The Relative Importance of Relationships and Knowledge Flows in New Product Development*

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Abstract:

The relationship and network literature has primarily focused on particular partner types e.g. buyer-supplier relationships or competitor interaction. This paper explores the relative importance of different international relationships for New Product Development processes. The paper is based on the KNOW survey[1], which was carried out in 2000 in seven European countries. The analyses highlight two apparently contradictory findings, first, that relationships with customers are used most frequently at both early and late stages of the product development process, and second, that customer relationships, at the same time, have a negative impact on innovative success. Moreover, the type of knowledge exchanged in the relationship can be either complementary or supplementary in nature and the present analysis points to the importance of supplementary knowledge for innovative success.

Key words: knowledge flows, inter-organisational relationships, innovative success, new product development, supplementary knowledge, complementary knowledge.

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Setting the scene

This paper investigates with whom firms interact and what type of knowledge they exchange for new product development. The paper explores both the relationships that firms utilise and the type of knowledge that is exchanged to gain innovative success. We expect the interaction with a specific type of partner to influence innovative performance by means of appropriate knowledge transfer. Depending on the particular needs for new product development (NPD), the knowledge base of the firm and the possibilities in the surrounding environment varying needs for external knowledge and thus relationship types may be observed.

In our empirical context we let external knowledge depend directly on the knowledge base of the firm by characterising the knowledge as either supplementary or complementary. The former refers to knowledge within the firms area of expertise and the latter refers to knowledge outside the firms area of expertise. The partner types include interaction with customers, competitors, suppliers, universities and public and private research institutes (PRI's) and consultants. Finally, innovative success refers to the share a particular innovation contributes with on total turnover. Thus, we expect differences in innovative success to be an effect of different relationship types and knowledge flows.

The motivation for this setup is to advance a more general perspective on relationships in NPD as opposed to previous specific orientations towards particular partner types like e.g. buyer-supplier relationships (Gadde and Håkansson, 1994; Gadde and Snehota, 2000; Croom, 2001; Jap, 2001) or competitor interactions (Dussauge, Garrette et al., 2000; Echambadi, Cavusgil et al., 2001). Furthermore, previous literature has focused intensively on the problems for the firm of transferring tacit knowledge both internally and externally (Ancori, Bureth et al., 2000; Cohendet and Steinmueller, 2000; Osterloh and Frey, 2000). The problems with the tacit/codified distinction in respect of this paper are first, the one-sided focus on tacitness and second, the problems of empirical measurement. The distinction between supplementary and complementary knowledge seems more promising for two reasons: first, the knowledge exchanged for NPD is not 'one thing' but a set of experiences and possibly documents, which may both be tacit and codified in nature. But with the supplementary / complementary distinction all knowledge transferred is captured by the degree of similarity between the firms and the partners knowledge bases and flows. Second, for the empirical analysis the firm may itself be able to categorise more accurately the knowledge that was exchanged and thus provide more precise estimates.

The questions guiding the paper are:

1) Which relationships[2] are utilised more frequently for new product development?
2) Which relationships and knowledge flows are important for innovative success[3]?

The paper is organised as follows: First, an introduction to relationships and knowledge flows describes the importance of these for New Product Development (NPD). Based on the descriptions, hypotheses on knowledge flows, relationship types and innovative success are outlined. The empirical sections are preceded by a description of the data source and the variables. The two empirical sections each analyse one question: the descriptive section addresses the first question regarding the frequency of relationship utilization. The second empirical section presents the results of a regression analysis to the importance of relationships and knowledge flows for innovative success. Finally, a concluding section discusses the results and presents the implications for management and future research.

Relationships and knowledge flows: An introduction

Business relationships are typically addressed from either of two theoretical perspectives, the IMP approach (Ford, 2002) or the social network theory (Scott, 1992; Wasserman and Faust, 1994). The recent upsurge of industrial network and relationship theories from both the Industrial Marketing and Purchasing project (IMP) and social network theory (SNT) carry important questions like, *why do firms engage in inter-organizational cooperation and when? With whom are firms likely to ally and why? How do firms organize and control their cooperation?* (Ebers, 1999: 32). In particular the form, the content and intensity of interaction have been analysed, where the latter is closely related to the strength of ties[4] perspective originating from SNT (Granovetter, 1973; Mathews, White et al., 1998; Hansen, 1999). This paper aims at contributing to the second question; With whom firms are likely to ally, and adding, what is the effect on innovative performance?

The importance of relationships

A strong conceptual approach analysing the importance of diverse external relationships was offered by Porter with the Diamond model on national competitiveness (1990). Porter describes a

[2] The relationships refer to an interaction with either a customer, a supplier, a competitor, a university or PRI or a consultant. The term relationships is used in lack of a better phrase. An alternative could be the actor type or the relationship type but these seemed also to be unsatisfactory.
[3] In the paper we use the terms innovative success and innovative performance interchangeably for the success of the most important innovation to a particular firm.
[4] For empirical investigation of the strength of ties perspective in marketing, see Hansen (1999) or McEvily and Zaheer (1999).

concentration of firms within a certain industry as industrial networks, within which firms are part of a web of relations to other firms including customers, suppliers and competitors. A strong home-based cluster unblocks the flow of information and allows for deeper contact between the firms than would otherwise be possible with e.g. foreign firms. However, within the cluster, rivalry is a natural element of the dynamics and these forces are seen as a powerful starting point for international competitiveness. Although Porters study is in many respects similar to the present, two important problems must be noted, first, rivalry is seen as the major driving force of competitiveness, and second the interactions are stressed but the content of the interaction left aside. Thus, the framework cannot be applied for the present purpose.

