	7	6	3	**3,5**	4	3	3	3	3	5	**5,5**	7	4	5	6	7	4	**3,2**	2	2	4	4	4	**3,5**	3	3	4	4	4	3	**4,4**	**4,1**	**4,2**
10	**4,2**	2	2	7	7	4	2	**4,3**	6	6	7	2	2	3	**4,3**	2	3	4	5	6	6	**6,4**	6	7	7	7	5	**6,8**	6	7	7	7	7	7	**4,3**	**5,9**	**5,1**
11	**5,2**	7	5	5	7	7	1	**5,0**	5	3	2	7	6	7	**4,0**	5	4	4	3	4	4	**5,5**	5	5	6		6	**6,0**	6	6		6		6	**5,1**	**5,2**	**5,1**
12	**7,0**	7	7	7	7	7	7	**5,3**	6	4	6	7	4	5	**6,3**	7	5	6	7	6	7	**3,4**	6	3	2	4	2	**4,5**	7	7	1	4	2	6	**6,2**	**4,7**	**5,5**
13	**5,5**	5	5	4	6	6	7	**3,2**	5	4	6	1	1	2	**5,7**	6	6	6	6	6	4	**4,8**	4	6	6	3	5	**6,3**	6	6	6	6	7	7	**4,4**	**5,6**	**5,0**
14	**5,8**	6	7	7	7	5	3	**5,0**	4	3	4	7	6	6	**4,3**	6	1	5	6	6	2	**2,4**	3	3	1	4	1	**3,7**	5	6	3	3	2	3	**5,4**	**3,5**	**4,4**
15	**4,4**	6	5	3	5	5	3	**3,3**	4	2	3	3	3	5	**2,7**	3	2	3	4	2	2	**4,0**	5	3	4	4	4	**4,7**	5	5	5	3	5	5	**3,8**	**3,8**	**3,8**
16	**6,2**	4	6	6	7	7	6	**5,2**	4	3	4	7	6	7	**2,7**	5	4	2	2	1	2	**6,0**		6	6	7	5	**4,5**	3	3	5	6	6	4	**5,7**	**4,4**	**5,0**
17	**5,0**	5	6	5	6	4	4	**5,0**	4	4	5	6	5	6	**5,2**	4	5	5	6	5	6	**4,2**	5	5	4	3	4	**4,2**	4	5	3	5	3	5	**5,0**	**4,5**	**4,8**
18	**3,5**	5	3	4	3	4	3	**3,7**	3	5	5	2	4	3	**4,0**	3	4	5	5	3	4	**4,8**	6	5	4	4	5	**3,5**	4	3	5	3	4	2	**3,6**	**4,1**	**3,9**
19	**5,2**	7	6	3	5	6	5	**5,0**	5	4	2	7	6	6	**4,2**	5	6	3	3	3	5	**3,8**	4	4	5	3	3	**4,2**		3	6	3	3	6	**5,1**	**4,1**	**4,6**
20	**5,8**	6	5	6	6	6	6	**5,7**	5	5	5	6	6	7	**5,7**	5	5	6	6	6	6	**5,2**	4	5	5	6	6	**5,8**	6	6	6	5	6	6	**5,7**	**5,6**	**5,7**
	5,2	**5,5**	**5,3**	**5,1**	**5,9**	**5,2**	**4,2**	**4,3**	**4,5**	**3,6**	**4,0**	**4,7**	**4,4**	**4,8**	**4,8**	**5,4**	**4,6**	**4,6**	**5,0**	**4,7**	**4,4**	**4,5**	**4,5**	**4,5**	**4,5**	**4,8**	**4,2**	**4,9**	**5,1**	**4,8**	**4,7**	**4,6**	**4,7**	**5,2**			**4,7**
	FMD							FC							SPD							PR						FL									

Table A2.1: Operational Effectiveness in the automotive sector

		SF FMD (Q20)							SF FC (Q21)							SF SDP (Q22)							SF PR (Q23)							SF FL (Q24)						PCE	NPD PE		SF
Firm	20	g	h	i	j	k	l	21	g	h	i	j	k	l	22	g	h	i	j	k	l	23	f	g	h	i	j	24	g	h	i	j	k	l			
1	**5,2**	5	5	5	6	5	5	**6,2**	6	6	7	4	7	7	**6,0**	7	7	5	6	6	5	**5,7**	6	5	5	6	6	**6,3**	5	7	7	7	6	6	**5,7**	**6,0**	**5,8**
2	**4,7**	1	5	7	3	6	6	**3,5**	2	6	1	1	5	6	**2,3**	5	5	1	1	1	1	**3,4**	6	2	6	2	2	**2,7**	3	3	3	3	2	2	**4,1**	**2,8**	**3,4**
3	**4,3**	6	5	3	3	2	7	**6,7**	7	7	5	7	7	7	**4,8**	4	4	5	5	4	7	**4,4**	3	5	4	5	5	**4,7**	5	4	6	6	2	5	**5,5**	**4,6**	**5,1**
4	**3,2**	4	2	3	3	2	5	**5,7**	6	6	4	6	6	6	**2,7**	2	2	2	4	2	4	**4,5**	4	5	4	5	5	**3,8**	5	5	3	4	3	3	**4,4**	**3,7**	**4,0**
5	**4,5**	3	6	4	3	6	5	**3,8**	3	3	5	3	3	6	**2,5**	3	2					**3,8**	5	2	5	4	3	**4,0**	5	5			3	3	**4,2**	**3,4**	**3,8**
6	**6,2**	6	6	7	7	5	6	**6,2**	6	7	6	6	6	6	**5,5**	6	6	5	5	6	5	**5,2**	5	5	5	6	5	**5,0**	5	5	4	5	5	5	**6,2**	**5,2**	**5,7**
7	**4,3**	5	4	4	4	4	5	**4,8**	4	5		5		5	**5,8**	6	6	6	6	5	6	**4,9**	5	5	5	5	5	**4,7**	5	5	5	5	4	4	**4,5**	**5,1**	**4,8**
8	**1,0**	1	1	1	1	1	1	**1,0**	1	1	1	1	1	1	**7,0**	7	7	7	7	7	7	**7,0**	7	7	7	7	7	**7,0**	7	7	7	7	7	7	**1,0**	**7,0**	**4,0**
9	**3,3**	3	4	3	2	4	4	**4,8**	4	5	3	4	6	7	**4,7**	5	4	4	5	5	5	**2,8**	2	1	3	3	4	**3,5**	4	4	3	4	3	3	**4,1**	**3,6**	**3,9**
10	**4,8**	6	5	2	7	4	5	**5,7**	7	5	6	5	5	6	**6,3**	5	7	7	6	6	7	**5,1**	4	5	5	6	5	**5,3**	6	6	5	4	5	6	**5,3**	**5,6**	**5,4**
11	**2,5**	1	1	1	5	6	1	**5,0**	4	4	5	6	5	6	**4,8**	5	5	3		6	5	**4,7**	5	5	5	4	4	**5,0**	6	5			5	4	**3,8**	**4,8**	**4,3**
12	**5,7**	6	7	7	6	3	5	**6,5**	7	6	6	6	7	7	**6,3**	7	7	6	6	5	7	**5,3**	5	6	5	6	5	**4,8**	5	5	4	6	5	4	**6,1**	**5,5**	**5,8**
13	**6,5**	7	7	7	7	6	5	**4,6**	5	5	1	5		7	**4,2**	2	4	2	7	5	5	**5,1**	5	5	5	5	5	**5,3**	4	5	5	6	6	6	**5,6**	**4,9**	**5,2**
14	**4,0**	5	6	3	2	4		**4,8**	5	4	6	6	3	5	**4,0**	3	6		4	4	3	**3,4**	3	5	2	3	3	**4,2**	4	3	3	4	5	6	**4,4**	**3,8**	**4,1**
15	**4,8**	2	6	3	6	6	6	**4,2**	5	4	4	4	3	5	**2,8**	3	4	3	2	2	3	**4,1**	4	5	4	4	4	**3,8**	5	4	3	3	4	4	**4,5**	**3,6**	**4,1**
16	**5,3**	7	6	6	4	6	3	**4,7**	4	5	5	4	4	6	**4,0**	3	4	5	6	3	3	**2,6**	6	1	2	1	2	**3,3**	4	3	2	2	6	3	**5,0**	**3,3**	**4,1**
17	**4,5**	5	4	4	4	5	5	**5,7**	6	7	6	5	5	5	**5,0**	5	5	4	5	5	6	**4,8**	5	4	5	5	5	**5,0**	5	6	5	5	4	5	**5,1**	**4,9**	**5,0**
18	**4,0**	6	4	3	4	3	4	**4,0**	4	4	5	4	4	3	**4,0**	5	4	4	4	3	4	**3,7**	4	4	3	4	3	**4,2**	4	4		4	4	5	**4,0**	**4,0**	**4,0**
19	**5,0**		7	5	1	7		**4,6**	5	4	6	4	4		**4,3**	5	5	5	3	4	4	**3,8**	5	3	4	3	3	**5,0**	6	4	5	3	6	6	**4,8**	**4,4**	**4,6**
20	**5,5**	6	5	6	6	5	5	**4,7**	5	5	5	4	5	4	**4,8**	5	5	5	5	4	5	**4,7**	4	6	4	4	6	**4,0**	4	4	4	4		4	**5,1**	**4,5**	**4,8**
	4,5	**4,5**	**4,8**	**4,2**	**4,2**	**4,5**	**4,6**	**4,8**	**4,8**	**5,0**	**4,6**	**4,5**	**4,8**	**5,5**	**4,6**	**4,7**	**5,0**	**4,4**	**4,8**	**4,4**	**4,8**	**4,4**	**4,7**	**4,3**	**4,4**	**4,4**	**4,4**	**4,6**	**4,9**	**4,7**	**4,4**	**4,5**	**4,4**	**4,5**			**4,6**
	FMD							FC							SPD							PR						FL									

Table A2.2: Strategic Flexibility in the automotive sector

Appendix 3: Questionnaire Patterns in NPD

Questionnaire

"Patterns in New Product Development"

- Strictly confidential -

'Patterns in New Product Development'

In the questionnaire you will find instructions for each set of questions. We understand that in some cases you may find that the particular question does not entirely fit your case. Whenever such situations happen, please use your best judgment to answer the question and try not to skip it. We sincerely appreciate your efforts in completing all questions.

Please note that individual responses will be strictly confidential and only known to the research team. However, sometimes it is relevant to us to cite a company name. We will always ask written permission in these cases. Please indicate whether you want to stay anonymous in all cases, and/or whether we may contact you again for further collaboration

☐ Yes, I wish to remain anonymous in all cases
☐ Yes, I am happy to be contacted again

Thank you very much for your cooperation!

Your name:	
Your email address:	
Your telephone number:	
Your position within the organization:	
The name of your business unit (if applicable):	
Your mailing address:	

Description of the Strategic Business Unit

1. What is the name of your business unit?

2. What best describes your business unit (tick one)

☐	Independent company	Go to 4
☐	A division / business unit belonging to a parent company	Go to 3
☐	A single location / plant	Go to 3

3. What is the name of your parent company?

4. What is the year of establishment of your business unit?

5. What is the primary geographic region where you do business?

- ☐ Limited to a single location
- ☐ Spread out over a single geographic region
- ☐ Nationwide
- ☐ International

6. Please answer the next questions about the size of your business unit:

What are total annual sales?		Million EUR
What is the total number of employees in full time equivalent?		FTE

7. How would you describe the primary product mix (tick one)?

- ☐ High volume/high mix
- ☐ High volume/low mix
- ☐ Low volume/ High Mix
- ☐ Low volume/low mix

Products and Processes

8. Identify the Core Products for which you will answer all questions in the questionnaire.

9. Please indicate the industry sector for this Core Product [SIC code(s)]:

10. What proportion of your customer orders for the Core Products identified are:

- % Industrial products (products to be used by other companies for their transformational processes).
- % Consumer products (products are intended to the final consumer market and no more transformations).

