ORGANIZING NPD NETWORKS FOR HIGH INNOVATION PERFORMANCE: THE CASE OF DUTCH MEDICAL DEVICES SMEs

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This research examines which combination of network characteristics (the network configuration) leads to high innovation performance for small and medium sized companies (SMEs). Even though research has paid significant attention to the relation between the external network and the innovation performance of SMEs, research has not yet clearly demonstrated which configurations most affect innovation in particular contexts. The context of the research is the Dutch medical devices sector. This sector is selected because collaboration with external partners for new product development means becomes increasingly important due to the complexity of the products and the fragmentation of the market. In addition the sector is characterized by very strict regulations. These regulations are the cause of the time and cost consuming product development process.
In triangulation with quantitative survey data (N=60), qualitative data was gathered through semi-structured interviews in these same companies (N=50), which resulted in a response rate of 61,9%. The systems approach was used to construct the successful network configuration that is related to high innovation performance. By using this approach we are able to simultaneously address multiple network characteristics. Correlation statistics between the Innovation Performance and the Euclidean Distance showed that the more a companies' network configuration differed from the successful network configuration, the lower the Innovation Performance of that company. Contrary to what we hypothesized from literature, the results of the social systems approach indicate that the network configuration that is related to high innovation performance includes high levels of resource complementarity and goal alignment, and low levels of trust and network position strength. Instead of the social way of networking, both our quantitative and qualitative findings show that a "businesslike" approach which is focused and consistent is related to high innovation performance.

INTRODUCTION

For successful New Product Development (NPD) SMEs[1] see themselves confronted with the need to collaborate (Karlsson and Olsson 1998, Rogers 2004). This need is caused by the fact that on the one hand, SMEs need to innovate to compete (Hanna and Walsh 2002, O'Regan et al. 2006) but on the other hand they also need to focus on their core competences for efficiency matters. This focus on core competences (Penrose 1959) inherently means that SMEs cannot do everything themselves. The question that remains unanswered is "how to organize, from the perspective of the SME, the interaction pattern between the SME and its external partners in the egocentric network[2], in order to achieve high innovation performance?"

What we know from previous research is that collaboration positively influences NPD and the innovation performance which is the result of NPD. For example Branzei and Thronhill (2006) conclude that diverse networks increase the positive payoffs of internal innovation capabilities (Branzei and Thornhill 2006). Furthermore, Teece (1989) states that the successful commercialization of technology often requires collaboration among horizontal competitors that have different capabilities (Teece 1989). Especially in the field of new product development networking activity becomes more and more popular as cooperation with other organizations increases the innovation performance of organizations (Ritter and Gemünden 2003, Ritter and Gemünden 2004, Hanna and Walsh 2002, Rothwell 1991, Chang 2003, Salman and Saives 2005). However, practice shows that numerous alliances fail in practice (Duysters et al. 1999, Spekman et al. 1996, Sadowski and Duysters 2008, Faems et al. 2005), mainly due to negative prospects and negative perceptions (Sadowski and Duysters 2008), differences in cognition, conflicting interests, differences in timing of contributions

(Mahnke and Overby 2008), opportunistic hazards, and managerial complexity and uncertainty (Park and Ungson 2001). However, up to this moment, research has not yet clearly demonstrated which combination of network variables (i.e. the network configuration) most affect innovation in particular contexts (Pittaway et al. 2004). Therefore, the objective of this research is to examine which combination of network characteristics (the network configuration) leads to high innovation performance.

The setting of this research is the Dutch medical devices sector. This sector was selected for data gathering because collaboration with external partners for new product development means becomes increasingly important due to the complexity of the products and the fragmentation of the market (Atun et al. 2002, MacPherson 2002, Prabhakar 2006). In addition the sector is characterized by very strict regulations. These regulations are the cause of the time and cost consuming product development process (Kaplan et al. 2004, Atun et al. 2002, MacPherson 2002). As Langerak and Hultink (2006) we focus on a single industry to rule out possible confounding effects due to unmeasured industry level factors.

This research contributes to theory as it addresses multiple network characteristics simultaneously in relation to innovation performance instead of focusing on individual network characteristics as past research did. In addition we use the systems approach (Drazin and Van de Ven 1985) instead of cluster analysis to examine the successful combination of network characteristics. Focusing on multiple network characteristics in combination and applying the systems approach leads to new insights in the external organization of new product development (NPD). In addition, the research contributes to practice by offering SMEs a guideline in organizing their NPD network,. This not only improves the innovation performance of the SME, but it also improves the innovativeness of the medical devices sector as a whole.

To answer our research question "how to organize, from the perspective of the SME the interaction pattern between the SME and its external partners in the egocentric network, in order to achieve high innovation performance?" we constructed hypotheses based on theory in section 1 of this paper. Section 2 describes the methodology which includes the research context (§2.1) and sample (§2.2), the research method of the social systems approach (§2.3) and the operationalization of variables (§2.4). The results of the quantitative data analysis (§3.1) which are complemented by a qualitative data analysis (§3.2) are described in section 3. In addition, section 4 discusses the research results. Section 5 presents the research limitations and suggestions for further research. Finally, the concluding remarks can be found in section 6.