The advantage of taking a cross-relationship perspective on innovative performance is the ability to investigate combinations of actors, e.g. if both suppliers and customers are involved in a NPD process and only the customers are investigated then the contributions to innovative performance or the characteristics leading to successful interaction may be wrongly identified, because the interdependencies are neglected.

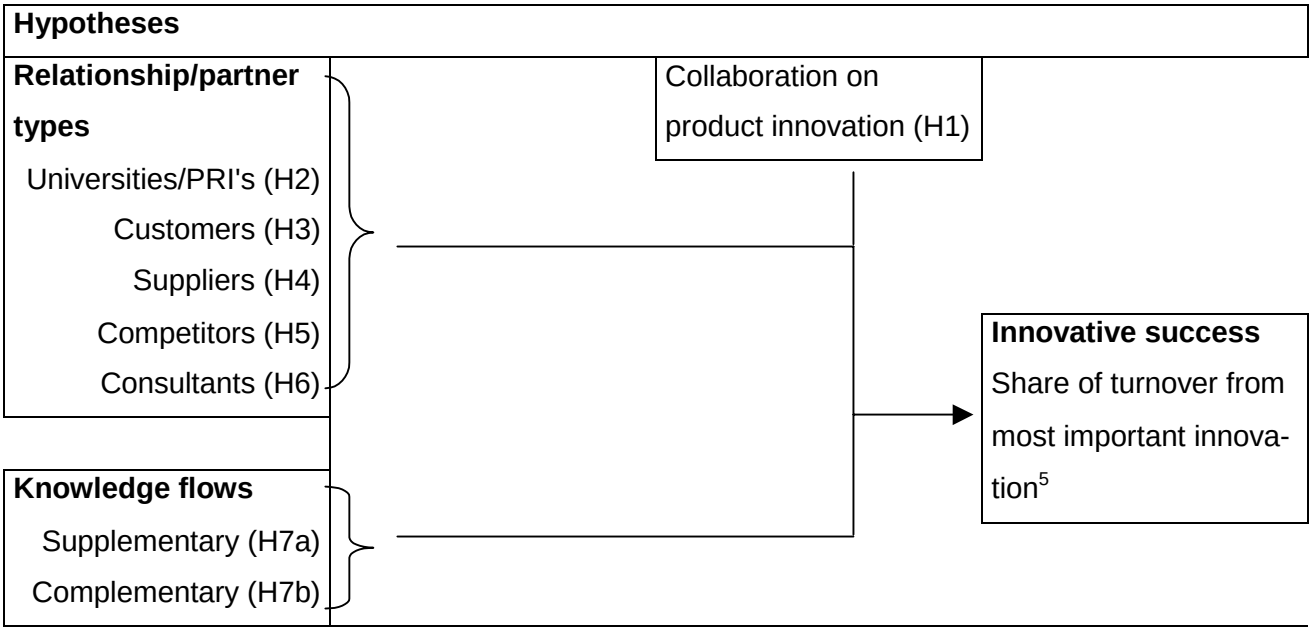
According to Sobrero and Roberts (2002) NPD can be viewed as the prototypical example of the need to include external partners to maintain competitiveness, because of the frequent and rapid changes in resources and products (Chakravarthy, 1997; Hitt, Ireland et al., 2000). A traditional assumption is that firms only build and maintain those relationships, which are particularly valuable to them (Gemünden, Ritter et al., 1996: 450). The present paper does not assume such rational behaviour but explores whether the relationships do in fact separately have a positive impact on innovative success.

Gemünden et. al. (1996) investigated cooperative relationships between different actor types in German high-tech industries. They investigated a similar set of problems working with a set of network configurations as unit of analysis to explicitly take into account the interrelatedness of the single firm configuration. Since this paper does not make such aggregations of data and does not take the interdependencies directly into account, but explores the relationships separately no direct comparisons can be made. Moreover, although Gemünden et. al. realised the importance of resource exchange these were not *directly* included in the analysis.

The product development process has typically been viewed in stage models (Rosenberg, 1982; Grupp, 1993). The underlying logic was to couple time with development phases. One of the early models was Schumpeter's distinction between invention, innovation and diffusion of innovations.

Later the so-called pipeline models (Schmidt-Tiedeman, 1982) were developed, which assume a simple sequence of the phases: research, development, production and marketing with only limited overlap. The sequential models were criticised for their simplistic view of product development and stood opposed to more processual models claiming feed-back processes and larger overlap between the phases to ensure product development success (Dosi, 1988). To simplify the matter, although recognizing the processual nature of NPD, the NPD process is divided into the stage of the original idea and the completion of the innovation, which may be compared to the research phase and the development phase in the sequential model above.

The question then remains; what type of relationships can contribute with relevant knowledge at what stages of NPD? The assumption is then that the type of knowledge a customer can contribute with can be seen as more important to generate new ideas compared to ideas relating to later phases of NPD. The external knowledge resources may therefore play different roles at different stages in the R&D process. The above mentioned assumptions are illustrated in figure 1 as a set of hypotheses that are presented in the following sub-sections.



[5] Innovative success is defined as the share of turnover in the latest accounting year coming from the most important innovation. Obviously, other measures of innovative performance may be suggested like number of innovations coming from product development, time to market, newness of the innovation compared to the market etc. The most important innovation was used as benchmark. The criteria for the identification of the most important innovation was the 'economically most important', which could be the innovation with highest realised or expected profit or turnover.

Hypotheses on relationships and innovative success

The accumulation of relational experience (Dyer and Singh, 1998; Sørensen and Reve, 1998; Kale, Singh et al., 2000; Sivadas and Dwyer, 2000; Kale, Dyer et al., 2002) within interorganisational relationships is one important variable to the achievement of successful knowledge flows (Child and Faulkner, 1998). Relational experience is related to alliance formation, partner choice, management and the interaction itself, that may all smoothen future collaborative ventures by easier conflict resolution, building of team synergies and goal achievement. An indirect effect may in addition be achieved after multiple collaborative ventures as the firms gets a reputation for good alliance performance.