11. Please indicate the type of process that is used to manufacture your Core Products (Tick one answer):

- ☐ Engineer to order: Design, purchasing, manufacturing and assembly is done for a designated customer. (Go to 12)
- ☐ Manufacture to order: Design, raw materials, and components are in stock. (Go to 13)
- ☐ Assemble to order: Just subsystems and subassemblies are in stock and the final assembly occurs based on a designated customer order. (Go to 13)
- ☐ Produce to stock: Products are produced and are kept in stock near the customer or at the company. (Go to 13)

12. Please specify the influence of customer demand (Tick one answer).
When an order arrives we start our engineering activities based upon …

- ☐ … a specific technology.
- ☐ … pre-defined product families.
- ☐ … pre-defined product sub-functions and solution principles.
- ☐ … pre-defined product modules.
- ☐ … pre-defined generally detailed finished goods.

Environment

13. Each of the following items consists of a pair of statements, which represent two extremes on characteristics of your industrial sector (as filled in for your Core Products) or on your business unit. Please circle the number on the scale that best approximates the actual conditions.

		1	2	3	4	5	6	7	
a.	**Safe**, little threat to the survival and well being of the organization.	☐	☐	☐	☐	☐	☐	☐	**Risky**, one false step can mean my organization's undoing.
b.	**Rich opportunities** in investment and marketing.	☐	☐	☐	☐	☐	☐	☐	**Few opportunities**, stressful, hostile, hard to keep afloat.
c.	A **dominant organization** that can control and manipulate the environment to its own advantage.	☐	☐	☐	☐	☐	☐	☐	A **dominating environment** in which our initiatives count for very little against environmental forces.
d.	Our organization **must rarely change** its practices to keep up with the market and competitors.	☐	☐	☐	☐	☐	☐	☐	Our organization **must frequently change** its practices.
e.	The rate at which products are getting obsolete in the industry is **low**.	☐	☐	☐	☐	☐	☐	☐	The rate at which products are getting obsolete in the industry is **high**.
f.	Actions of competitors are **easy to predict**.	☐	☐	☐	☐	☐	☐	☐	Actions of competitors are **unpredictable**.
g.	Demand for the product and consumer tastes are **easy to predict**.	☐	☐	☐	☐	☐	☐	☐	Demands for the product and consumer tastes are **unpredictable**.
h.	The production technology is subject to **little change**.	☐	☐	☐	☐	☐	☐	☐	The production technology is subject to **much change**..
i.	The nature of the competition is about **the same** for all products.	☐	☐	☐	☐	☐	☐	☐	The nature of the competition **varies a great deal** from one product to another.
j.	The required methods of production are about **the same** for all products.	☐	☐	☐	☐	☐	☐	☐	The required methods of production **vary a great deal** from one product to another.
k.	Customers' buying habits are about **the same** for all products.	☐	☐	☐	☐	☐	☐	☐	Customers' buying habits **vary a great deal** from one product to another.

Business Strategy

14. Which of the texts below most closely describes your business unit's approach your Core Product's marketplace?

- [x] We continuously search for market opportunities and regularly experiment with potential responses to emerging environmental trends. Therefore, we often are the creators of change and uncertainty to which our competitors must respond.

- [x] We attempt to maintain a stable, limited line of products or services, operating routinely and efficiently through the use of formalized structures and processes. At the same time, we monitor a carefully selected set of promising new product and market developments in different industries.

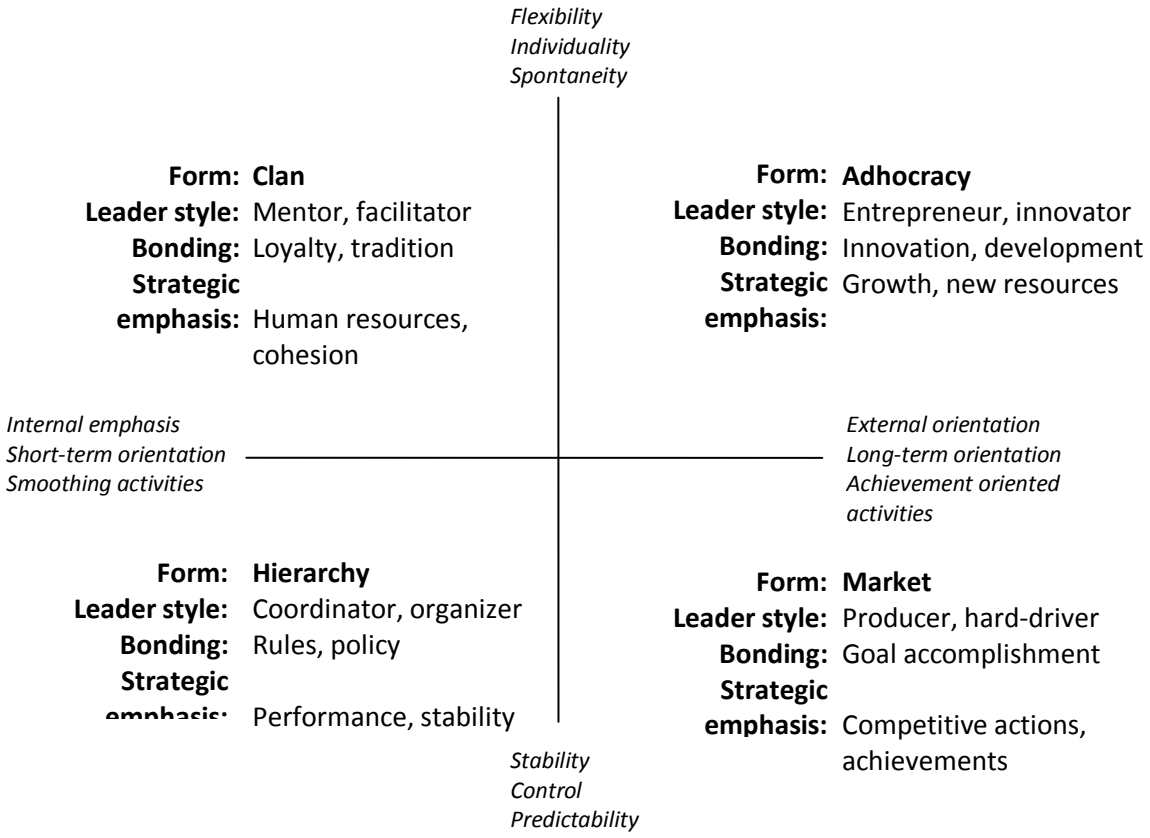
- [ ] We have narrow product-market domains. Our top-managers are experts in their business-limited area of operation but do not tend to search outside of their domains for new opportunities. We seldom need to make major adjustments in our technology, structure, or methods of operation. We devote primary attention to improving the efficiency of our operations.

- [ ] We frequently perceive change and uncertainty occurring in our organizational environments but are unable or unwilling to respond effectively. We lack a consistent strategy-structure relationship, and we seldom make adjustments of any sort until we are forced to do so by environmental pressures.

Business Unit's Culture

15. Please have a look at the picture below visualizing various types of organizational culture. Which of these most closely describes your *business unit's* culture (choose one)?

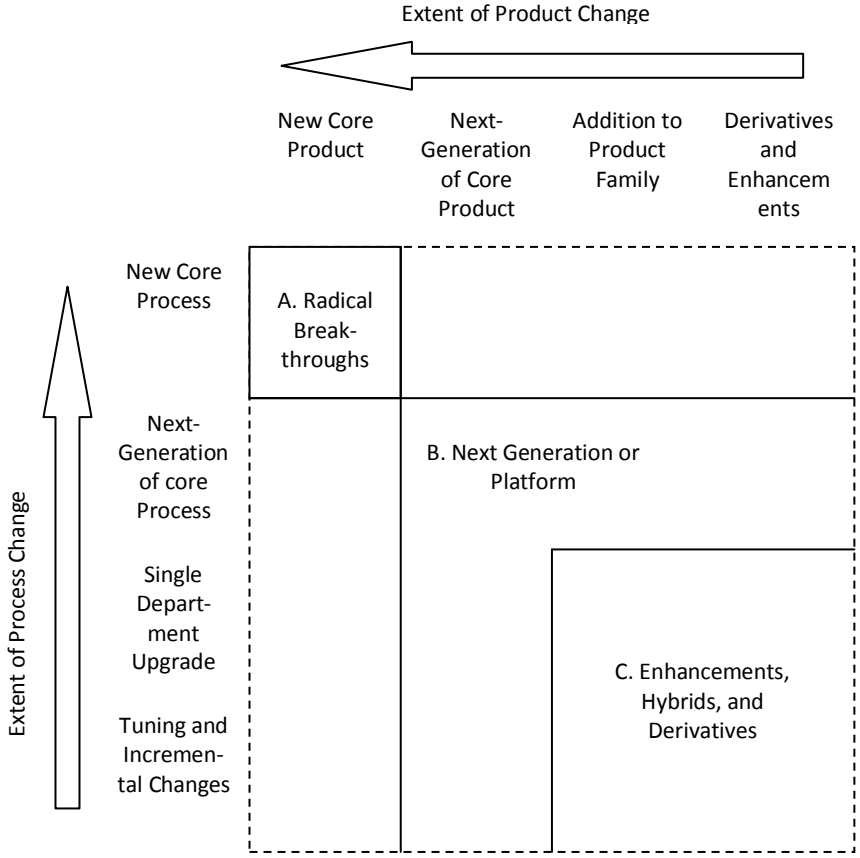
- ☐ **Clan**
- ☐ **Adhocracy**
- ☐ **Hierarchy**
- ☐ **Market**



Description of the New Product Development Function

With the *NPD Function*, the set of activities necessary to initiate, coordinate, and accomplish the product and related production process development activities of the business unit is meant. Please note therefore that the NPD function includes but is not necessarily restricted to the activities of the NPD department.

16. Please estimate the percentage of your organization's total new product development activities accounted for by the Core Products of each of the following three types.



%	A. Radical breakthroughs in core products and processes
%	B. Next generation of core product and / or process
%	C. Enhancements, hybrids, and derivatives of core product and or process
100 %	

17. Please distribute the percentages of your total annual sales (as filled in in question 6) originating from the following types of new products, which have been introduced the last **three** years (the total sums up to 100%).

%	Breakthrough new products
%	Next generation new products
%	Addition to Product Family and/or Derivatives/Enhancements
%	Non modified products
100 %	

18. Please indicate below for which part of the NPD function you are responsible (more than one answer is possible):

☐ Radical Innovation (Breakthrough New Products and/or Next Generation)
☐ Incremental Innovation (Addition to Product Family and/or Derivatives/enhancements)

19. Please answer the following questions about the size of your NPD function:

What is your total NPD budget in % of annual sales?	
How is this divided over the different types of NPD activities?	☐ Not divided ☐ Radical Innovation: % ☐ Incremental Innovation: %
What is the total number in fulltime equivalent of employees in NPD?	
How is this divided over the different types of NPD activities?	☐ Not divided ☐ Radical Innovation: FTE ☐ Incremental Innovation: FTE

Operational Effectiveness and Strategic Flexibility of your NPD Function

20. In this section please indicate your level of achievement on objectives concerning the *fit with market demands* achieved by your NPD function and the ability to *anticipate* on them.