1. THEORETICAL FRAMEWORK AND HYPOTHESES

The theoretical framework covers literature on the relation of several network characteristics in relation to innovation performance. We start by briefly introducing and defining the concept of Innovation Performance (§1.1) after which we elaborate on the relation between Innovation Performance and network characteristics and construct the research hypothesis. Prior research has frequently considered the effect of firm network characteristics on innovation performance. A literature study on the network characteristics that are most often used in research in relation to innovation performance indicated that the network characteristics "resource complementarity" (§1.2), "trust" (§1.3), "network position strength" (§1.4), "distrust" (§1.3), and "goal alignment" (§1.5) are most often used (Pullen et al. forthcoming 2010b). Therefore we use these characteristics in this research.

1.1. Innovation Performance

In this research the definition of innovation proposed by Afuah (1998) is used, which states that in the field of high technology innovation is invention + commercialization (Afuah 1998). Garcia and Calantone (2002) align with this definition as they state that innovation is ‘‘an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention’’ (Garcia and Calantone 2002).
The performance that is achieved as a result of new product development is the innovation performance (Salomo et al. 2007). For this research a measure of innovation performance which is not bound to a certain time span and which is also applicable at the project level is needed. Such a measure is developed by Atuahene-Gima, Slater, and Olsen (2005; 2007) who present a measure for product innovation performance which focuses on whether the product development objectives were achieved. (Atuahene-Gima et al. 2005). Therefore we use the innovation performance measure of Atuahene-Gima et al. (2005)

1.2. Resource Complementarity

In relationships between companies the physical and organizational resources of the company are exchanged and combined with those of its counterparts in order to achieve the set goals (Haythornthwaite 1996, Tichy et al. 1979). Firms are encouraged to innovate by searching out new resources, or new ways of using existing resources, as the basis for future organizational rents (Galunic and Rodan 1998, Håkansson 1989, Oerlemans et al. 1998). Such resources will fuel the firm’s innovative activities by providing the external information necessary to generate new ideas. Equally, the innovative work of the firm will benefit from access to new knowledge necessary to resolve design and manufacturing problems (Tsai 2001). Simply having resources is not enough to produce innovative output. It is also the way these resources are utilized in the innovation process, which determines whether innovative outputs are produced in an effective and efficient way (Oerlemans et al. 2001). In fact, the innovation effects of resource exchange in NPD collaborations can be located at two levels. First, the adaptation of external resources leads to an extension of firms’ technological capabilities of developing new products. Second, the implementation of additional capacities from outside raises the probability of realizing innovations (Becker and Dietz 2004).

The resources of the companies are affected, both in terms of how they are used and how they develop (Gadde et al. 2003).
Lambe et al (2002) distinguish between resources that are developed and resources that are used in external collaboration: idiosyncratic and complementary resources. Idiosyncratic resources are developed during the life of the collaboration, are unique, and facilitate the combining of resources contributed by the partner firms. Complementary resources are defined as the degree to which firms in an alliance are able to eliminate deficiencies in each other’s portfolio of resources by supplying distinct capabilities, knowledge, and other entities (Lambe et al. 2002). Since both resource types should be present as they affect the success of the external collaboration (Lambe et al. 2002), we use the measure for complementary and idiosyncratic resources of Lambe et al. (2002)

1.3. Trust

Trust is defined as the belief that the results of somebody’s intended action will be appropriate from our point of view (Nahapiet and Ghoshal 1998). Trust is necessary for people to work together on common projects, even if only to the extent that all parties believe they will be compensated in full and on time (Leana and Van Buren III 1999). Faems et al (2008) distinguish between competence trust, which is defined as encompassing positive expectations about a partner’s ability to perform according to an agreement, and goodwill trust, which is defined as the partner's intention to perform according to an agreement. They find that competence trust is a crucial condition for subsequent transactions and goodwill trust is found to be a condition that determines how contracts are applied (Faems et al. 2008). Trust that builds up over time may in itself lead to unforeseen benefits, even when the expected gains are not fully realized over a given time period. Trust is an important factor in determining commitment, over and above any strict cost-benefit accounting, particularly among small and medium sized producers (Suarez-Villa 1998). Some element of trust will be required for any transaction in which simultaneous exchange is unavailable to the parties (Ring and Van de Ven 1992) as in new product development. We are interested in the level of trust between the focal SME and its external partners. Gulati & Sytch (2008) investigate the formation of trust between firms. To measure interorganizational trust we use the measure of Gulati & Sytch (2008).

1.4. Network Position Strength

Even though the extensive body of literature concerning network characteristics repeatedly indicates the importance of the structure of the network in terms of the presence of structural holes (Burt 1992b), the density of the network (Burt 1992b, Gilsing and Nooteboom 2005) and the size of the network (Borgatti et al. 1998) in relation to innovation performance it lacks a solid measure to measure the structure of the ego network. Therefore, based on literature, a measure for "network position strength" was developed (Pullen et al. forthcoming 2010b). "Network position strength" includes the items "density", "size", and "structural holes" (Pullen et al. forthcoming 2010b).