Collaboration on product innovation[6] (as opposed to process innovation) in joint R&D projects has the particular characteristic of being market oriented, which may ensure innovative performance. By market orientation is meant that the innovation is directly aimed for immediate market introduction. Product innovation encompasses both new and improved products thus allowing for both incremental and radical innovations. On the other hand, collaboration on process innovation is concerned with efficiency and effectiveness in improving e.g. production facilities, which is only indirectly related to innovative performance and with limited market focus. Thus, collaboration on process innovation is only included in the analysis later on as a control variable.

These effects lead to the following hypothesis 1:

> *Hypothesis 1: Collaboration on product innovation has a positive effect on innovative performance*

The success of inter-organisational knowledge flows is expected to be associated with the particular partner with which knowledge is exchanged. For instance, *universities and public and private research institutes* focus on fundamental and basic research projects with longer development duration and are thus less likely to lead to immediate payoffs. However, over longer periods the basic science insights achieved through these relationships are more likely to have significant positive effects on innovative performance (Rynes, Bartunek et al., 2001). Relationships with universities do no include graduate students that are employed with the firm although this is considered an important source of knowledge. Furthermore, since the knowledge provided by universities and public research institutes is more basic in character it is expected to contribute significantly at the stage of the original idea, but not at the stage of the completion of the innovation[7].

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[6] Collaboration on product innovation was assessed by asking: Did your company introduce new or improved products within the last 3 years developed in collaboration with external partners. In the same way was collaboration on process innovation assessed.

[7] The long term nature of the projects is a particular characteristic in the case of Universities and PRI's. For the other relationship types these differences are not expected. Later on the distinction is relevant for the

Hypothesis 2a: Relationships with universities and PRI's have a positive effect on innovative performance at the stage of the original idea.
Hypothesis 2b: Relationships with universities and PRI's have no effect on innovative performance at the stage of the completion of the innovation.

Customer involvement should lead to more application-oriented development projects with shorter time horizons compared to university involvement. The application orientation may, however, be too focused on the needs of single customer groups; an effect that may lead to negative overall success. The reason being that a too narrow focus on particular customer needs will diminish the possibilities of addressing needs of other customer types caused by increasing specialisation. Obviously, the particular group of customers will be more likely to stay loyal to the product, and thus may lead to creation of customer clusters that are provided with different levels of innovativeness in the product range. Hence, collaboration with customers is expected to be frequent but with a negative effect on overall innovative success.

Hypothesis 3: Customer involvement has a negative effect on innovative performance at both the stage of the original idea and the stage of completion of the innovation.

Suppliers may deliver valuable insights into the integration of the NPD and production phases ensuring a higher overlap between the stages in the product development process as stressed earlier on e.g. by testing the innovation and developing prototypes in collaboration. Croom (2001) and Nesheim (2001) both pointed to the boundaries for supplier involvement. Nesheim found that external suppliers are in fact involved in core activities within the firms, which was supported by Croom. Nevertheless, Croom identified some important sources of problems that were related to logistics, fitting and integration with other components, and thus not related to NPD (2001: 34). Wynstra and ten Pierick (2000) argue that supplier involvement rests in effectiveness and efficiency arguments and a natural step is therefore to include suppliers into the later stages of NPD, whereas inputs at earlier stages may not support these arguments. Nevertheless, supplier involvement may be viewed as a preliminary step towards outsourcing of the development efforts (Wognum, Fischer et al., 2002), which may lead to increased supplier involvement. Presently, however we focus on the first effect that some boundary should be set for supplier involvement leading to formulation of hypotheses 4a and 4b:

Hypothesis 4a: Supplier involvement has a negative effect on innovative performance at the stage of the original idea.

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hypotheses on the knowledge characteristics as well. It should be noted however, that the dependent variable covers only the last accounting year and can therefore not capture these learning effects, which is the reason why they are not included in the hypotheses.

Hypothesis 4b: Supplier involvement has a positive effect on innovative performance at the stage of completion of the innovation

Competitors may possess relevant supplementary knowledge that can lead to immediate success, but why should they engage in joint development efforts? As the firms are direct competitors many opportunities for learning may arise and these learning effects may have major competitive consequences (Dussauge, Garrette *et al.*, 2000: 100) leading to increased competitiveness of the partner. Sivadas and Dwyer (2000: 35) posed the hypothesis that non-competitor alliances would foster higher cooperative competence than competitor alliances indicating that non-competitors are more likely to foster collaboration and competitors are more likely to foster competition and hence stresses the second element of Dussauge et. al.'s argument. Sivadas and Dwyer did however not find support for their argument. Perks and Easton (2000: 334) support this dilemma and argue that the only defendable reason to interact with competitors is to compete better against third-party competitors. Based on this assumption, we argue that knowledge flows between competitors at the completion stage of the NPD process may lead to positive effects due to shortening of the development periods providing quick and easy access, but are considered less likely due to the competitive struggle. Joint R&D projects between competitors at early stages of the R&D process are even less likely as the transfer of knowledge for idea generation can turn out to cannibalise own efforts. Thus, collaboration with competitors is expected to be infrequent but may lead to positive effects.

Hypothesis 5a: Competitor involvement has no effect on innovative performance at the stage of the original idea.
Hypothesis 5b: Competitor involvement has a positive effect on innovative performance at the stage of completion of the innovation.