		Not at all achieved						Very well achieved	Don't know
a.	Our new products meet customer requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Our new products are delivered on time.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	The cost of our new products is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	The quality of our products is good.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	The impact of our NPD program on our sales level is positive.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	We get good returns from our NPD program relative to our spending on it.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	Our current development projects include new product-market options.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	We prefer NPD projects that generate options for future product development	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
i.	NPD is successful in opening new markets to our organization.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
j.	NPD is successful in leading our organization into new product areas.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
k.	Our NPD activities open new technologies to our organization.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
l.	We incorporate solutions to unarticulated customer needs in our new products.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

21. In this section please indicate your level of achievement on objectives concerning the *fit with firm competences* achieved by your NPD function and the ability to *build* these competencies.

		Not at all achieved						Very well achieved	Don't know
a.	The degree of manufacturing cost advantage that NPD provides is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Few manufacturing problems occur during production start-up phases.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Only few product design changes are needed to solve manufacturing performance.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Marketing and NPD often share information.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	Conflicts between marketing and NPD are of a constructive kind.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	Marketing and NPD are more like teammates than competitors.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	Our competence to explore new technological developments from inside the BU is well developed	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	We built upon manufacturing competences for the exploration of new technological developments	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
i.	We are very much inspired by marketing for the development of new ideas form inside the BU.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
j.	We can pass lessons learned on across organizational boundaries.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
k.	We can pass lessons learned on over time.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
l.	We are able to enhance our competences by tapping into external sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

In the following section please indicate your level of achievement on objectives concerning the *speed* of the processes carried out by your NPD function as well as your ability to *anticipate* on future time constraints.

You may first want to take a look at this figure that shows the concepts of Development Time, Concept To Customer time and Total Time which are used in this question.

Stage	**0**	**1**	**2**	**3**	**4**
Name	**Concept generation**	**Project evaluation**	**Development**	**Manufacturing development**	**Commercialization**
Starting activity	Surfacing of idea	Developing of specs	Spending on physical development	Documentation of process development	Production trials (End: manufacturing for sales)
			Development Time (DT)		
		Concept To Customer time (CTC)			
Total Time (TT)					

22. Please indicate your level of achievement on following objectives:

		Not at all achieved						Very well achieved	Don't know
a.	Our new products are launched on schedule.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Scheduled time is in line with total development time (TT).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Our Development Time (DT) is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Our Concept to Customer Time (CTC) is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	Our Total Time (TT) is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	The speed of the NPD decision making process is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	We can estimate future requirements on our total development time (TT).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	We are able to adjust our NPD process to future time requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

i.	We can estimate future requirements on the speed of our NPD decision making process.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
j.	We are able to adjust our NPD decision making process to future requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
k.	We are able to forecast the future requirements on the commitment to translating our NPD decisions into actions.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
l.	We are able to adjust the commitment to translating NPD decisions into actions to the requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

23. In this section please indicate your level of achievement on objectives concerning the *productivity* of your NPD function as well as your ability to *anticipate* on future productivity constraints.

		Not at all achieved					Very well achieved		Don't know
a.	We can develop the same products with a lower budget than assigned.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Development costs of our products hardly exceed budgets.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Beyond-budget products do not exceed budgets with a large amount.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Our development costs are relatively low.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	Realized development hours do not often exceed budgeted hours.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	We can estimate the future internal cost requirements for our development process.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	We are able to adjust our development process to the future cost requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	Our ability to predict future development costs is well developed.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
i.	We are well capable to adjust development costs	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
j.	We are able to adjust the number of development hours to future requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

24. In this section please indicate your level of achievement on objectives concerning the *flexibility* of the processes of your NPD function as well as the ability to *anticipate* on future needs for operational process flexibility.

		Not at all achieved						Very well achieved	Don't know
a.	The average time of product enhancement is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	The average time of product redesign is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Our ability to change the design fast, after being confronted with new specs, is well developed.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	The average cost of redesign is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	We can process a change of specs without a lot of extra financial resources.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	Our ability to change specs late is satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	We are able to forecast the requirements on the time of redesign.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	We are able to adjust the average time of product redesign to future requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
i.	We are capable in forecasting the future requirements on the cost of product redesign.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
j.	We are capable to adjust the average cost of product redesign to future requirements.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
k.	We are able to predict changes in specifications.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
l.	We are able to anticipate on changes in specifications.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

NPD process and roles

25. Please check the box that most closely describes your business unit's incremental development processes. Please tick one answer.

- ☐ No standard approach to new product development.
- ☐ While no formally-documented process is followed, we have a clearly understood path of the tasks to be completed in product development.
- ☐ We have a formally-documented process where one function completes a set of tasks, then passes the results on to the next function which completes another set of tasks.
- ☐ We have a formally-documented process where a cross-functional team completes a set of tasks; management reviews the result and gives the go-ahead for the team to complete the next set of cross-functional tasks.
- ☐ We have a formally-documented process where a facilitating "process owner" helps cross-functional teams move through stages and management reviews.
- ☐ We have a formally-documented process where a cross-functional team uses a staged process with overlapping, fluid stages and "fuzzy" or conditional stage decisions.

26. Please check the box that most closely describes your business unit's radical development processes. Please tick one answer.

- ☐ No standard approach to new product development.
- ☐ While no formally-documented process is followed, we have a clearly understood path of the tasks to be completed in product development.
- ☐ We have a formally-documented process where one function completes a set of tasks, then passes the results on to the next function which completes another set of tasks.
- ☐ We have a formally-documented process where a cross-functional team completes a set of tasks; management reviews the result and gives the go-ahead for the team to complete the next set of cross-functional tasks.
- ☐ We have a formally-documented process where a facilitating "process owner" helps cross-functional teams move through stages and management reviews.
- ☐ We have a formally-documented process where a cross-functional team uses a staged process with overlapping, fluid stages and "fuzzy" or conditional stage decisions.

27. The development of a new product is often described as a series of interdependent and possibly overlapping stages. Below are descriptions of several development activities. Please cross the activity if your business units' new product development process includes this activity. (Tick one or more answers for each type of innovation.)

	Incremental	Radical
Project Strategy Development: Delineate the target market, determine market need, attractiveness.	☐	☐
Idea / Concept Generation: Identify opportunities and initial generation of possible solutions.	☐	☐
Idea Screening: Sort and rank solutions, eliminate unsuitable and unattractive options.	☐	☐
Business Analysis: Evaluate the concept financially, write business case, prepare protocol/development contract.	☐	☐
Development: Convert concept into a working product.	☐	☐
Test and Validation: Product use, field, market and regulatory	☐	☐

testing with customers.

Manufacturing Development: Developing and piloting the manufacturing processes.	☐	☐
Commercialization: Launching the new product or service into full scale production and sales.	☐	☐

28. Please indicate for each of the roles described below whether these behaviors can be identified throughout your NPD function.

	Present in NPD? [yes/no]	Limited to one phase			Throughout the whole NPD process		
Idea Generator							
- searching for breakthroughs by linking diverse ideas - testing feasibility of ideas	☐ Yes ☐ No	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
Champion							
- sells new ideas to others in the organization and gets resources - recognizes, proposes and pushes a new technical idea for formal management approval	☐ Yes ☐ No	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
Project Leader							
- provides the team leadership and motivation - plans and coordinates the diverse sets of activities and people involved in moving a demonstrated idea into practice	☐ Yes ☐ No	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
Gatekeeper							
- collects and channels information about important changes in the internal and external environments - passes information on to others	☐ Yes ☐ No	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
Sponsor							
- provides encouragement, guidance, and acts as a sounding board for the project leader and others - guides and develops less experienced personnel in their roles	☐ Yes ☐ No	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

NPD Strategy

29. How important is the role of the following competitive priorities in your business unit's NPD strategy? Please indicate for each of the indicators if their priority has changed over the last three years and also if you expect their importance to change over the next three years.

	Over the last three years the competitive priority has							Over the next three years the competitive priority will							
	become less important			stayed the same			become more important	become less important			stay the same			become more important	Don't know
Product price	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Product functionality	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Conformance quality	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Time-to-market for new products	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Product design/innovation	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Product customization	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Product range	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Company reputation	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Environmentally sound products	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
Others, namely: _____	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

30. In this section please indicate your level of agreement with each statement about NPD strategy.

		Strongly disagree						Strongly agree	Don't know
a.	The role of NPD in achieving business goals is clearly articulated.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	There is a formally stated NPD strategy.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	We have clearly defined goals for all our individual new products.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Systematic project portfolio management is in place.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	The project portfolios are aligned with the business strategy.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

31. Each of the following items consists of a pair of statements, which represent the two extremes on goals mentioned in your NPD Strategy. Please circle the number on the scale that best approximates the actual content of your NPD strategy.

a.	We primary focus on **long-term growth**.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	We primary focus on **short-term profit**.
b.	We primary focus on projects with **risky** outcomes.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	We primary focus on projects with **predictable** outcomes.
c.	We are mainly focused on creating **breakthrough** new products.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	We are mainly focused on creating **incremental** new products.
d.	We mainly focus on **long-term performance** of our NPD function.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	We mainly focus on **short-term performance** of our NPD function.

32. In this section please indicate your level of agreement with each statement about NPD technology strategy

		Strongly disagree						Strongly agree	Don't know
a.	We clearly identify technological areas that focus our NPD efforts.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Future technological trends are important in our NPD planning.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Our project portfolio is balanced across technologies.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

33. In this section please indicate your level of agreement with each statement about NPD product strategy

	Strongly disagree						Strongly agree	Don't know
a. We clearly identify future products as a focus of our NPD efforts.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b. Future products are explicitly included in our NPD planning.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c. Our project portfolio is balanced across products.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

34. In this section please indicate your level of agreement with each statement about NPD market strategy

	Strongly disagree						Strongly agree	Don't know
a. The focus of our NPD efforts clearly relates to target markets.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b. Future markets are explicitly addressed in our NPD planning.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c. Our project portfolio is balanced across markets.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

NPD structure

35. How are people within the NPD function organized?

☐ Departments
☐ Project teams
☐ Matrix management
☐ Self-managed work teams
☐ Other

36. Please indicate which of the structures pictured and described in the next figure is / are the most common NPD structure(s) within your business unit.

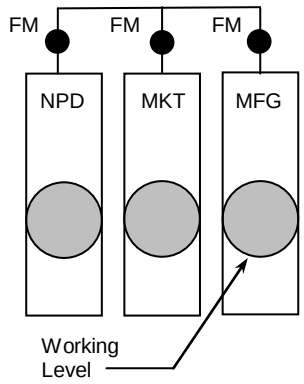
If your NPD function is divided, please tick the most common structures for both incremental and radical innovation. If your NPD function is not divided, just fill in the appropriate structure for the whole NPD function.