Density is the number of actual links in the network as a ratio of the number of possible links in the network (Kerssens-VanDrongelen and Groen 2004, Haythornthwaite 1996, Burt 1992a, Borgatti et al. 1998, Inkpen and Tsang 2005, Liao and Welsch 2005, Nahapiet and Ghoshal 1998, Tichy et al. 1979, Rowley 1997). As density increases, communication across the network becomes more efficient. Furthermore as interorganizational linkages become more dense, behaviors become more similar across the network, and the likelihood that shared behavioral expectations will be established increases (Rowley 1997). Irrespective of one's position, high density inhibits the existence and utilization of diversity, and hence of novelty value, while at low levels it does not support absorption sufficiently (Gilsing et al. 2008).

When ego occupies a structural holes position in the network, ego is able to broker connections between alters in his network (Burt 1992a, Haythornthwaite 1996). In an ego network, ego is connected to every other actor (by definition). If these others are not connected directly to one another, ego may be a "broker" if ego falls on the paths between the others (Hanneman and Riddle 2005). Firms occupying the favored network position of bridging structural holes are likely to perform better because of the their superior access to information (Burt 1992b, Zaheer and Bell 2005). Actors in a network rich in structural holes will be able to access novel information from remote parts of the network, and exploit that information to their advantage (Burt 1992b, Burt 2001, Burt 2004). Consequently, networks rich of structural holes are more likely to yield new information, which can lead then to the discovery of entrepreneurial opportunities (Arenius and De Clerq 2005).

The size of the network is determined by the number of alters that an ego is directly related to (Koka and Prescott 2002, Kerssens-VanDrongelen and Groen 2004, Borgatti et al. 1998, Tichy et al. 1979).

1.5. Goal Alignment

Value, in terms of innovation performance, can be created through cooperation and knowledge sharing (Inkpen and Tsang 2005). When the objectives and strategies of an alliance are clearly stated, a foundation of common understanding and the means to achieve

the collaborative purpose is established among the partners. Subordinating cooperation to strategic goals can provide longer-term horizons for the alliances, compared with circumstantial cooperative outsourcing, even when an alliance is structured to deal with specific projects of a pre-determined duration (Suarez-Villa 1998).
Goal alignment is the degree to which every pair of individuals has clearly defined expectations about each other's behavior in the relation (Tichy et al. 1979), or the degree to which network members share a common understanding and approach to the achievement of network tasks and outcomes (Inkpen and Tsang 2005). When partners have contradicting or inconsistent goals, inter-partner conflicts may arise. This is not conducive to the flow of knowledge between the partners and the alliance. For goal alignment Bourgeois III (1980) uses the term goal consensus. In his research on goal consensus Bourgeois III (1980) concludes that a coalition of strategy makers cannot focus on alternative means without a clearly conceived set of goals in mind. Therefore goals agreement is paramount/ predominant. Dess (1987) builds on the research and questionnaire of Bourgeois (1980). He finds that consensus on competitive methods has an important relationship to performance. We adopt the measure of Dess (1987) to measure goal alignment.

The literature on network characteristics as described above, states that all these network variables when considered separately are related to innovation performance. The focus on one or more network characteristics in solitude in relation to innovation performance leads to a form of reductionism (Drazin and Van de Ven 1985), as 1) real-life organizations and networks consist of multiple characteristics in combination, and 2) the interaction between the variables is ignored which might lead to different research results. This form of reductionism can be overcome by addressing the characteristics of organizations in combination (Miller and Friesen 1982). The network characteristics in combination, or in other words the network configuration, must be taken into account when analyzing technological networks. In their research on the underlying structure of network characteristics and innovation performance, Pullen et al. (forthcoming 2010a) find that the network characteristics in solitude do not have a direct main effect on innovation performance. However the interaction effect of the network characteristics has a direct significant effect on innovation performance (Pullen et al. forthcoming 2010a). However research has not yet clearly demonstrated which configurations most affect innovation in particular contexts (Pittaway et al. 2004). In the context of SMEs in the medical devices sector we hypothesize that:

H1: The network configuration of SMEs that is related to high innovation performance in the medical devices sector includes high levels of resource complementarity and trust, a strong network position, and a high level of goal alignment.

The variables that are included in the hypothesis and their hypothesized relations are visualized in the research model below.

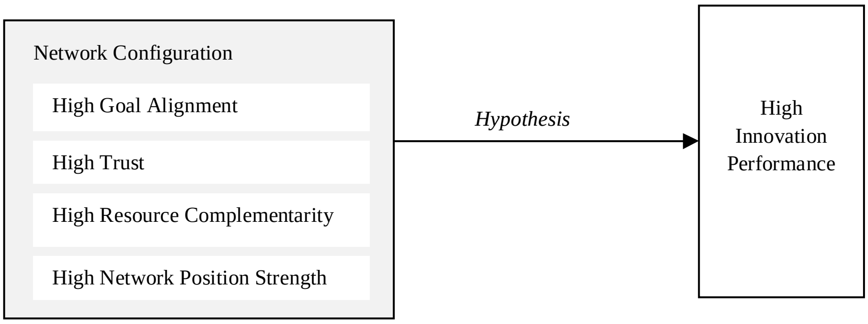

Figure 1: Research Model

2. METHODOLOGY

This methodology section first explains more in-depth why the medical devices sector was selected as research context (§2.1). Second, it describes the sampling and datagathering process (§2.2). §2.3 describes the operationalization of variables we conducted to test the validity of the self-administered questionnaire. The research method of the systems approach is described in §2.4.