Finally, the role of *consultants* is less clear; they can either provide technical knowledge for tailored projects and act as an additional work force or they can be seen as an advisor on the NPD process in general. From the above, a positive effect of consultant involvement should be expected on innovative performance, but such an effect is dependent on the general labour availability in the industry and is therefore more likely to be significant in industries characterised by technical bottlenecks. Thus, we pose an explorative hypothesis on the consultant involvement:

Hypothesis 6: Consultant involvement has no effect on innovative performance at either of the stages.

The role of knowledge in NPD

An important aspect of relationships is the knowledge transfer. Knowledge flows as well as mediators and barriers to knowledge flows has attracted increasing interest in recent years (Lane and Lubatkin, 1998; Mangematin and Nesta, 1999; Zahra and George, 2002). Originally,

knowledge flows were studied in the context of strategic alliances and networks (Inkpen, 1998; Simonin, 1999), but they have also proven to be of interest in internationalisation both at the firm and the regional level (Almeida and Kogut, 1999; Lipparini and Fratocchi, 1999; Kinder and Lancaster, 2001), and finally, knowledge flows have been studied within MNC's (Gupta and Govindarajan, 2000; Pedersen, Pedersen et al., 2001).

The process of knowledge transfer depends on several factors of which especially the notion of absorptive capacity has attracted massive interest (Cohen and Levinthal, 1989; 1990). Absorptive capacity is defined as the ability of the receiving partner to identify, assimilate and exploit the transferred knowledge. A precondition for successful knowledge transfer is therefore a well-developed absorptive capacity[8]. Typically, absorptive capacity has been measured using R&D intensity originating from Cohen and Levinthal (1989) and applied by e.g. Stock et. al. (2001), Veugelers (1997), Keller (1996), Liu and White (1997) and Shenkar and Li (1999). The main problem with R&D intensity as a measure of absorptive capacity is the lack of possibilities to capture the process of knowledge absorption. The R&D intensity is only a measure of the amount of resources dedicated to a specific functional area, but says nothing about whether knowledge is actually transferred or whether the knowledge is utilised as prescribed by the definition. It is however not the purpose of this paper to suggest new measures of absorptive capacity and thus, the same measure is applied in this paper. Bearing in mind the above problems the indicator will only be interpreted as a control variable.

A second factor influencing the ease of knowledge transfer is the characteristics of the knowledge to be transferred. The characteristics or dimensions of knowledge can be defined as either tacit vs. codified[9] or as supplementary vs. complementary. The tacit-codified dimension is defined on an absolute scale, whereas the supplementary-complementary knowledge axis depends on the relative nature of the knowledge bases and flows. Complex and tacit knowledge requires as a minimum face-to-face interaction remaining however problematic and costly (Rocha, 1999). Simonin (1999) tested knowledge ambiguity as a dimension of tacitness on technological knowledge transfer in 147 MNC's and found a positive and significant relationship between ambiguity and tacitness leading to a negative relationship with knowledge transfer. Hence, ambiguity and tacitness seem to hinder technological knowledge transfer. On the other hand, codified knowledge like prototypes can more easily be transferred and likely at lower cost. As a

[8] For operationalisation of absorptive capacity in new product development see e.g. Stock et. al. (2001) or Bosch, Volberda et. al. (1999).

relationship is likely to involve several transfer processes, an analysis based on the tacit-codified dimension should lead to several observations for each relationship. Instead, this paper focuses on the relative similarity of the knowledge bases and knowledge transfers among the partners as captured by the supplementary[10] vs. complementary knowledge dimensions[11].

Supplementary knowledge is defined as high degrees of redundancy in the form of similar product development knowledge and skills (Rindfleisch and Moorman, 2001: 2) implying that supplementary knowledge is easier to transfer given the overlap in knowledge by the receiving and the transmitting firm. Exchange of supplementary knowledge allows the partners to achieve scale economies and to reduce excess capacity. Complementary knowledge comprises a larger potential for learning through the combination of different and complementary skills and resources viewed as a lower overlap (Dussauge, Garrette *et al.*, 2000; Echambadi, Cavusgil *et al.*, 2001; Rothaermel, 2001). Exchange of supplementary knowledge is therefore associated with the dangers of double jeopardy through first, the lack of learning potential, and second, through the threat of potential competition caused by the decrease in knowledge gaps to the partner firm. Thus, supplementary knowledge can be expected to provide quicker and more successful product development in the short term, whereas complementary knowledge may take longer to utilise depending on the level of absorptive capacity, but also carries a higher learning potential and associated potential for innovative performance.

Hypotheses on knowledge characteristics and innovative success

The expected success of knowledge exchange depends on the stage of the innovation process. At the stage of idea generation, supplementary knowledge may fit better with the existing idea set and positively support the process, whereas complementary knowledge is more likely to trigger unrelated ideas and thus requires redefinition of the idea set and ultimately affect innovative performance negatively. Consequently, complementary knowledge is more likely to lead to radical innovation and development risks, but also higher performance. Both types of knowledge may

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[9] See e.g. Nonaka and Takeuchi (1994; 1995); Cohendet and Steinmueller (2000); Zack (1999) and Ancori et. al. (2000) for in-depth discussions on the problems of codification and transfer of tacit knowledge.

[10] The supplementary dimension has also been labelled knowledge compatibility, see e.g. Nielsen (2000).