	Functional Team Structure	Lightweight Team Structure	Heavyweight Team Structure	Autonomous Team Structure
Structure for Radical innovation	☐	☐	☐	☐
Structure for Incremental Innovation	☐	☐	☐	☐

(If your NPD function is not divided:)

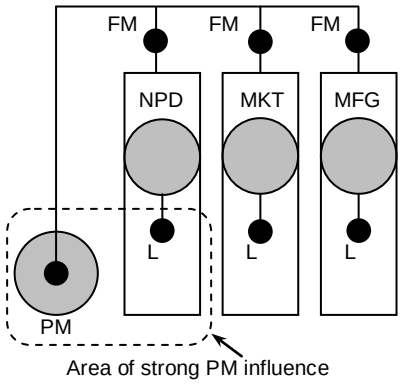
One structure for the whole NPD function	☐	☐	☐	☐

Functional Team Structure



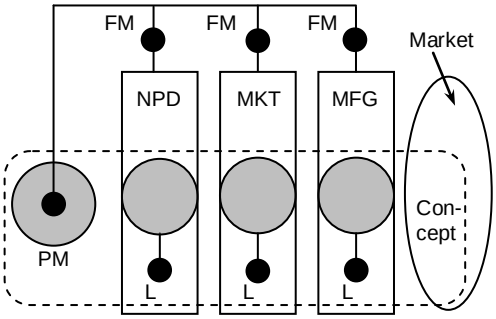
1. People are grouped principally by functional areas.
2. They work under the direction of a Functional Manager (FM).
3. Over time, primary responsibility for the project passes sequently from one function to the next.

Lightweight Team Structure



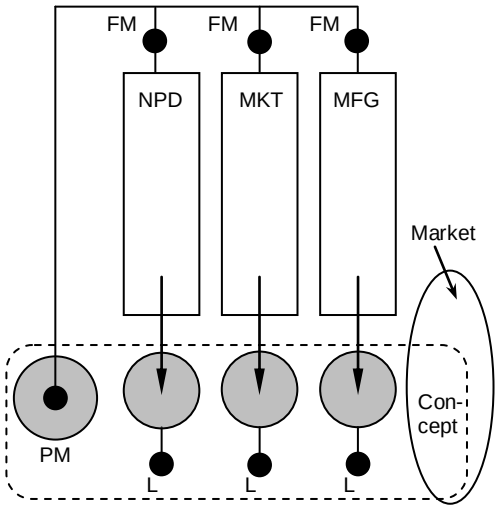
1. Like structure A, those assigned to the team reside physically in their functional areas
2. However, they designate a Liaison person (L) to "represent" it on a coordinating committee.
3. A Project Manager (PM) coordinates the different functions' activities. The Project Manager does not have power to reassign people or reallocate resources.

Heavyweight team Structure



1. Liaisons from the functions still reside in the team.
2. In contrast to structure B, the Project Manager (PM) has primary responsibility for the work of all those involved in the project.
3. However, team members are not assigned to a team on a permanent basis as is the case in structure D.

Autonomous Team Structure



1. Individuals from the different functional areas are formally assigned, dedicated, and co-located to the project team.
2. The Project Manager (PM) is given full control over the resources contributed by the different functional groups.
3. Team members are assigned permanently and the team will be held fully accountable for the results of the project.

NPD climate

37. In this section please indicate your level of agreement with each statement regarding your overall innovative climate

		Strongly disagree						Strongly agree	Don't know
a.	People are emotionally involved in goals set.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	People have freedom to define their own work.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	There is a high level of trust between people.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	There is time for people to develop unplanned new ideas.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	There is a relaxed atmosphere.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	There is a high level of conflict.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	There is a strong support for further development of new ideas.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h	People are involved in debates about differing viewpoints.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
I	High risk taking behavior is tolerated.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

38. If your radical innovation activities are organized separately from your incremental innovation, please indicate to what extent the climate in your more radical NPD differs from the overall innovative climate.

	In our radical NPD…	Strongly disagree						Strongly agree	Don't know
a.	The degree to which people are emotionally involved in goals is higher.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	People have more freedom to define their own work.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	There is a higher level of trust between people.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

d.	There is more time for people to develop unplanned new ideas.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	There is a more relaxed atmosphere.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	There is often a higher level of conflict.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	There is a stronger support for further development of new ideas.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	People are more involved in debates about differing viewpoints.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
i.	Higher risk taking behavior is tolerated.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

This is the end of the questionnaire. Thank you again for your cooperation!

Your answers will be treated with full confidentiality and the names of companies, business units, products or individuals will not be released!

Appendix 4: Questionnaire supplier involvement in NPD

Introduction

This questionnaire will be conducted at the organizations (first- and second-tier suppliers) which are subject to this research. The questionnaire will be taken together with the standard 'Patterns in NPD' questionnaire for the organizations that participate in the research. This questionnaire has the goal to identify specific characteristics of the relationship between the organization and its most important supplier that contributes to NPD.

Questionnaire concerning supplier involvement – NPD Manager

Name of firm/organization: _____

Place: _____

Name of respondent: _____

Contact details: _____

Date: _____

Supplier Characteristics

Consider by answering the questions the *most important supplier* in your Strategic Business Unit that is involved in NPD.

1. Please indicate in this section the size, tier-level, and product type of this supplier.

		Strongly disagree						Strongly agree	Don't know
a.	These suppliers are larger organizations (in FTE's) than our organization.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Our organization is the link between low-tier suppliers and car manufacturers.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	The product that these suppliers deliver is a key component in our NPD.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

Supplier Performance & Competition

2. Please indicate in this section the level of supplier performance & supplier competition of this supplier.

		Strongly disagree						Strongly agree	Don't know
a.	The quality of supplier's products are good.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	The costs of supplier's products are satisfactory.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	The suppliers' products are delivered on time.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Our NPD department uses measurements for supplier performance.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	With our position in the value chain, we have an advantage over our suppliers.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	Our organization can easily switch from one supplier to another.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

Degree of Supplier Involvement

3. Please indicate in which part(s) of the NPD process this supplier is involved.

		Strongly disagree						Strongly agree	Don't know
a.	Stage 0: Concept generation (product idea).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	Stage 1: Project evaluation (develop specifications).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Stage 2: Development.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	Stage 3: Manufacturing development (documentation of process development).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	Stage 4: Commercialization (manufacturing production trials).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

Organization of Supplier Involvement

4. Please indicate how the relation with this supplier is organized within the NPD and Manufacturing (NPM) function?

		Strongly disagree						Strongly agree	Don't know
a.	These suppliers have influence on the design of NPD.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	These suppliers form part of our internal NPD.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Our organization has frequent communication with these suppliers in the early stages of the NPD process.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	These suppliers are involved in both R&D (NPD) and Manufacturing (NPM).	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	These suppliers solve manufacturing problems during production start-up phases.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

5. In what way does this supplier participate in NPD?

[ ] Standard products taken from concept to manufacturing by the supplier – sold to buyer through a **catalogue** (Supplier proprietary parts)

[ ] Developmental work is **split** between buyer and supplier (Black box parts)

[ ] Suppliers take responsibility for process engineering and production based on blueprints provided by buyers on **functional parts** (Detail-controlled parts)

[ ] Suppliers take responsibility for process engineering and production based on blueprints provided by buyers on **body parts** (Detail-controlled parts)

6. Please indicate if you agree/disagree with the level of cooperation in NPD with each statement regarding supplier involvement.

		Strongly disagree						Strongly agree	Don't know
a.	These suppliers are not involved; we develop new products internally.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	The NPD department exchanges know-how with these suppliers.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	These suppliers are involved in purchasing of components, products and technologies for NPD.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
d.	The NPD department licenses to these suppliers.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
e.	The NPD department outsource to these suppliers by contract development.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
f.	The NPD department outsource to these suppliers by coordinated development.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
g.	The NPD department outsource to these suppliers by joint development.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
h.	The NPD department has a contractual joint venture with these suppliers.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

7. Which assets from the NPD department are shared with this supplier?

[ ] Intellectual assets (technology information, customer requirements, direct cross-functional inter-company communication)

[ ] Human assets (co-location, supplier participation on project team)

[ ] Physical assets (common and linked information systems, technology sharing, shared plant & equipment)

Internal development team integration processes

8. Please indicate how several actors internally support NPD.

		Strongly disagree						Strongly agree	Don't know
a.	The manufacturing department is early and intense involved in NPD.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
b.	At our R&D/NPD department, we work in cross-functional teams.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐
c.	Top management supports NPD and is committed to the project team.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	☐

Thank you for participating in this study!

Appendix 5: List of correlation tables made for the pre-analysis

Correlations

		PCE	NPD_PE	OE
PCE	Pearson Correlation	1	-,339	,689**
	Sig. (2-tailed)		,144	,001
	N	20	20	20
NPD_PE	Pearson Correlation	-,339	1	,446*
	Sig. (2-tailed)	,144		,048
	N	20	20	20
OE	Pearson Correlation	,689**	,446*	1
	Sig. (2-tailed)	,001	,048	
	N	20	20	20

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

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

Table A5.1: Correlations of Product Concept Effectiveness and NPD Process Effectiveness on Operational (NPD) Effectiveness

Correlations

		OE_FMD	OE_FC	OE_SDP	OE_PR	OE_FL	OE
OE_FMD	Pearson Correlation	1	,656**	-,119	-,589**	-,406	,507*
	Sig. (2-tailed)		,002	,616	,006	,076	,022
	N	20	20	20	20	20	20
OE_FC	Pearson Correlation	,656**	1	,039	-,112	-,251	,748**
	Sig. (2-tailed)	,002		,870	,640	,286	,000
	N	20	20	20	20	20	20
OE_SDP	Pearson Correlation	-,119	,039	1	,199	,328	,469*
	Sig. (2-tailed)	,616	,870		,401	,158	,037
	N	20	20	20	20	20	20
OE_PR	Pearson Correlation	-,589**	-,112	,199	1	,724**	,255
	Sig. (2-tailed)	,006	,640	,401		,000	,278
	N	20	20	20	20	20	20
OE_FL	Pearson Correlation	-,406	-,251	,328	,724**	1	,326
	Sig. (2-tailed)	,076	,286	,158	,000		,161
	N	20	20	20	20	20	20
OE	Pearson Correlation	,507*	,748**	,469*	,255	,326	1
	Sig. (2-tailed)	,022	,000	,037	,278	,161	
	N	20	20	20	20	20	20

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

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

Table A5.2: Correlations of fit with market demand, fit with firm competencies, speed, productivity/costs and NPD process flexibility on Operational Effectiveness

Correlations

		A21	B21	C21	D21	E21	F21	OE_FC
A21	Pearson Correlation	1	,457*	,424	,239	-,176	,122	,439
	Sig. (2-tailed)		,043	,063	,309	,471	,620	,053
	N	20	20	20	20	19	19	20
B21	Pearson Correlation	,457*	1	,790**	,221	,169	,282	,647**
	Sig. (2-tailed)	,043		,000	,349	,488	,242	,002
	N	20	20	20	20	19	19	20
C21	Pearson Correlation	,424	,790**	1	,023	-,147	,084	,453*
	Sig. (2-tailed)	,063	,000		,922	,549	,734	,045
	N	20	20	20	20	19	19	20
D21	Pearson Correlation	,239	,221	,023	1	,842**	,886**	,867**
	Sig. (2-tailed)	,309	,349	,922		,000	,000	,000
	N	20	20	20	20	19	19	20
E21	Pearson Correlation	-,176	,169	-,147	,842**	1	,789**	,705**
	Sig. (2-tailed)	,471	,488	,549	,000		,000	,001
	N	19	19	19	19	19	19	19
F21	Pearson Correlation	,122	,282	,084	,886**	,789**	1	,850**
	Sig. (2-tailed)	,620	,242	,734	,000	,000		,000
	N	19	19	19	19	19	19	19
OE_FC	Pearson Correlation	,439	,647**	,453*	,867**	,705**	,850**	1
	Sig. (2-tailed)	,053	,002	,045	,000	,001	,000	
	N	20	20	20	20	19	19	20