2.1. Research Context

The context of the research is the Dutch medical devices sector[3]. This sector was selected, because collaboration with external partners for new product development becomes increasingly important due to the complexity of the products and the fragmentation of the market. 80% of the companies in this sector are SMEs and based on theory and in line with earlier research we assume that they need to cooperate with external partners to share resources for the development of new products (Prabhakar 2006, Biemans 1989, Millson and Wilemon 2000). In addition the sector is characterized by very strict regulations (Kaplan et al. 2004). Mainly due to these regulations which cause a very time- and cost consuming new product development process (Kaplan et al. 2004, Nieto and Santamaría 2010) SMEs in the medical devices sector face the problem of a lack of financial resources and a lack of qualified personnel in their NPD process. This makes it necessary for them to cooperate (Kaufmann and Tödtling 2002, Rogers 2004). In addition, the intense competition, high rate of growth, continuing technological innovation, and customer sophistication suggest a significantly above average level of new product development activity (Rochford and Rudelius 1997).

2.2. Data gathering and Sample

The data gathering has taken place during the autumn and winter of 2009. Through a telephone pre-survey among 751 Dutch medical devices companies, companies that actively participate in the development of new medical devices and that have less than or equal to 250 Full Time Equivalents were identified as suitable companies to participate in the research. In this telephone pre-survey also key respondents were identified, the purpose of the research was explained and the potential respondents were asked to participate in the research. A total of 105 suitable companies were identified. A total of 97 potential respondents indicated that they were willing to cooperate with the research. They received a personalized letter explaining the purpose of the study, along with a questionnaire by e-mail. The questionnaire could be filled-in electronically and returned by e-mail. Non-respondents received reminder telephone calls and a second questionnaire. Respondents were new product development managers, R&D Managers, CTO's and CEO's. These efforts yielded 60 usable responses, giving a response rate of 61,9% percent (see Table 1).
In triangulation with quantitative survey data, also qualitative data was gathered through semi-structured interviews in 50 of these same companies. Gathering both quantitative and qualitative data enriches the data to a large extent

		Frequency	Percent	**Cumulative Percent**
Valid	filled-in questionnaire	13	13,4	13,4
	filled-in questionnaire + interview	47	48,5	**61,9**
	withdrawn participation	37	38,1	100,0
	Total	97	100,0	

Table 1: Response rate of the sample

2.3. Research method

To examine which combination of network characteristics leads to high innovation performance we use the systems approach of Drazin and Van de Ven (1985). The systems approach examines the impact of the network characteristics taken as a set on innovation performance by calculating the distance from an ideal profile (Govindarajan 1988). This ideal profile is in the context of this research the combination of network characteristics that is related to high innovation performance (i.e. the successful network configuration). The successful network configuration of design variables can be generated either theoretically or empirically. As Drazin and Van de Ven (1985), we chose to use the empirical-based successful network configuration.

Next to this quantitative data analysis we use qualitative interview data in triangulation to verify and complement the quantitative data results.

2.4. Operationalization of Variables

This section describes the operationalization and validity of the variables “innovation performance”, “goal alignment”, “trust”, “resource complementarity” and “network position strength”. In addition, the research method is of the social systems approach is described.

Innovation Performance

The measure of Atuahene-Gima, Slater and Olsen (2005) to measure innovation performance was used. Innovation performance was measured through 5 items on a 7-point Likert scale . After factor analysis (see “Questionnaire Validity” in this section) the factor scores of innovation performance were used in the analyses. The 15% of companies with the highest factor scores for innovation performance together formed the “successful configuration sample (top 15%)” (N=7). The other 85% of companies together formed the “calibration sample (bottom 85%)”.

Network Characteristics

From literature we extracted 4 network characteristics (a total of 19 items) that are suggested to have a relation to the companies’ innovation performance (Pullen et al. forthcoming 2010b). We used the measures of Lambe et al (2002) to measure the level of idiosyncratic and complementary resources. The items were measured on a 7-point Liker scale ranging from “Not true at all” to “Very True”. To measure “trust”, Gulati and Sytch’s (2008) measure of “trust” was used. The measurement consists of 6 items that are all measured on a 7-point Likert scale ranging from “Disagree strongly” to “Agree Strongly” (Gulati and Sytch 2008). The measurement of “goal alignment” of Dess (1987) was used, which uses the sum of the standard deviations between ego’s goals and the goals of its external partners (Dess 1987).

To measure “network position strength” a measure was developed by Pullen et al. (forthcoming 2010b) in which respondents are asked to indicate the direct relations between the partners in the network in a matrix. Based on this matrix UCINET (Borgatti et al. 2002) iss able to compute the values of density, structural holes position, and network size, which together build the measurement for the “network position strength”.