[11] Some confusion exist in the literature regarding the relativeness of the dimensions. Some (Rindfleisch and Moorman, 2001) associate supplementarity and complementarity with exchange between firms that are in horizontal (e.g. between competitors) versus vertical relationships (e.g. between channel members), others (Dussauge, Garrette *et al.*, 2000) associate the knowledge flows with firms at same (projects within marketing) or different (between marketing and R&D) stages of the value chain. Darr and Kurtzberg (2000) distinguish between strategic, customer and geographic similarity. Hence, no apparent coherence in the use of the terms can be identified in the literature. In the present paper, supplementary knowledge is defined as knowledge within the area of expertise of the receiving firm and complementary knowledge is defined as knowledge outside the area of expertise of the receiving firm.

support the stage of completion of the innovation, as supplementary knowledge adds to the quality of the existing knowledge, whereas complementary knowledge may broaden the scope of the present invention and provide valuable insights for e.g. extensions or differentiated applications. Hence, the hypotheses are formulated as follows:

> *Hypothesis 7a: Supplementary knowledge has a positive effect on innovative performance at both the stages of the original idea and the completion of the innovation.*
> *Hypothesis 7b: Complementary knowledge has a negative effect on innovative performance at the stage of the original idea, but a positive effect on innovative performance at the stage of the completion of the innovation.*

In conclusion, we expect some knowledge to not necessarily lead to positive effects on short term performance. This does not mean that complementary knowledge should be avoided, but only that it takes longer before a positive effect may be seen.

The data set

The survey of European manufacturing and service industries on innovation related knowledge flows (Know) was carried out during 2000 using CATI. The sample covered seven European countries (Denmark, France, Germany, Greece, Holland, Italy and UK), five industrial sectors (food and beverages; paint and varnishes; telecom equipment; telecom services and computer services – respectively NACE codes 15, 24 (-24.4), 32, 64 and 72) and firms of size between 10 and 999 employees. The survey was concerned with both general innovation-related activity but also focused some questions on the most important innovation of the firm in the last three years, the latter being drawn upon in this article (see footnote 5).

Table 1: Response rates for each country in KNOW

	Number contacted	Responses	Response rate (%)	Innovators
Greece	260	110	42.3	100
Italy	278	97	34.9	80
Denmark	170	130	76.5	98
UK	1003	96	9.6	46
France	613	79	12.9	76
Germany	470	101	22.0	94
Netherlands	331	151	45.6	138
Total	**3017**	**764**	**25.3**	**632**

Table 1 reveals high differences between the participating countries, especially the sampling data for the UK must be carefully interpreted. The sample is limited to innovators although some material was gathered on non-innovators as well. The data set comprised 632 firms, of these some proved afterwards to be outside the targeted sectors and some to have passed the size limits from the day of sampling to actual response by more than 25% (i.e. inclusion of firms up to 1250 firms was allowed). In total, the cleaned data set contains 557 firms. Due to the particularities of NPD we might also expect sector differences to be of importance. Table 2 highlights the distribution by country and sector of the sample. Here it can be seen that in particular telecom services is under-represented compared to the other sectors.

Table 2: Distribution of sample by country and sector

	Sectors						
	Food & beverages	Paint and varnishes	telecom equipment	telecom services	Computer services	Total	**Percentage**
Greece	18	16	21	4	20	79	14.2
Italy	13	12	14	13	13	65	11.6
Denmark	19	20	13	2	24	78	14.0
UK	35	33	13	4	29	114	20.4
France	6	19	6	4	9	44	7.9
Germany	20	11	15	11	21	78	14.0
Netherlands	21	21	19	10	29	100	17.9
Total	132	132	101	48	145	**557**	**100.0**
Percentage	**23.7**	**23.7**	**18.1**	**8.6**	**26.0**		

The relationship types (competitors, suppliers, customers, universities or PRI's, or consultants) are identified by asking the respondents with whom they collaborated during two different stages in the product development process, namely at the stage of the original idea and at the completion of the innovation stage. For each stage, the respondent was asked to mark the type(s) that was actively involved in NPD. These variables are therefore dichotomous (yes/no). All of these could be chosen or neither of them. Notice that the interrelationships cannot be assessed with this data set as described in the theoretical section, which must be considered a short-coming.

The knowledge characteristics (supplementary/complementary) were assessed for the exchanges that were taking place, in general, and not for the single relationship. The options to mark were whether they received knowledge in areas where they had expertise already or in areas where they lacked expertise (yes/no).

The dependent variable[12] (innovative performance) is measured as the share of turnover coming from the most important innovation to total turnover in the last completed year of accounting (percentage). There are several problems associated with this measure. First, the innovative performance measure relates to sales within the last year of accounting, but it is well-known from the literature that relationships are costly and time consuming to build and are very resource-intensive to maintain and manage. Therefore, the measure may not be closely related to the relationship types as these may refer to a longer time horizon than the performance measure can account for. Second, the break-through period of innovations to full acceptance on the market may be longer than 3 years leading again to lower levels of significance. The dependent variable represents a short-term oriented outcome[13] especially because the innovation may just have been introduced on the market last year and no longer than 3 years ago. Thus, a renewed inquiry on the share after 5 years or even 7 years may expectedly result in higher shares and thus more positive effects stemming from the relationships.

Collaboration on product innovation is measured as described in footnote 6 and as mentioned in the above section collaboration on process innovation is included as a control variable. A key variable, stressed in the literature, is general alliance experience (and not specifically associated with NPD), which is expected to increase the absorptive capacity of the receiver as well as to contribute to conflict resolution and smoothening of the alliance evolution and process in itself (Gulati, 1995; Dyer and Singh, 1998: 672). The variable was originally included in the regression analysis, but due to a poor response rate the variable disturbed the regression and was subsequently deleted. Instead, collaboration on product and process innovation were included to capture the specific alliance experience effect.