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

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

Table A5.3: Correlation of fit with firm competencies on item scale on Operational Effectiveness

Appendix 6: List of measurement tables

NPD	OE FC (Q21)		
21	a	b	c
(A→C) / 3	1-7	1-7	1-7

RDMI

Table A6.1: R&D/Manufacturing Integration

FMD	FC	SPD	PR	FL	PCE	NPD PE	OE
20	21	22	23	24			
1-7	1-7	1-7	1-7	1-7	**(20+21) / 2**	**(22+23+24) / 3**	**(PCE+NPD PE) / 2**

FMD FC SPD PR FL OE

Table A6.2: Operational Effectiveness

SI NPD	MI-NPD	NPD	MI-NPD
8	a	21	h
A	1-7	**H**	1-7

SI NPD **(SI NPD+NPD) / 2** NPD

MI NPD

Table A6.3: Manufacturing involvement in NPD

NPD Questionnaire Question 27	
Nr	**Definition**
0 or 1	Project Strategy Development
0 or 1	Idea / Concept Generation
0 or 1	Idea Screening
0 or 1	Business Analysis
0 or 1	Development
0 or 1	Test & Validation
0 or 1	Manufacturing Development
0 or 1	Commercialization

Table A6.4: Stages in the NPD process

		SI NPD	CTE (Q8)
Firm	**Company code**	8	b
		B	1-7

CTE

Table A6.5: Collaborative team environment

NPD Questionnaire Questions 25 & 26	
Nr	**Definition**
1	No standard approach to NPD
2	No FDP is followed, we have a clearly understood path of the tasks to be completed in product development
3	FDP where one function completes a set of tasks, then passes the results on to the next function which completes another set of tasks
4	FDP where a cross-functional team completes a set of tasks; management reviews the result and gives the go-ahead for the team to complete the next set of cross-functional tasks
5	FDP where a facilitating 'process owner' helps cross-functional teams move through stages and management reviews
6	FDP where a cross-functional team uses a staged process with overlapping, fluid stages and 'fuzzy' or conditional stage decisions

Table A6.6: Team structure in radical and incremental NPD

SI NPD	TMS	NPD	NPD Roles (Q28)									
8	c	28	IdGen		Champ		PrLdr		Gtkpr		Sp	
C	1-7		YES/NO	1-6	YES/NO	1-6	YES/NO	1-6	YES/NO	1-6	YES/NO	1-6

TMS

Table A6.7: Top management support

SI NPD	SC (Q1)		
1	a	b	c
(A→C) / 3	1-7	1-7	1-7

SC

Table A6.8: Supplier characteristics

SI NPD	SPC (Q2)					
2	a	b	c	d	e	f
(A→F) / 6	1-7	1-7	1-7	1-7	1-7	1-7

SPC

Table A6.9: Supplier performance and competition

SI NPD	DSI-NPD (Q3)				
3	a	b	c	d	e
(A→E) / 5	1-7	1-7	1-7	1-7	1-7

DSI-NPD

Table A6.10: Degree of supplier involvement in NPD

SI NPD	OSI-NPD (Q4)					SI NPD	OSI-NPD (Q6)								OSI-NPD	SI NPD	SI NPD
4	a	b	c	d	e	6	a	b	c	d	e	f	g	h		5	7
(A→E) / 5	1-7	1-7	1-7	1-7	1-7	**(A→H) / 8**	1-7	1-7	1-7	1-7	1-7	1-7	1-7	1-7	**(NPD-NPM+ LevCoNPD) / 2**	**1-4**	**1-3**

NPD-NPM LevCoNPD OSI-NPD

Table A6.11: Organization of supplier involvement in NPD

SI-NPD Questionnaire Question 5	
Nr	**Definition**
1	Standard products taken from concept to manufacturing by the supplier – sold to buyer through a catalogue (Supplier proprietary parts)
2	Developmental work is split between buyer and supplier (Black box parts)
3	Suppliers take responsibility for process engineering and production based on blueprints provided by buyers on functional parts (Detail-controlled parts)
4	Suppliers take responsibility for process engineering and production based on blueprints provided by buyers on body parts (Detail-controlled parts)

Table A6.12: Supplier involvement in NPD

SI-NPD Questionnaire Question 7	
Nr	**Definition**
1	Intellectual assets (technology information, customer requirements, direct cross-functional inter-company communication)
2	Human assets (co-location, supplier participation on project team)
3	Physical assets (common and linked information systems, technology sharing, shared plant & equipment)

Table A6.13: Supplier asset sharing

SC (Q1)	SPC (Q2)	DSI-NPD (Q3)	OSI-NPD (Q4 & 6)	MSI-NPD (Q1-4 & 6)
SupChar	SupPerfComp	DgrSupInvNPD	OrgSupInvNPD	ManSupInvNPD
				(SC+SPC+DSI-NPD+OSI-NPD) / 4
SC	SPC	DSI-NPD	OSI-NPD	**MSI-NPD**

Table A6.14: Management of supplier involvement in NPD

Appendix 7: List of descriptive statistics tables

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
R&D/Manufacturing Integration	11	3,3	5,7	4,455	,8745	,765
Valid N (listwise)	11					

Table A7.1: Descriptive statistics of the R&D/Manufacturing integration in the Portuguese automotive parts and components industry

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
RDMI	20	1,0	6,3	4,010	1,1849	1,404
Valid N (listwise)	20					

Table A7.2: Descriptive statistics of the R&D/Manufacturing integration in the PNPD database (N=20)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Manufacturing involvement in NPD	11	3,5	6,5	5,091	,9439	,891
Valid N (listwise)	11					

Table A7.3: Descriptive statistics of the Manufacturing involvement in NPD

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Collaborative team environment	11	3,0	7,0	5,455	1,5076	2,273
Valid N (listwise)	11					

Table A7.4: Descriptive statistics of the collaborative team environment

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Top management support	11	6,0	7,0	6,455	,5222	,273
Valid N (listwise)	11					

Table A7.5: Descriptive statistics of the top management support

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Supplier characteristics	11	3,0	6,0	4,145	1,1527	1,329
Supplier performance & competition	11	3,4	6,0	5,009	,7148	,511
Degree of supplier involvement in NPD	11	1,0	5,4	3,309	1,4543	2,115
Organization of supplier involvement in NPD	11	1,4	5,1	3,636	1,2143	1,475
Management of supplier involvement in NPD	11	2,8	4,9	4,045	,7435	,553
Valid N (listwise)	11					

Table A7.6: Descriptive statistics of the constructs of management of supplier involvement in NPD

Appendix 8: List of correlation tables for the exploratory analysis

Correlations

		R&D/ Manufacturing Integration A	R&D/ Manufacturing Integration B	R&D/ Manufacturing Integration C	R&D/ Marketing Integration D	R&D/ Marketing Integration E	R&D/ Marketing Integration F	OE Fit with firm competencies
R&D/Manufacturing Integration A	Pearson Correlation	1	,204	,725*	,627	,856**	,811**	,787**
	Sig. (2-tailed)		,547	,027	,052	,007	,008	,004
	N	11	11	9	10	8	9	11
R&D/Manufacturing Integration B	Pearson Correlation	,204	1	,035	,526	,191	,395	,583
	Sig. (2-tailed)	,547		,929	,118	,651	,293	,060
	N	11	11	9	10	8	9	11
R&D/Manufacturing Integration C	Pearson Correlation	,725*	,035	1	,387	,441	,543	,619
	Sig. (2-tailed)	,027	,929		,343	,274	,164	,075
	N	9	9	9	8	8	8	9
R&D/Marketing Integration D	Pearson Correlation	,627	,526	,387	1	,823*	,814**	,907**
	Sig. (2-tailed)	,052	,118	,343		,012	,008	,000
	N	10	10	8	10	8	9	10
R&D/Marketing Integration E	Pearson Correlation	,856**	,191	,441	,823*	1	,873**	,832*
	Sig. (2-tailed)	,007	,651	,274	,012		,005	,010
	N	8	8	8	8	8	8	8
R&D/Marketing Integration F	Pearson Correlation	,811**	,395	,543	,814**	,873**	1	,912**
	Sig. (2-tailed)	,008	,293	,164	,008	,005		,001
	N	9	9	8	9	8	9	9
OE Fit with firm competencies	Pearson Correlation	,787**	,583	,619	,907**	,832*	,912**	1
	Sig. (2-tailed)	,004	,060	,075	,000	,010	,001	
	N	11	11	9	10	8	9	11

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

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

Table A8.1: Correlation of fit with firm competencies on item scale in the Portuguese automotive parts and components industry

Correlations

		R&D/ Manufacturing Integration	Development team integration processes
R&D/Manufacturing Integration	Pearson Correlation	1	,214
	Sig. (2-tailed)		,527
	N	11	11
Development team integration processes	Pearson Correlation	,214	1
	Sig. (2-tailed)	,527	
	N	11	11

Table A8.2: Correlation of development team integration processes with R&D/Manufacturing integration in the Portuguese automotive parts and components industry

Correlations

		Development team integration processes	Management of supplier involvement in NPD
Development team integration processes	Pearson Correlation	1	,720*
	Sig. (2-tailed)		,012
	N	11	11
Management of supplier involvement in NPD	Pearson Correlation	,720*	1
	Sig. (2-tailed)	,012	
	N	11	11

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

Table A8.3: Correlation of development team integration processes with management of supplier involvement in NPD in the Portuguese automotive parts and components industry

Correlations

		Supplier characteristics	Supplier performance & competition	Degree of supplier involvement in NPD	Organization of supplier involvement in NPD	Management of supplier involvement in NPD
Supplier characteristics	Pearson Correlation	1	-,590	,265	,334	,504
	Sig. (2-tailed)		,056	,431	,316	,114
	N	11	11	11	11	11
Supplier performance & competition	Pearson Correlation	-,590	1	,064	-,113	-,018
	Sig. (2-tailed)	,056		,851	,740	,959
	N	11	11	11	11	11
Degree of supplier involvement in NPD	Pearson Correlation	,265	,064	1	,847**	,937**
	Sig. (2-tailed)	,431	,851		,001	,000
	N	11	11	11	11	11
Organization of supplier involvement in NPD	Pearson Correlation	,334	-,113	,847**	1	,909**
	Sig. (2-tailed)	,316	,740	,001		,000
	N	11	11	11	11	11
Management of supplier involvement in NPD	Pearson Correlation	,504	-,018	,937**	,909**	1
	Sig. (2-tailed)	,114	,959	,000	,000	
	N	11	11	11	11	11

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

Table A8.4: Correlation of management of supplier involvement in NPD on construct level in the Portuguese automotive parts and components industry

Correlations

		Management of supplier involvement in NPD	R&D/ Manufacturing Integration
Management of supplier involvement in NPD	Pearson Correlation	1	-,070
	Sig. (2-tailed)		,837
	N	11	11
R&D/Manufacturing Integration	Pearson Correlation	-,070	1
	Sig. (2-tailed)	,837	
	N	11	11

Table A8.5: Correlation of the management of supplier involvement in NPD and the R&D/Manufacturing integration in the Portuguese automotive parts and components industry

Correlations

		Degree of supplier involvement in NPD	R&D/ Manufacturing Integration
Degree of supplier involvement in NPD	Pearson Correlation	1	,130
	Sig. (2-tailed)		,703
	N	11	11
R&D/Manufacturing Integration	Pearson Correlation	,130	1
	Sig. (2-tailed)	,703	
	N	11	11

Table A8.6: Correlation of the degree of supplier involvement in NPD and the R&D/Manufacturing integration in the Portuguese automotive parts and components industry

Appendix 9: Analysis on the current NPD performance

Table A9.1 visualizes the results on the current NPD performance of the 11 organizations from the Portuguese automotive parts and components industry.