After factor analyses (see “Questionnaire Validity” below) the mean scores of the full sample (N=59) on the network characteristics are 0, since the scores of the network characteristics are factor scores. As a consequence the standard deviations of each network characteristic for the full sample are all 1. Mean scores of network characteristics above 0 are considered “high” and scores below 0 are considered “low”.

	Component					
	1 Resource Complementarity	**2 Innovation Performance**	**3 Trust**	**4 Network Position Strength**	**5 Distrust**	**6 Goal Alignment**
Q19.6_IfPartnerSwitchInvestmentsWasted	,836					
Q19.1_CreatedUniqueCapabilities	,807					
Q19.3_TogetherInvestedInBuildingBusiness	,806					
Q19.4_TogetherInvestedInRelationship	,798					
Q19.2_TogetherDevelopedKnowledge	,794					
Q19.5_IfEndedKnowledgeWasted	,734					
Q20.1_ContributeDifferentResources	,708					,472
Q20.3_SeparateAbilitiesCombined	,708		,438			
Q20.2_ComplementaryStrengths	,619					
Q8.3_ReturnAssets_Objective		,891				
Q8.4_ReturnInvestment_Objective		,874				
Q8.5_Profitability_Objective		,868				
Q8.2_Sales_Objective		,864				
Q8.1_MarketShare_Objective		,811				
Q25.2_ConfidentialityOfInformation			,879			
Q25.1_TreatYouFairly			,852			
Q25.3_PartnersAlwaysEvenHanded			,746			
Ties_Brokered_normalized				,911		
Density				-,828		
Network_Size				,721		
Q25.5_Inv_CannotCompletelyRelyOnPromises					,847	
Q25.4_Inv_ProfitAtYourExpense					,796	
Q25.6_Inv_HesitantVagueSpecifications					,767	
Goal_Alignment						-,830
Eigenvalue	**6,97**	**3,96**	**2,47**	**2,09**	**1,66**	**1,12**
% Variance explained	**29,04**	**16,51**	**10,31**	**8,72**	**6,93**	**4,68**
Cronbach's α	**0,925**	**0,923**	**0,886**	**0,815**	**0,750**	**x**
# items	**9**	**5**	**3**	**3**	**3**	**1**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Table 2: Factor analysis results

Questionnaire Validity

Since not all measures were directly extracted from literature, nor previously tested in combination, an exploratory factor analysis was conducted. Factor analysis on the 4 network characteristics and innovation performance (excluding innovativeness since this is a categorical variable) indicated that the 24 items in the questionnaire together build six constructs (Innovation Performance and five network characteristics) (see Table 2) that together explain 76,19% of the variance (Pullen et al. forthcoming 2010b). Items with loadings greater than 0,40 on a factor are considered significant. As can be seen in Table 3 there are two items (Q20.1 and Q20.3) that load on more than one factor. There is some disagreement in literature about what to do when items load on multiple factors. Kline (2000) suggests to drop the items that load on multiple factors, because they are difficult to interpret (Kline 2000). However Hair et al. (1995) argues that the meaning of an item must be taken into account when assigning labels to a factor (Hair et al. 1995). In line with Hair et al. (1995) Pett et al. (2003) suggest placing the item with the factor it is most closely related to conceptually instead of dropping the item. They argue that reliability tests of the factors will show the internal consistency of a factor and will also indicate whether or not reliability of a factor will increase by dropping an item (Pett et al. 2003). As Hair et al. (1995) and Pett et al.

(2003) we do not drop the items with multiple (significant) factor loadings, rather we assign the item to the factor it is most closely related to and use reliability test for internal consistency. All six constructs had high reliabilities, and high Eigenvalues. In some cases the grouping of the items differs from literature. This might be explained by the fact that literature focuses on each of these network characteristics individually, whereas we focus on these network characteristics in combination.

3. RESULTS

This section describes the research results of both the quantitative data analysis (social systems approach) which tests our hypothesis (§3.1), and the qualitative data analysis (§3.2) which is used to complement and clarify the quantitative data results.

3.1. Quantitative data analysis

The empirical-based successful network configuration consists of the best performing 15% of companies (top 15%) in terms of Innovation Performance[4]. The other 85% of companies in the sample is the calibration sample. Table 3 below shows the mean scores[5] of the five network characteristics for both the successful network configuration sample and the calibration sample. The mean scores of the top 15% best performing companies is considered as the empirical-based successful network configuration.

	SampleInnovationPerformance	Mean	Std. Deviation	N
FAC1_2ResourceComplementarity	Calibration Sample (bottom 85%)	-,0374675	1,02977594	51
	Successful network configuration Sample (top 15%)	,2729774	,75109526	7
	Total	,0000000	1,00000000	58
FAC3_2Trust	Calibration Sample (bottom 85%)	,0438780	1,04397646	51
	Successful network configuration Sample (top 15%)	-,3196824	,53105098	7
	Total	,0000000	1,00000000	58
FAC4_2NetworkPositionStrength	Calibration Sample (bottom 85%)	,0018533	1,01170593	51
	Successful network configuration Sample (top 15%)	-,0135023	,98497919	7
	Total	,0000000	1,00000000	58
FAC5_2Distrust	Calibration Sample (bottom 85%)	-,0340582	,99872564	51
	Successful network configuration Sample (top 15%)	,2481384	1,05175950	7
	Total	,0000000	1,00000000	58
FAC6_2GoalAlignment	Calibration Sample (bottom 85%)	-,0489618	1,02477099	51
	Successful network configuration Sample (top 15%)	,3567219	,76149048	7
	Total	,0000000	1,00000000	58