The science share measures the share of engineers or scientists with an academic degree to the total number of employees (percentage). The R&D intensity (HR) is calculated as the number of employees employed in research and development to the total number of employees. The problems with this measure on absorptive capacity stemming from Cohen and Levinthal (1989) were pointed out above. In fact, by using this measure based on employees and not expenditures a high correlation with the actual (but un-measurable) absorptive capacity of the firm can be

[12] The dependent variable had a missing value rate of 41%, which appears to be quite high. A t-test of the split sample (first group contained all cases with the question missing and the second group contained all cases that had in fact answered the question) was conducted on key variables and only in the case of firm size could the relationship not be rejected at 95% significance level. This means that for all other variables, the use of the dependent variable is statistically unproblematic and thus the variable is accepted as the dependent variable.

[13] The question posed was, what percentage of your firms total sales in the last accounting year can be attributed to the most important innovation?

expected. The formal training and education of the employees can be seen as an important part of absorptive capacity since knowledge is transferred between employees of the two firms.

Dummies are included for countries with the Netherlands as reference category even though we have no particular assumption about national differences in usage of relationships. The inclusion of the country dummies is based on the relative large differences in response rates as seen in table 1, which requests care in interpretation of the results. Sector dummies are included with food and beverages as the reference category, and finally, a size dummy is included with small firms as the reference category.

Frequency of relationship interaction

In the following descriptive section the first question is investigated, namely:

Which relationships are utilised more frequently for new product development?

First of all, the average number of relationships in the stage of the original idea was 1.50 and for the completion of the innovation the average was 1.22, which is significantly different at 5% level (t-test). Thus, on average more relationships are explored and utilised at the early stages of the NPD processes as compared to the completion of the innovation. However, from a company perspective the difference between 1.5 and 1.22 may not seem high. If however the assumption that small firms on average interact with fewer firms can be accepted, then the fact that 62.2% of the firms are small may raise the perception of the number of relationships. In total, the firms have between 0.94 relationship to 1.17 pr. firm depending on the industry[14], irrespective of the stage.

Table 3 presents the inter-industry differences based on the sample. For all sectors customers are more frequently involved in NPD than in any other sector. Furthermore, competitors are relatively more important in paint and varnishes (44.7%) than in any other sector. Suppliers are more important in the food industry, but is high for all industries. Both Universities and PRI's and consultants are used much less frequent (ranging from 12 to 29%) than the other relationship types.

[14] For the five industries the average number of relationships are: food and beverages=1.12; paint and varnishes and computer services=1.17; telecom equipment=0.94 and telecom services=1.06 relationships pr. firm for the most important innovation.

Table 3: Tendency to collaborate in each industry

	Competitors	Suppliers	Customers	Uni/PRI	Consultants
Food and beverages	32.6	**51.5**	56.8	14.4	20.5
Paint and var.	**44.7**	41.7	56.8	**20.5**	18.2
Telecom equip.	31.0	46.0	55.0	13.0	12.0
Telecom serv.	31.3	47.9	47.9	12.5	22.9
Computer services	31.7	46.2	**63.4**	15.9	**29.0**

Calculated as the number of 'yes' answers to each type in each industry divided by the total number of firms in the sample for each industry

One argument for inclusion of consultants stressed in the literature review is the problems with getting enough highly skilled employees. This particular labour market problem has been prevalent especially in telecom software. Thus, it is not surprising that consultants are used more frequently in this sector compared to the others. This result can be coupled with the relative high growth rates within the IT-sectors where the use of external consultants is viewed as one way to respond to the increasing demand and explosion in technological development. Hence, consultants may be used as a labour market buffer, where they are hired to do specific jobs e.g. software development of a limited duration (Knudsen, 2002).

A second approach is to view the differences in use of the relationships for each of the two stages of the NPD process. These differences are reflected in table 4 for suppliers and table 5 for customers, and just described for the other relationship types (Chi Square tests reveal that for all relationships types are the relations highly significant (1% level)).

A large share of firms use suppliers for NPD; at the stage of the original idea 35% used suppliers and at the stage of completion the share rose to 43.6%. In the literature review it was argued that suppliers would more frequently be involved in the completion of the innovation as compared to the original idea and this was supported here. It now remains to be tested whether this observation is then positively related to innovative performance (see the following section).

Not very surprisingly are customers the most preferred external partner for NPD with shares of 54.6% at the original idea and 39.2% at the completion of the innovation. More surprisingly though, almost the same share of firms either did not use customers at all or used customers in both stages of NPD (37.9% and 31.7%). The firms that do not use customers at all (37.9%) may then be less customer oriented or at least integrates these to a smaller extent, which may prove to be

successful as stressed in hypothesis 3, where a negative impact was anticipated on innovative performance.

Use of Suppliers for NPD

			Suppliers - completion		
			No	Yes	Total
Suppliers - original idea	No	Count	250	81	331
		% of Total	49,1%	15,9%	65,0%
	Yes	Count	37	141	178
		% of Total	7,3%	27,7%	35,0%
Total		Count	287	222	509
		% of Total	56,4%	43,6%	100,0%

Table 4: Suppliers in NPD in original idea and completion (Count and %)

Use of Customers for NPD

			Customers -completion		
			No	Yes	Total
Customers - original idea	No	Count	195	39	234
		% of Total	37,9%	7,6%	45,4%
	Yes	Count	118	163	281
		% of Total	22,9%	31,7%	54,6%
Total		Count	313	202	515
		% of Total	60,8%	39,2%	100,0%

Table 5: Customers in NPD in original idea and completion (Count and %)

For competitors 36.4% of the respondents indicate that collaborations with competitors has taken place, whereas only 9.4% related to the completion of the innovation and in only 9 cases where these not continuations from the original idea indicating that competitors are used more often at the stage of the original idea and only rarely at the stage of completion alone. These results comply with the theoretical discussion above, where it was argued that it was rather unlikely that competitors would be included in product development, because of the rivalrous nature.