	NPD	OE FMD (Q20)							OE FC (Q21)							OE SDP (Q22)							OE PR (Q23)						OE FL (Q24)						PCE	NPD PE	OE
Firm	20	a	b	c	d	e	f	21	a	b	c	d	e	f	22	a	b	c	d	e	f	23	a	b	c	d	e	24	a	b	c	d	e	f			
1	**6,2**	7	6	6	7	5	6	**5,5**	5	7	5	6	5	5	**5,7**	5	5	5	7	6	6	**6,2**	6	7	6	7	5	**6,5**	6	6	7	7	7	6	**5,8**	**6,1**	**6,0**
2	**5,3**	6	5	5	5	6	5	**3,3**	4	2	4	3	4	3	**4,3**	6	4	4	4	5	3	**3,2**	3	3	3	4	3	**5,2**	4	4	6	5	7	5	**4,3**	**4,2**	**4,3**
3	**6,8**	7	7	7	7	7	6	**5,5**	6	4		6		6	**6,3**	7	7	6	6	6	6	**5,8**	6	6	7	5	5	**5,0**	5	5	6	6	3	5	**6,2**	**5,7**	**5,9**
4	**5,2**	4	6	6	5	5	5	**4,7**	5	2	4	6	6	5	**5,5**	6	5	5	5	6	6	**4,0**	4	4	5	4	3	**4,5**	3	5	5	5	4	5	**4,9**	**4,7**	**4,8**
5	**5,2**	4	4	6	6	5	6	**3,7**	5	3		3			**4,2**	3	4	4	4	4	6	**4,3**			5	5	3	**5,0**			4		6	5	**4,4**	**4,5**	**4,5**
6	**6,0**	6	6	6	6	6	6	**5,0**	6	3	6				**4,8**	6		4	4	4	6	**4,0**	5	5	4	3	3	**4,0**	3	4	5	3	4	5	**5,5**	**4,3**	**4,9**
7	**6,2**	7	7	5	7	6	5	**5,7**	6	5	5	6	6	6	**4,8**	5	4	5	5	5	5	**4,8**	4	5	5	5	5	**5,0**	5	5	5	5	5	5	**5,9**	**4,9**	**5,4**
8	**5,8**	6	5	6	6	6	6	**5,2**	5	4	5	5	6	6	**4,2**	4	4	4	4	3	6	**4,6**	5	5	5	5	3	**5,0**	4	5	6	5	5	5	**5,5**	**4,6**	**5,0**
9	**4,8**	6	4	5	6	4	4	**4,3**	4	5	2	5	5	5	**3,2**	3	2	5	3	2	4	**4,4**	4	4	6	4	4	**3,0**	3	4	4	2	2	3	**4,6**	**3,5**	**4,1**
10	**3,5**	4	3	2	6	3	3	**3,7**	3	3	4	4	4	4	**2,5**	3	1	2	3	3	3	**3,6**	4	3	4	5	2	**3,8**	4	4	4	3	4	4	**3,6**	**3,3**	**3,4**
11	**5,7**	7	6	5	7	4	5	**5,8**	6	4	6	6	6	7	**5,2**	6	5	5	4	6	5	**5,2**	6	6	7	4	3	**4,8**	5	6	6	5	4	3	**5,8**	**5,1**	**5,4**
	5,5							**4,8**							**4,6**							**4,6**						**4,7**									**4,9**
	FMD							**FC**							**SPD**							**PR**						**FL**									**OE**

Table A9.1: Operational Effectiveness in the Portuguese automotive parts and components industry

Table A9.1 points out that the scores on the Product Concept Effectiveness are all higher or equal to 3.6. The NPD Process Effectiveness indicates more variation; the scores lie between 3.3 and 6.1. Further, the constructs of Operational Effectiveness show a specific pattern. The fit with firm competencies, speed of the development process, productivity/costs, and NPD process flexibility all score between 4.6 and 4.8. Only the fit with market demands with a score of 5.5 is considerably better. Therefore, the organizations in the Portuguese automotive parts and components industry are scoring high on meeting customer requirements, on-time delivery, costs, quality, and NPD program. At last, the Operational Effectiveness contains some variance, but the score is above average with 4.9. The descriptive statistics of the Operational Effectiveness can be found below in tables A9.2 & A9.3.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
OE Product Concept Effectiveness	11	3,6	6,2	5,136	,8250	,681
OE NPD Process Effectiveness	11	3,3	6,1	4,627	,8344	,696
Operational Effectiveness	11	3,4	6,0	4,882	,7833	,614
Valid N (listwise)	11					

Table A9.2: Descriptive statistics of the Operational Effectiveness

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
OE Fit with market demands	11	3,5	6,8	5,518	,8807	,776
OE Fit with firm competencies	11	3,3	5,8	4,764	,8891	,791
OE Speed of development process	11	2,5	6,3	4,609	1,1013	1,213
OE Productivity	11	3,2	6,2	4,555	,9048	,819
OE Flexibility	11	3,0	6,5	4,709	,8994	,809
Operational Effectiveness	11	3,4	6,0	4,882	,7833	,614
Valid N (listwise)	11					

Table A9.3: Descriptive statistics of the constructs of Operational Effectiveness

The comparison between these results and the data of the pre-analysis (Appendix 2), indicates that the scores on the Product Concept Effectiveness point out more variance, where the scores lie between 1.3 and 6.5. Furthermore, the NPD Process Effectiveness shows the reverse; it points out less variance and all scores are higher or equal to 3.4. Regarding the constructs of the Operational Effectiveness, the pre-analysis data points out the same pattern as the Portuguese data, namely the close scores of the fit with firm competencies, speed of the development process, productivity/costs, and NPD process flexibility (scores between 4.3 and 4.9). In addition, the fit with market demands shows the best score; 5.2. The Operational Effectiveness is a bit lower in comparison to the Portuguese data (4.7).

A small reference can be made to the Strategic Flexibility, which shows at the Portuguese data the same score of 4.9 compared to the Operational Effectiveness. The Strategic Flexibility of the pre-analysis data differs only 0.3; the score is 4.6. Overall, the Portuguese automotive industry as well as the automotive sector in other countries indicates that NPD processes contribute reasonably well to realizing the innovation goals set by the organization. Furthermore, the organizations in the automotive industry are reasonably well prepared to adapt to, anticipate, or create future NPD performance requirements.

Figures A9.4 and A9.5 give a better view in the scores per organization. Organization 1 scores best, and has an Operational Effectiveness of 6.0. In addition, organizations 3 and 11 score high.

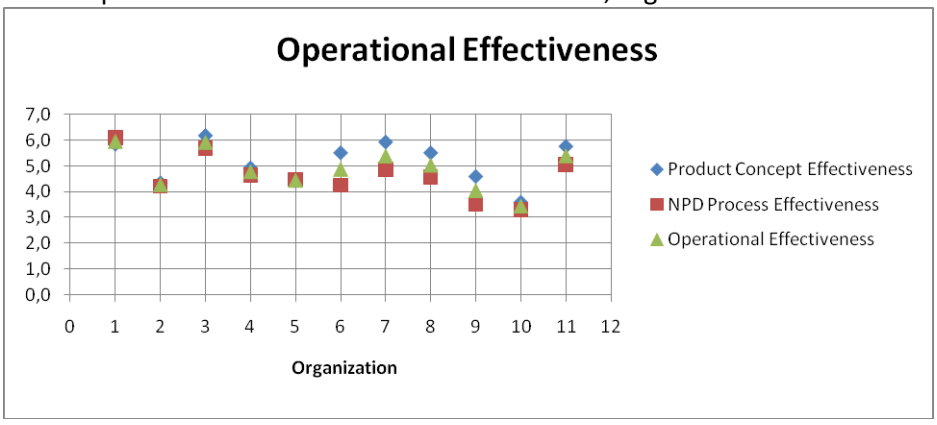


Figure A9.4: Operational Effectiveness

Another remarkable aspect is the lower scores of the organizations in the stamping business. These organizations score lower than average. The organizations in the die casting parts business score higher or on average.

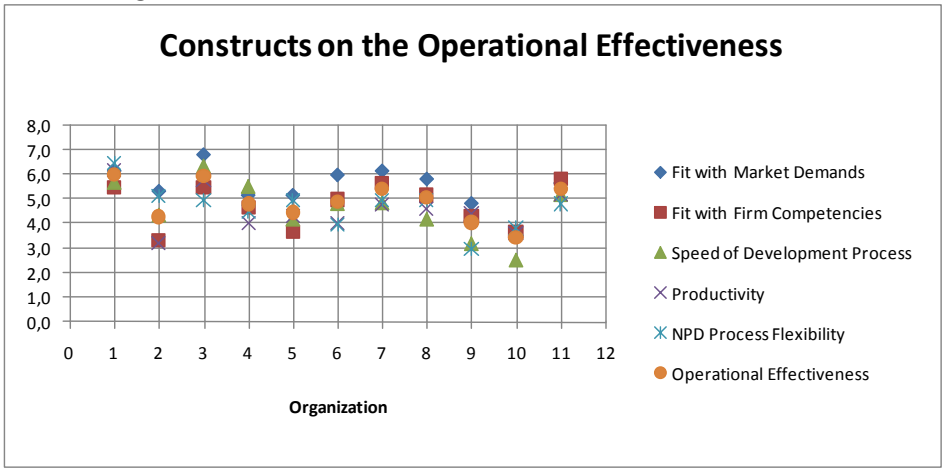


Figure A9.5: Constructs on Operational Effectiveness

Figure A9.5 indicates that most organizations score low on the speed of the development process. On the contrary, the fit with market demands is relatively high. In both figure A9.4 and A9.5, it is visible that

organization 10, which operates in the stamping business scores very low. Therefore, the current NPD performance of organization 10 is not good. Organization 3, operating in the head linings (window lifters), has a high current NPD performance and is noticeable by the high scores on the Product Concept Effectiveness and the NPD Process Effectiveness.

Now, a correlation analysis is made on the Operational Effectiveness to compare the results from the Portuguese organizations to the organizations, which are already in the database.
The Operational Effectiveness depends on the Product Concept Effectiveness and NPD Process Effectiveness. The correlations are visualized in table A9.6. Both Product Concept Effectiveness and NPD Process Effectiveness have a significant effect on the score of Operational Effectiveness. The NPD Process Effectiveness has a slightly higher correlation (0.957). However, this advantage is negligible. The data from the pre-analysis pointed out a different view, which showed only a significant relation for the Product Concept Effectiveness. In order to have an accurate insight in the relations, specific correlations are also made with the Portuguese data between the constructs of the Operational Effectiveness.