Table 3: Descriptive statistics for the Ideal Profile (top 15%) and the Calibration Sample (bottom 85%)

The next step was to calculate the Euclidean Distance for each case which is the difference between the successful network configuration and the network configuration of an individual case company. The Euclidean distance was calculated as follows: Euclidean Distance = $\sqrt{\Sigma(X_{is} - X_{js})^2}$, where X_{is} is the score of the successful network configuration on the s^{th} network characteristic and where X_{js} is the score of the j^{th} case company on s^{th} network characteristic (Drazin and Van de Ven 1985).

After calculating the Euclidean Distance for all cases in the sample this distance measure was correlated with the innovation performance measure to test the pattern approach to contingency theory. Table 4 shows the correlation between the Euclidean Distance and the Innovation Performance.

		FAC2_2Innovation Performance	EuclideanDistance
FAC2_2InnovationPerformance	Pearson Correlation	1,000	-,305*
	Sig. (2-tailed)		,020
	N	58,000	58
EuclideanDistance	Pearson Correlation	-,305*	1,000
	Sig. (2-tailed)	,020	
	N	58	58,000

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

Table 4: Correlations

Euclidean Distance correlates -0,305 (p<0,05) with Innovation Performance. The results indicate that as the network configuration (i.e. the combination of network characteristics) of a company differs more from the successful network configuration (i.e. the Euclidean distance increases), the Innovation Performance will decrease. In other words, the more the combination of network characteristics is similar to the successful network configuration of the top 15% best performing companies, the higher the Innovation Performance of the company will be. In addition these results show significant support for the systems approach in the context of networks in new product development.

Table 5 shows the mean scores of the top 15% performing companies on the network characteristics. As described in §2.4 (operationalization) are scores above 0 considered “high” and scores below 0 considered “low”. As the last column in table 5 shows can the successful network configuration be described as one having high levels of “resource complementarity”, “distrust” and “goal alignment”, and low levels of “trust” and “network position strength”.

	N	Minimum	Maximum	Mean	Std. Deviation	**Level**
FAC1_2ResourceComplementarity	7	-,65443	1,39224	,2729774	,75109526	**High**
FAC3_2Trust	7	-1,27900	,24147	-,3196824	,53105098	**Low**
FAC4_2NetworkPositionStrength	7	-1,63854	,93432	-,0135023	,98497919	**Low**
FAC5_2Distrust	7	-1,02712	1,59827	,2481384	1,05175950	**High**
FAC6_2GoalAlignment	7	-1,16537	1,13650	,3567219	,76149048	**High**
Valid N (listwise)	7					

Table 5: Successful Network Configuration

The network configuration of the calibration sample (the bottom 85%) is the inverse of the successful network configuration (see table 6). This network configuration, that is related to a lower level of Innovation Performance, has low levels of “resource complementarity”, “distrust” and “goal alignment”, and high levels of “trust” and “network position strength”.

	N	Minimum	Maximum	Mean	Std. Deviation	**Level**
FAC1_2ResourceComplementarity	51	-2,67224	1,31463	-,0374675	1,02977594	**Low**
FAC3_2Trust	51	-3,33155	1,90883	,0438780	1,04397646	**High**
FAC4_2NetworkPositionStrength	51	-2,00956	1,88500	,0018533	1,01170593	**High**
FAC5_2Distrust	51	-2,50056	2,71374	-,0340582	,99872564	**Low**
FAC6_2GoalAlignment	51	-2,14984	2,46205	-,0489618	1,02477099	**Low**
Valid N (listwise)	51					

Table 6: Network configuration of the Calibration Sample

The contents of the successful network configuration (table 5) show that the top 15% best performing companies have a clear focus and are functional when it comes to collaboration with other companies. They collaborate only when their goals and the goals of the partner firm are aligned and if the partner firm is able to offer the resources that the company initially lacks. Instead of trusting the partner firm blindfolded, the company has a certain level of distrust towards the partner firm. The network of the company consists of a limited number of partners (small size) and, in addition, these partners are not directly connected to each other (low density). Even though the company occupies the structural holes position, its network position strength is low due to the small size and the low density. These companies are very focused, functional and consistent in collaborating for new product development.
In contrast, the lower performing companies express high levels of trust towards their partners. Also, partners in the network know each other. It seems that they rather select partners based on trust, than on more objective selection criteria like the complementarity of resources. These lower performing companies are far more shifty and devious than the straight and focused high performing companies.
These findings do not support our hypothesis in which we stated that the successful network configuration included high levels of resource complementarity and trust, a strong network position and a high level of goal alignment. Rather we find a low level of trust and a low level of network position strength included in the successful network configuration.