External relationships with universities or PRI's only exist to a very limited degree with 11.5% at the stage of the original idea and 13.5% at the stage of completion. A total of 82.5% of the firms did not use universities or PRI's at any level of product development.

Relationships, knowledge flows and innovative success

This final empirical section analyses question 2:

Which relationships and knowledge flows are important for innovative success?

Table 6: Results on regression analysis for types of relationships, knowledge flows and innovative success

	Original idea		Completion of innovation	
	Unstand. coeff.	Significance	Unstand. coeff.	Significance
Constant		0.000***		0.000***
Collaboration on product innovation	-	-	-	-
Collaboration on process innovation	-	-	-	-
Supplementary knowledge	12.53	0.000***	13.60	0.000***
Complementary knowledge	-	-	-	-
Competitors	-	-	-	-
Suppliers	5.86	0.071*	-	-
Customers	-5.74	0.059*	-7.23	0.041**
Uni's or PRI's	9.067	0.055*	-	-
Consultants	-	-	-	-
Science share	-	-	-	-
RD intensity (HR)	0.12	0.069*	0.12	0.047**
Paint and varnishes (NACE 24)	-4.70	0.245	-5.06	0.211
Telecom equipment (NACE 32)	7.08	0.121	5.87	0.194
Telecom services (NACE 64)	20.87	0.000***	17.32	0.003***
Computer services (NACE 72)	0.51	0.901	1.13	0.783
Germany	-16.35	0.091*	-23.21	0.021**
France	-19.20	0.025**	-26.38	0.003***
Italy	-20.94	0.013**	-22.43	0.010***
Holland	-21.58	0.004***	-23.58	0.003***
Denmark	-18.21	0.023**	-24.20	0.004***
Greece	-15.52	0.032**	-23.29	0.003***
Size (large firms)	-9.65	0.004***	-5.06	0.017**
N	210		207	
R^2	0.283		0.248	
F	4.763***		4.532***	

- : not included in stepwise regression analysis
*: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.
Industry dummy in comparison to the largest industry: food and beverages.
Country dummy in comparison to the largest country: the Netherlands.
Size dummy in comparison to small firms between 10 and 249 employees.

Table 6 presents the results of a stepwise backward regression analysis for each of the stages in the NPD process. The purpose of the stepwise regression is to select from a large number of independent variables a subset of variables under some pre-specified criteria to explain the dependent variable. The cut-off points were set at 0.10 for inclusion into the model and 0.15 for exclusion from the model. All dummy variables (country, industry and firm size) were entered into the model and specified to be included irrespective of their explanatory power.

A correlation analysis to test for multi-collinarity for each relationship type at each stage of the innovation process based on Spearmans Rho for non-metric variables is reported in the appendix. At the stage of the original idea the three significant relations are less correlated than the remaining variables as suppliers and universities/PRI's are not correlated and the other two relationships correlated at 5% significance level. Only correlations including consultants are less correlated thus pointing to the special status of consultants in the sample mentioned above. Thus, a careful interpretation states that multi-collinarity is not a significant problem in the present analysis. For the stage of the completion of the innovation, the level of collinarity is even lower than in the other case. The use of universities and PRI's and consultants are uncorrelated except in two separate cases. Since customer involvement was the only significant variable we consider multi-collinarity to be unimportant for the analysis at the stage of completion of the innovation.

The results of the regression highlight first of all the difference in number of relations that have an impact on innovative performance. At the stage of the original idea, three relationship types, customers (-), suppliers (+) and universities and PRI's (+) are important, whereas only customers have a significant, but negative effect on innovative performance at the stage of completion.

Tests on the stage of the original idea

Hypothesis 1 on the impact of collaboration on product innovation did not find support in the regression. Neither did hypothesis 5a and 5b on the impact of involving competitors in NPD. Also hypothesis 7b on the transfer of complementary knowledge did not find support at the stage of the original idea.

Hypothesis 2a on the positive impact of universities and PRI's at the stage of the original idea did however find support in the analysis. Moreover, customer involvement had a negative impact on innovative performance as was posed in the hypothesis 3. Previously it was found that customers was the most often used type of relationship in NPD, and combined with the negative effect we may conclude that the inclusion of customers for the idea generation may have important consequences for alliance management, which we discuss further in the conclusion. Supplier

involvement has a positive effect though only tentatively significant (7.1%), which stands in contrast to the expected effect posed in hypothesis 4a. This may indicate that the boundaries discussed in the theoretical review may be much closer to the core than was expected and that the suggested problems are less important than suspected. Finally, supplementary knowledge is positive and highly significant as expected from hypothesis 7a.

Tests on the stage of the completion of the innovation

For the completion of the innovation, customer involvement results again in a negative and significant effect on innovative success, which is in favour of hypothesis 3. Hypothesis 2b was rejected since universities and PRI's did not have any impact on performance. Hypothesis 4b and 5b on respectively supplier and competitor involvement found no support. Hypothesis 6 that consultants play no role for innovative performance was supported and the results could therefore not lead to further clarification of the role played by this particular external knowledge source.
Finally, hypothesis 7a is supported and strongly significant as already mentioned above, whereas no support is given to hypothesis 7b on the complementary knowledge flows.

For the *country dummies,* all are significantly different from the reference country, although Germany at the idea stage is only tentatively significant. However, the results seem to indicate problems of multi-collinarity, which could lead to exclusion of the country dummies. The *sector dummies* reveal that only telecom services is significantly different from food and beverages. Finally, the *size dummy* indicates that the new innovations of larger firms tend to contribute with smaller shares of total sales leading to a negative effect on innovative performance. This also indicates that smaller firms have fewer products that contribute to innovative performance. Finally, if the measure of *R&D intensity* as an indicator of absorptive capacity is accepted, the results indicate that absorptive capacity is an important and significant feature of knowledge transfer in relationships. The *science share* had no significant impact on innovative performance.