Correlations

		OE Product Concept Effectiveness	OE NPD Process Effectiveness	Operational Effectiveness
OE Product Concept Effectiveness	Pearson Correlation	1	,812**	,944**
	Sig. (2-tailed)		,002	,000
	N	11	11	11
OE NPD Process Effectiveness	Pearson Correlation	,812**	1	,957**
	Sig. (2-tailed)	,002		,000
	N	11	11	11
Operational Effectiveness	Pearson Correlation	,944**	,957**	1
	Sig. (2-tailed)	,000	,000	
	N	11	11	11

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

Table A9.6: Correlations of Product Concept Effectiveness and NPD Process Effectiveness on Operational (NPD) Effectiveness in the Portuguese automotive parts and components industry

Correlations

		OE Fit with market demands	OE Fit with firm competencies	OE Speed of development process	OE Productivity	OE Flexibility	Operational Effectiveness
OE Fit with market demands	Pearson Correlation	1	,724*	,857**	,670*	,565	,925**
	Sig. (2-tailed)		,012	,001	,024	,070	,000
	N	11	11	11	11	11	11
OE Fit with firm competencies	Pearson Correlation	,724*	1	,657*	,782**	,326	,840**
	Sig. (2-tailed)	,012		,028	,004	,329	,001
	N	11	11	11	11	11	11
OE Speed of development process	Pearson Correlation	,857**	,657*	1	,649*	,623*	,903**
	Sig. (2-tailed)	,001	,028		,031	,041	,000
	N	11	11	11	11	11	11
OE Productivity	Pearson Correlation	,670*	,782**	,649*	1	,535	,851**
	Sig. (2-tailed)	,024	,004	,031		,090	,001
	N	11	11	11	11	11	11
OE Flexibility	Pearson Correlation	,565	,326	,623*	,535	1	,684*
	Sig. (2-tailed)	,070	,329	,041	,090		,020
	N	11	11	11	11	11	11
Operational Effectiveness	Pearson Correlation	,925**	,840**	,903**	,851**	,684*	1
	Sig. (2-tailed)	,000	,001	,000	,001	,020	
	N	11	11	11	11	11	11

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

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

Table A9.7: Correlations of fit with market demands, fit with firm competencies, speed, productivity/costs and NPD process flexibility on Operational Effectiveness in the Portuguese automotive industry

Table A9.7 indicates that the fit with market demands has the highest significant correlation with the Operational NPD Effectiveness in the Portuguese automotive industry (0.925). Thus, the fit with market demands is the most important construct in determining the current innovation performance of organizations in this industry. The lowest correlation is found on the NPD process flexibility (0.684). Therefore, the costs and time of modifying a (re)design are compared to the other constructs not high.

The pre-analysis pointed out that the fit with firm competencies was the most important construct. To infer from the latter, there is no resemblance in the correlation analysis made on the Operational Effectiveness of the pre-analysis data and the Portuguese data, because the fit with firm competencies is not the most important construct anymore and scores 0.840.

To go beyond the pre-analysis, the Operational Effectiveness is also subject to analysis in order to investigate whether and what the relation is between the development team integration processes and the NPD performance. In addition, the relationship between the management of supplier involvement in NPD and the NPD performance is investigated.

Table A9.8 points out the correlations between the development team integration processes and the Operational Effectiveness. The correlation scores 0.337. Thus, there is a positive relationship identifiable. Yet this relationship is not significant. However, when the processes of the development team integration are better, the NPD performance will increase. A scatter plot, as in figure A9.9, gives more insight in the measure and direction of a relationship.

Correlations

		Development team integration processes	Operational Effectiveness
Development team integration processes	Pearson Correlation	1	,337
	Sig. (2-tailed)		,311
	N	11	11
Operational Effectiveness	Pearson Correlation	,337	1
	Sig. (2-tailed)	,311	
	N	11	11

Table A9.8: Correlation of development team integration processes with Operational Effectiveness in the Portuguese automotive parts and components industry

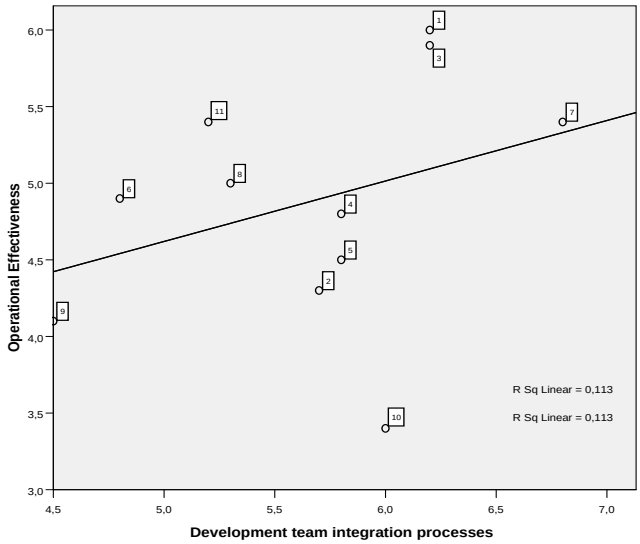


Figure A9.9: Scatter plot of the development team integration processes and the Operational Effectiveness

As pointed out in figure A9.9, the linear R square is 0.113. This indicates that there is a positive, but weak relationship between the scores on the processes of development team integration and the NPD performance.

Second, the relationship between the management of supplier involvement in NPD and the Operational Effectiveness is measured. Table A9.10 indicates that there is a positive correlation of 0.156.

Correlations

		Management of supplier involvement in NPD	Operational Effectiveness
Management of supplier involvement in NPD	Pearson Correlation	1	,156
	Sig. (2-tailed)		,647
	N	11	11
Operational Effectiveness	Pearson Correlation	,156	1
	Sig. (2-tailed)	,647	
	N	11	11

Table A9.10: Correlation of management of supplier involvement in NPD with Operational Effectiveness in the Portuguese automotive parts and components industry

In the analysis of a scatter plot, as in figure A9.11, it is visible that there is no linear relation, but a cubic. The R square cubic is 0.471. Thus, there is a special relation between the management of supplier involvement in NPD and the NPD performance. It is not always true that when the management of supplier involvement is better, there is a higher NPD performance. This only counts for the organizations 1, 3-5, and 7.

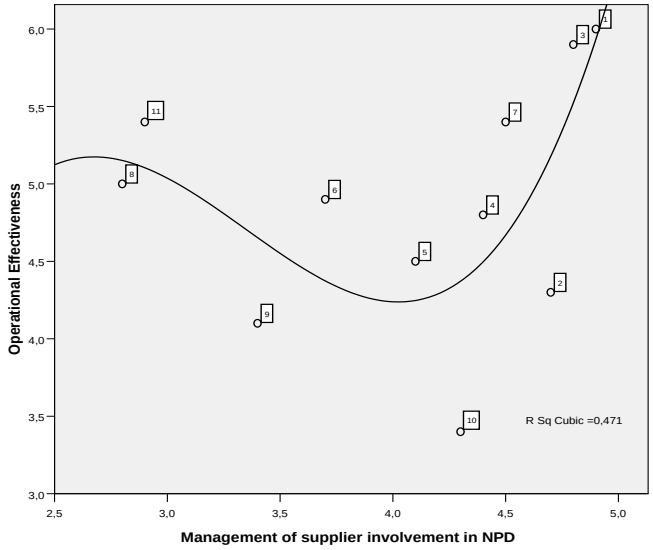


Figure A9.11: Scatter plot of the management of supplier involvement in NPD and the Operational Effectiveness

Furthermore, there is no specific pattern visible between the organizations of the stamping and die casting parts businesses. For example, organization 7, which is in the die-casting parts, scores high on the management of supplier involvement in NPD and on the Operational Effectiveness. On the contrary, organization (11) scores low on the management of supplier involvement in NPD and high on the Operational Effectiveness. Therefore, not at all the organizations in the dataset indicate a positive relationship between the management of supplier involvement in NPD and the NPD performance.

Appendix 10: Analysis on scatter plots

In order to choose the proper scatter plots, an analysis is made on the R Squares of the linear, quadratic, and cubic scatter plots.

First, the scatter plots of the development team integration processes and the R&D/Manufacturing integration.

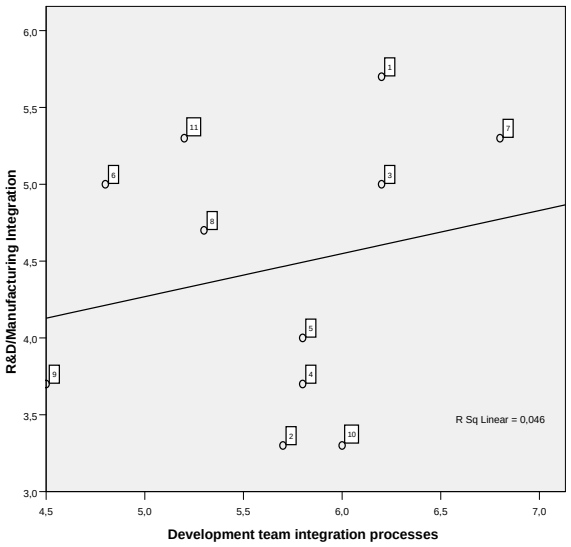


Figure A10.1: Scatter plot of the Development team integration processes and the R&D/Manufacturing integration (linear)

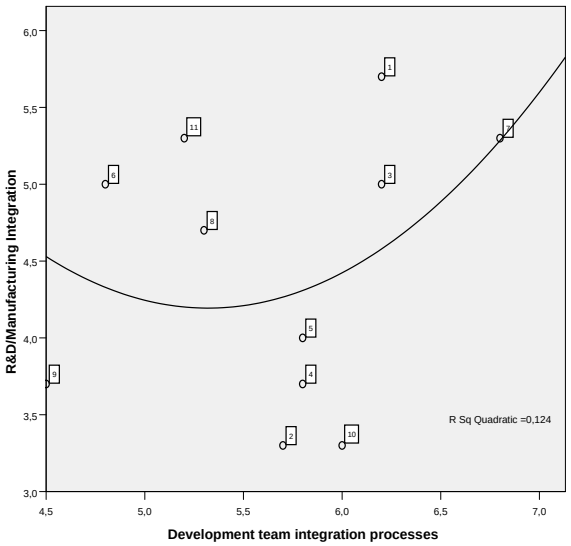


Figure A10.2: Scatter plot of the Development team integration processes and the R&D/Manufacturing integration (quadratic)

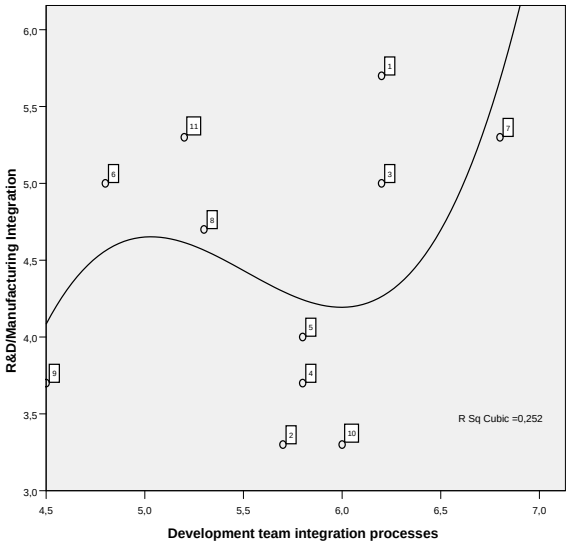


Figure A10.3: Scatter plot of the Development team integration processes and the R&D/Manufacturing integration (cubic)

These three figures show that there are several lines possible to indicate a probable relation. In comparing the R Squares, the cubic line indicates the highest with 0.252. Therefore, this possible relation is used in chapter 5.