3.2. Qualitative data analysis

To complement and clarify these quantitative results and, we conducted semi-structured interviews with companies in both the top 15% sample and the bottom 85% sample. In general, the top 15% best performing companies do not deliver their products to the end-market (see table 7). In case of the medical devices industry this end-market most of the time consists of hospitals and other health care institutions. Rather they deliver their products to distributors. Instead of the company having to deal with the difficult commercialization of medical devices to the end-market, the distributor deals with these difficulties like negotiations with health care insurance companies. For the company this a more efficient sales strategy than direct sales to health care institutions.

			DeliveryToEndMarket			
			Yes	No	Mixed	Total
Sample	Calibration sample (Bottom 15%)	Count	12	19	7	38
		% within Sample	31,6%	50,0%	18,4%	100,0%
	Successful network configuration (Top 15%)	Count	1	5	0	6
		% within Sample	16,7%	83,3%	,0%	100,0%
	Total	Count	13	24	7	44
		% within Sample	29,5%	54,5%	15,9%	100,0%

Table 7: Position of companies from both samples in the supply chain with regard to end market delivery

Table 8 shows that for the majority of companies in the calibration sample (59,5%) the NPD project is initiated by the company itself. In contrast, in only 33,3% of the top 15% best performing companies the project is initiated internally. In the majority of the top 15% best performing companies the company is approached by an external company who is not able or not willing to execute the NPD process itself. By not internally initiating the NPD project, but by executing the NPD project "on demand", the top 15% best performing companies guarantee their external revenues from the NPD project.

			SourceNPDProject				
			Client Order (external)	Development Order (external)	Physician (external)	Company (internal)	Total
Sample	Calibration sample (Bottom 85%)	Count	10	1	4	22	37
		% within Sample	27,0%	2,7%	10,8%	59,5%	100,0%
	Successful netwok configuration (Top 15%)	Count	3	1	0	2	6
		% within Sample	50,0%	16,7%	,0%	33,3%	100,0%
	Total	Count	13	2	4	24	43
		% within Sample	30,2%	4,7%	9,3%	55,8%	100,0%

Table 7: Initiation sources of the NPD project

As table 8 shows, the attitude that these companies have towards their partners in the NPD project is far more business-like than the attitude that the lower performing companies have. The top 15% best performers use a focused strategy in contacting their partners with specific resource requests. It is rather a customer-supplier relationship than a collaborative relationship. The lower performing companies are far more collaborative towards their NPD partners. Not only are partners consulted, they also share ideas in NPD and are developing the new product together. Often IP is shared.

			AttitudeTowardsPartners		
			Business-like	Collaborative	Total
Sample	Calibration sample (Bottom 85%)	Count	17	22	39
		% within Sample	43,6%	56,4%	100,0%
	Successful network configuration (Top 15%)	Count	3	2	5
		% within Sample	60,0%	40,0%	100,0%
	Total	Count	20	24	44
		% within Sample	45,5%	54,5%	100,0%

Table 8: Attitude towards partners

4. DISCUSSION

We began by observing that cooperation with other organizations increases the innovation performance of organizations (Ritter and Gemünden 2003, Ritter and Gemünden 2004, Hanna and Walsh 2002, Rothwell 1991, Chang 2003, Salman and Saives 2005). Especially for SMEs, as they are bounded by a lack of financial resources, manpower and substitutes for lack of sales (Kaufmann and Tödtling 2002, Hanna and Walsh 2002). We examined which combination of network characteristics (the network configuration) is related to high innovation performance and we thereby address the issue raised by Pittaway et al. (2004) who state that research has not yet clearly demonstrated which configurations most affect innovation in particular contexts.

We used the systems approach to examine which network configuration is related to high innovation performance. Using the systems approach we were able to address multiple network characteristics simultaneously which led to new insights in the successful external organization of new product development.

Contrary to what we predicted we found that the successful network configuration includes high levels of resource complementarity and goal alignment and low levels of trust and network position strength, instead of high levels of all these network characteristics. The high performing companies have a businesslike mentality and are very focused and consistent in how they collaborate in NPD. The relation with their partners is almost like a customer-supplier relationship as the company contacts their partners with specific resource requests for which the partner is paid. Instead of trusting the partner firm blindfolded, the company has a certain level of distrust towards the partner firm. The network of the company consists of a limited number of partners (small size) and, in addition, these partners are not directly connected to each other (low density). In contrast, the lower performing companies are searching for partners with whom they can collaborate and build resources. Trust is considered crucial for these companies. Their approach to collaboration in new product development is more soft and subjective in comparison to the approach of the high performing companies. These results are in line with the findings of Lindman (2002) who finds that NPD can be highly successful regardless of the degree of cooperation (Lindman 2002). Even though past research argues that a social way of networking is related to high innovation performance, both our quantitative and qualitative findings indicate that a businesslike way of networking is related to high innovation performance.

An explanation for the fact that the businesslike, objective network configuration of the high performers is related to high innovation performance can be explained by the fact that the high performers face less risk in the NPD process. The NPD projects are most of the time initiated outside the company: the high performers develop new products on request which secures their NPD revenues. In addition by not trusting their partners blindfolded and by maintaining a businesslike relationship towards partners the risk of being deceived is minimized. As Duysters et al. (1999) concluded, effective technology partnering selection should involve an evaluation of the potential partner on the basis of that partner's competitive and technological position and access to business networks but also on its track record of successful partnerships and the transferability of desired resources (licenses, patents etc.) (Duysters et al. 1999).