Conclusion

This paper has demonstrated that external relationships are in fact important. An apparent paradoxical relation was revealed by the analyses, namely that, on the one hand, customer relationships are used more often than other types of relationships, but on the other hand, in both the original idea and the completion of the innovation stages did customer involvement have a negative impact on innovative performance. The term ‘customer’ is most often used as if

customers constitute a coherent whole with similar needs, wants and preferences. But customers do in fact represent a very diverse set of relationships that should be managed as such.

Development of new products for specialised customer needs may not be sufficient or relevant for other customer groups. The relevance for the included customers should lead to higher motivation and loyalty towards the products, but does not automatically lead to overall innovative success. Herein lies also the reasoning for serving special needs by grouping customers according to importance in Alfa and Beta groups. But if the set of Alfa customers cannot outweigh the Beta customers in terms of volume on sales then the service of this group may lead to the observed negative effects. One way to manage these groups is by introducing modularity (Sanchez, 1999) into the product structure allowing different dimensions or product criteria to serve particular needs for particular product elements or modules. Obviously, the need to develop modules for several diverse needs may raise a discussion on cost, which should be dealt with in future research. Besides customers, suppliers and universities and PRI's are important for innovative performance.

The supplementary knowledge was positively associated with innovative success. Since continued exchange of supplementary knowledge may lead to increasing specialisation and decreasing knowledge gaps, the firm may over time be less able to serve diverse needs of customers and thus may eventually lead to loss of customers and renewed negative effects on performance. The above results support the theoretical expectations that supplementary knowledge is easier to apply and utilise in the short run, whereas complementary knowledge had no significant effect on innovative success. If the theoretical expectation is correct, that complementary knowledge is a source of success in the long term, then the challenge for managers will be to include knowledge compatibility as a decision variable and accordingly to balance the exchange of supplementary and complementary knowledge requiring a balance of short and long term payoffs. This balance is closely related to the discussion of exploration and exploitation (March, 1991).

Through the importance of supplementary knowledge, the issue of double jeopardy becomes a managerial challenge. First, supplementary knowledge leads to innovative success very quickly but carries only a limited potential for learning. Second, the exchange of compatible knowledge sources may lead the partner to become a competitor later on. This has become a new research topic known as ‘coopetition’ (Bengtsson and Kock, 2000; Tsai, 2002). The challenge for managers is therefore again to balance the partners according to an appropriate mix of supplementary and complementary knowledge to ensure the continuous renewal of the knowledge base and to avoid that the partners become competitors. Too much complementarity may, on the other hand, lead to

a dispersed knowledge base and thus highly fragmented development efforts with high risk. Hence, both for partner choice and knowledge exchange, managers need to balance the long term and short term goals by managing the external relationships directly.

Some methodological problems should however be stressed. The measure of absorptive capacity is highly simplistic and must be further refined to capture the real value of the theoretical notion. Presently, R&D intensity and other related constructs do not capture the different process aspects of knowledge absorption. Second, NPD is not accurately described in a stage model and especially not one as simple as applied in this paper. Product development represents processes of continuous trial and error. These elements of learning, both within the R&D department as well as in interdependent departments, must play a vital role in the utilisation of external relationships. Finally, as mentioned earlier the performance construct is a very simplistic one. Obviously, measures of longer term performance and evolution would be preferred, but also here must further research be called for.

The presented results highlight the need for further research, especially on four aspects; First, the mix of relationships and their contribution to the knowledge base must be investigated further. This paper has presented some preliminary evidence but also discussed the problems in the present approach. Do particular relationship types contribute with e.g. complementary knowledge and does it have an effect on longer term? Following on that, how can the performance measure be associated with the length of the relationships and longer term measurements to allow for empirical testing of the remaining hypotheses? Third, the strength of ties perspective could prove valuable to the assessment of the relationship between knowledge flows and innovative success based on the stage of relationship evolution and content. Finally, does it matter and how, whether the firm is of type, e.g. first mover as compared to being a follower and what about the innovation type? Do radical innovations appear in more closed settings and incremental innovations in close collaboration with external partners? These are all questions that would further our understanding of new product development in a network perspective and should be encouraged for future research.

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Appendix

Table A1: Spearman's Rho correlation for relationships at the stage of original idea

		Competitors	Suppliers	Customers	Universities	Consultants
Competitors	Correlation	1.0				
	Significance					
	N	516				
Suppliers	Correlation	0,17	1.0			
	Significance	0,00				
	N	512	513			
Customers	Correlation	0,25	**0,09**	1.0		
	Significance	0,00	0,038			
	N	514	512	516		
Universities	Correlation	0,13	**0,04**	**0,11**	1.0	
	Significance	0,004	0,330	0,018		
	N	512	509	511	512	
Consultants	Correlation	-0,00	0,14	0,044	0,19	1.0
	Significance	0,944	0,001	0,33	0,00	
	N	510	507	509	508	510

Table A2: Spearman's Rho correlation for relationships at the stage of completion

		Competitors	Suppliers	Customers	Universities	Consultants
Competitors	Correlation	1.0				
	Significance					
	N	511				
Suppliers	Correlation	0,14	1.0			
	Significance	0,001				
	N	509	514			
Customers	Correlation	0,28	0,10	1.0		
	Significance	0,00	0,025			
	N	510	513	517		
Universities	Correlation	0,08	-0,03	0,12	1.0	
	Significance	0,088	0,50	0,008		
	N	506	506	508	508	
Consultants	Correlation	0,09	0,08	0,043	0,09	1.0
	Significance	0,045	0,075	0,329	0,056	
	N	509	509	511	507	512