Second, the scatter plots of the development team integration processes and the management of supplier involvement in NPD.

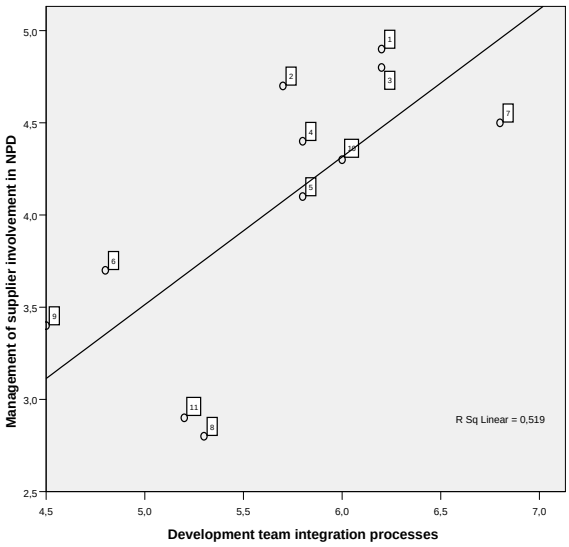


Figure A10.4: Scatter plot of the Development team integration processes and the management of supplier involvement in NPD (linear)

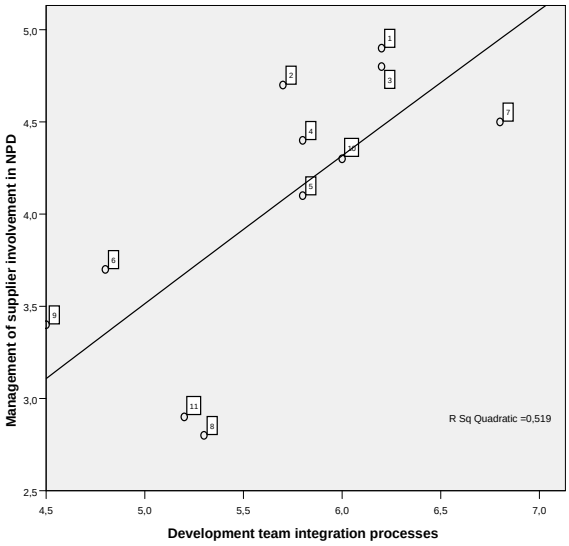


Figure A10.5: Scatter plot of the Development team integration processes and the management of supplier involvement in NPD (quadratic)

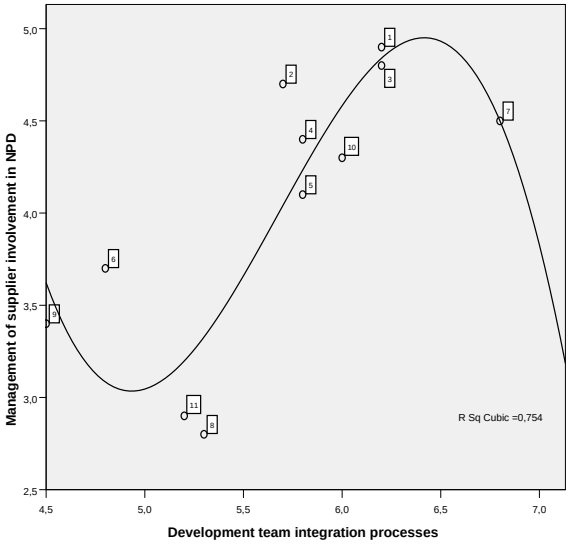


Figure A10.6: Scatter plot of the Development team integration processes and the management of supplier involvement in NPD (cubic)

As figures A10.4-6 point out, there are several indications possible. In comparing the R Squares, the cubic line indicates the highest with 0.754. Therefore, this possible relation is used in chapter 5.

Third, the scatter plots of the management of supplier involvement in NPD and the R&D/Manufacturing integration.

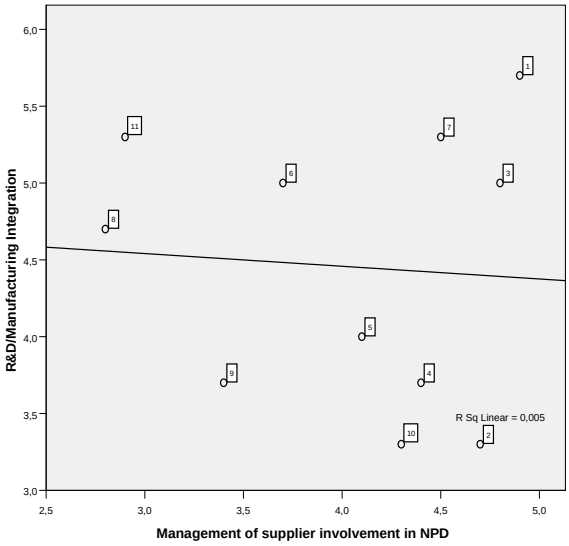


Figure A10.7: Scatter plot of the management of supplier involvement in NPD and the R&D/Manufacturing integration (linear)

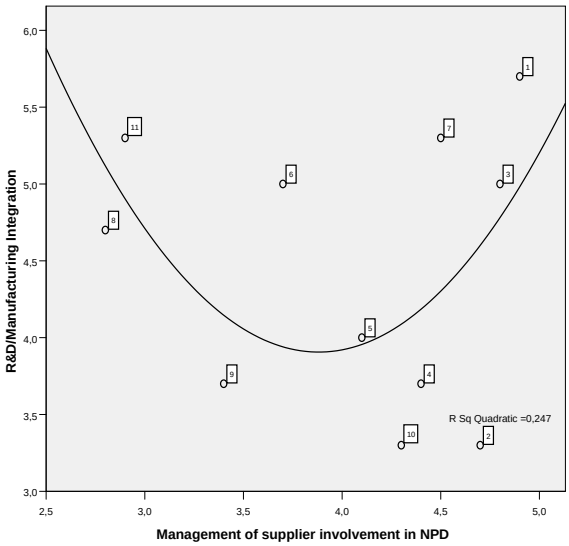


Figure A10.8: Scatter plot of the management of supplier involvement in NPD and the R&D/Manufacturing integration (quadratic)

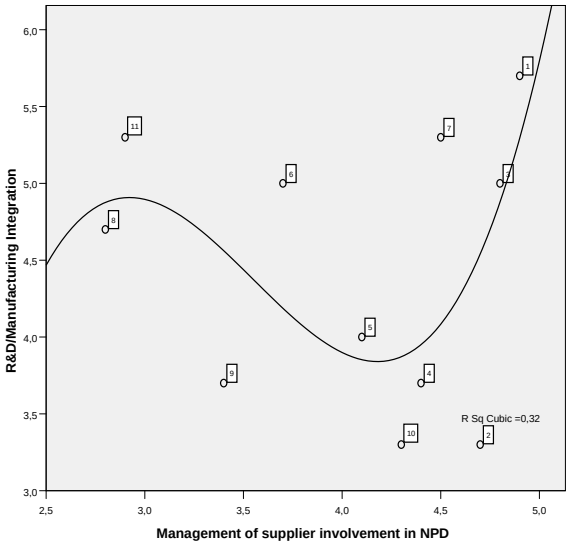


Figure A10.9: Scatter plot of the management of supplier involvement in NPD and the R&D/Manufacturing integration (cubic)

As figures A10.7-9 indicate, there are several possible relationships. In comparing the R Squares, the quadratic line indicates the best possible relation; 0.247. Therefore, this possible relation is used in chapter 5.

Finally, the scatter plots of the degree of supplier involvement in NPD and the R&D/Manufacturing integration.

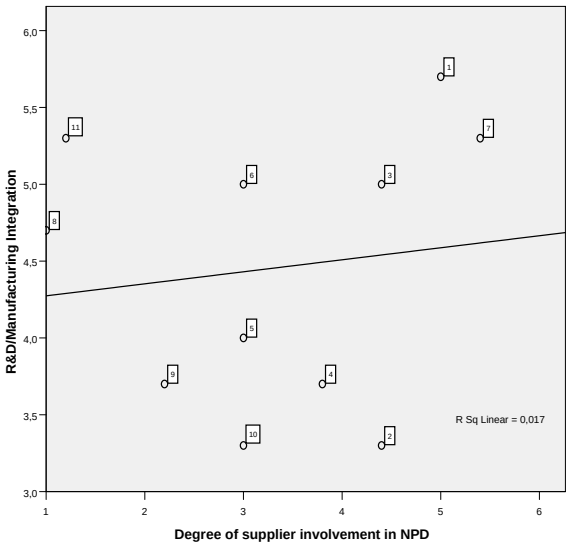


Figure A10.10: Scatter plot of the degree of supplier involvement in NPD and the R&D/Manufacturing integration (linear)

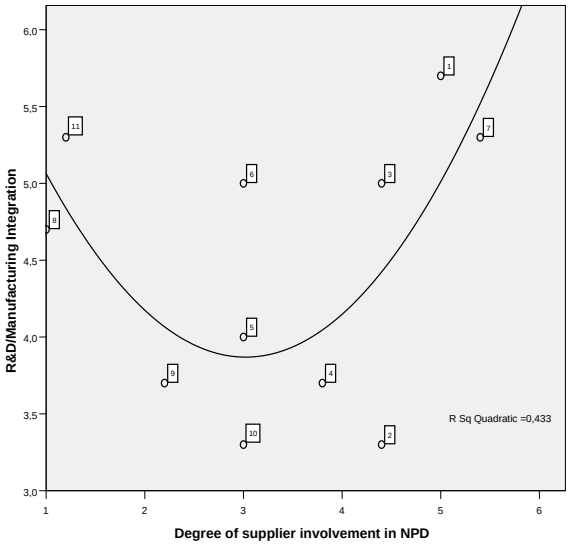


Figure A10.11: Scatter plot of the degree of supplier involvement in NPD and the R&D/Manufacturing integration (quadratic)

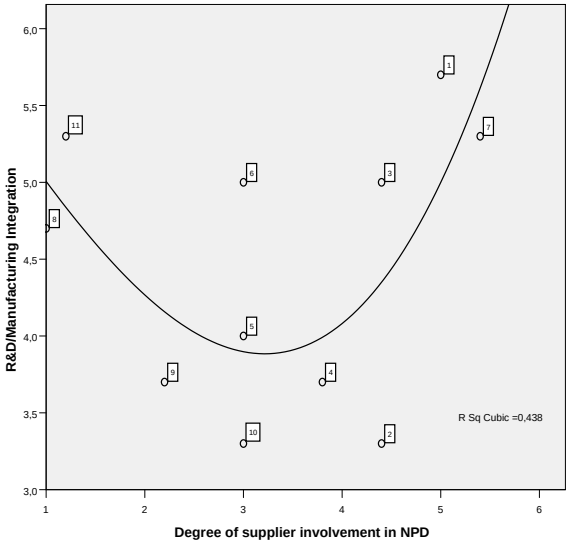


Figure A10.12: Scatter plot of the degree of supplier involvement in NPD and the R&D/Manufacturing integration (cubic)

As figures A10.10-12 indicate, there are several lines possible. In comparing the R Squares, the cubic line indicates the highest score (0.438). Therefore, this possible relation is used in chapter 5.