An explanation for the fact that the successful network configuration is a businesslike configuration might be caused by the fact that companies in our dataset mainly focus on low (incremental) and moderately innovative new products. We assume that this is caused by the strict sector regulations. The average development time for medical devices ranges from 1-2 years for incremental devices and 5-7 years for radical devices, dependent on the product type, complexity, and degree of risk to the patient that dictates their regulatory defined conformance and approval route (Hourd and Williams 2008). Since the developed products are not highly innovative the SME can focus more on efficiency and routines instead of focusing on the early research and development stages. There is less need for the company to involve the partner in the development project. Rather, the company is able to pose a specific resource request. Also, because the company and the partner do not develop brand new products of which the market and competitors are unaware of, trust is not a prerequisite for collaboration. Resource complementarity and goal alignment are more important, which is in line with research of Oerlemans et al. (2001), Becker and Dietz (2004), Inkpen and Tsang (2005) and Suarez-Villa (1998).

5. LIMITATIONS AND FURTHER RESEARCH

Our study has some limitations that suggest a number of directions for further research. The companies in our dataset mainly focus on low to moderately innovative development projects. Even though we expect that companies that focus on highly innovative development projects do not achieve high innovation performance due to sector specific regulations, a direction for further research might be to gather additional data on these companies in order to examine their innovation performance and related network configuration.

We showed how the network configuration that is related to high innovation performance for SMEs in the medical devices sector is organized. A suggestion for further research is to conduct a cross-industry study in multiple highly regulated sectors for generalizability of the research findings.

A final suggestion for further research is to examine the interaction between the network characteristics in relation to the innovation performance. Earlier research showed that the interaction between network characteristics (the network configuration) is directly related to innovation performance (Pullen et al. forthcoming 2010a). In this research we demonstrated which configuration of network characteristics is related to high innovation performance for SMEs in the medical devices and thereby addressed the issue of Pittaway et al (2004). It was out of the scope of this research to also examine how the different network characteristics are related to each other and how they interact. Further research might address this issue.

6. CONCLUDING REMARKS

We argued that the successful network configuration of SMEs in the medical devices sector consists of high levels of resource complementarity, trust, network position strength, and goal alignment. Using the context of SMEs in the Dutch medical devices sector, we show that the a network configuration that includes high levels of resource complementarity and goal alignment, but low levels of trust and network position strength is related to high innovation performance.

In line with both our quantitative and qualitative research findings, we argue that a “soft and friendly” approach towards external NPD collaboration in which trust is an important prerequisite is not related to high innovation performance. Rather a more “businesslike” approach which is focused and consistent is related to high innovation performance.

Managers of SMEs in the medical devices sector that aim to achieve high innovation performance, should use objective criteria to select partners. Partner selection should not be mainly determined by trusting a partner. Developing new products “on demand” is a more effective way to achieve high innovation performance than by initiating NPD projects internally. Even though the latter is often associated with high firm innovativeness in a highly

regulated sector like the medical devices sector it is not related to high innovation performance.
In conclusion, SMEs in the medical devices sector should aim for a businesslike organized network configuration that includes high levels of resource complementarity and goal alignment with development partners, a low network position strength and in which partners are not trusted blindfolded in order to achieve high innovation performance.

NOTES

[1] According to European standards, SMEs are defined as companies that have 250 or fewer fulltime employees (Commission of the European Communities 2003. 'Commission Recommendation of 6 May 2003 Concerning the Definition of Micro, Small and Medium-Sized Enterprises *(notified under document number C (2003) 1422)* 2003/362/EC.' 36–42. Official Journal of the European Union.)

[2] There are many different types of social networks that can be studied. One can distinguish between one-mode networks which study just a single set of actors, two-mode networks which focus on two sets of actors, or higher mode networks Wasserman, S. & Faust, K. 1994. *Social network analysis: methods and applications.* New York: Cambridge University Press.. Another design is and ego-centered network which consists of a focal actor, termed ego, a set of alters who have ties to ego, and measurements on the ties among these alters Wasserman, S. & Faust, K. 1994. *Social network analysis: methods and applications.* New York: Cambridge University Press.. Since we take the perspective of the SME to analyze its network, we adopt the *ego-centered network perspective* in our research.

[3] According to medical device directive 93/42/EEC , a medical device is:*…any instrument, apparatus, appliance, material, or other article, whether used alone or in combination, including the software necessary for its proper application, intended by the manufacturer to be used for human beings for the purpose of a) Diagnosis, prevention, monitoring, treatment or alleviation of a disease, b)Diagnosis, monitoring, treatment or alleviation of or compensation for an injury or handicap, c)Investigation or modification of the anatomy or of a physiological process, or, d)Control of conception. And which does not achieve its principal intended action in or on the human body by a) Pharmacological, b)Immunological or c) Metabolic means, but which may be assisted in its function by such means.*

[4] The scores for Innovation Performance were factor scores

[5] The scores for network characteristics were factor scores

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