Organization of Inter-Firm Knowledge Flows in New Product Development

Paper prepared for EURAM 2002 in Stockholm, May 2002
Track: Managing the Knowledge-based Firm

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First preliminary draft – not to be quoted

Abstract:

This paper explores two questions; first, which relationships are relatively more important for New Product Development processes and through which mechanisms is knowledge transferred? Recent research has either focused on a general broad view relying on survey data or a more in-depth approach, which allows for detailed mapping of the underlying processes, but with no possibility of drawing more general conclusions. The data sources that are drawn upon in this study combines these two data sources. The findings show that relationships with external partners are important at the early stages of the product development processes, whereas in the later stages only competitors contribute positively to innovative success. Moreover, depending upon the organizational form different mechanisms and potential problems can be identified.

Key words: knowledge flows, organizational forms, innovative success, relationship marketing, new product development

SETTING THE SCENE

The recent focus on hyper-competition and the changed rules of competition are setting the existing organizational structures under pressure leading to reorganizations (Ilinitch, D'Aveni et al. 1996). Endorsement of network structures and extensive external relations is one such type of reorganization. Network structures, external relations or alliances can be characterised and analysed not just by their existence but by the content of the exchange within the relationship. Knowledge represents one such exchange, where the most critical knowledge source relates to new product development. This paper aims at exploring the relative importance of different types of inter-organizational relationships for new product development (NPD) processes in terms of more successful knowledge transfers yielding higher returns from innovation.

Despite the recent upsurge in research on both intra-firm and inter-firm knowledge transfer the development of methodologies for empirical studies has been left largely uncovered. The second aim of this paper is to draw on both case studies and questionnaire-based data in uncovering differences in ways of organizing inter-organizational knowledge flows in NPD and differences in the mechanisms of transferring knowledge. The methodological contribution lies in the combination of survey data with results from qualitative case studies to capture both the general trends and to combine them with the more detailed evidence.

The topics of this paper therefore spans the questions: which relationships are relatively more important for NPD processes, how is the knowledge characterised and through which mechanisms is it transferred?

LITERATURE REVIEW: ORGANIZATION AND CHARACTERISTICS OF KNOWLEDGE FLOWS

The subject of knowledge flows and the mediators and barriers to knowledge flows has attracted interest in recent years (Mangematin and Nesta (1999); Lane and Lubatkin (1998); Stock et. al. (2001)). Knowledge flows have originally been studied in the context of strategic alliances and networks (Inkpen (1998); Simonin (1999)), but has for instance also been applied to issues in internationalisation both at the firm level and in regional development (e.g. Gupta and Govindarajan

(2000); Kinder and Lancaster (2001)). The ease of knowledge transfer depends on several factors, where especially the notion of absorptive capacity has led to extensive research (Cohen and Levinthal (1989) and (1990)). Absorptive capacity is defined as the ability of the receiving partner to assimilate, value and utilise the transferred knowledge. A precondition for successful knowledge transfer is therefore a well-developed absorptive capacity. Irrespective of the popularity of the concept the empirical operationalisation of absorptive capacity has lacked clear definitions and indicators, which has resulted in dubious results.

A second factor influencing the ease of knowledge transfer is the characteristics of the knowledge to be transferred; is the knowledge of a complex and tacit type then the transfer requires face-to-face interaction remaining however burdensome (Rocha 1999). Another example is the transfer of tacit knowledge through different incentive systems, see e.g. Osterloh and Frey (2000). On the other hand, more codified knowledge forms like prototypes can more easily be transferred and likely at lower cost. A second dimension to consider is whether the knowledge is supplementary or complementary to that of the receiving firm. Supplementary knowledge is easier to transfer given the overlap in knowledge by the receiving and the transmitting firm, whereas complementary knowledge comprises a larger potential for learning and thus value creation, but a lower overlap (see e.g. Dussauge and Garette (2000), Echambadi et. al. (2001), Rothaermel (2001)). Thus, supplementary knowledge can be expected to provide a short term advantage, whereas the complementary assets may take longer to utilise depending on the absorptive capacity but also yield a longer term advantage.

However, successful knowledge transfer is not just about the knowledge type and the ability to absorb but also a matter of organizational form– in particular, we expect the reliance on certain types of relationships to be more important and others to act as barriers to knowledge flows. For instance is customer input input in the R&D process highly appraised neglecting 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 the completion of innovations. The external knowledge resources may therefore play different roles at different stages in the R&D process. The question is then what type of relationships can contribute with relevant knowledge at what stages of NPD? Then, once these relationships are established the question arises of what is transferred and how.

In the following section (*theoretical expectations*) the theoretical expectations and hypotheses are formulated. Then the survey and the methodological considerations are presented (*methodological considerations*) followed by two sections that presents respectively the results of the survey analysis (*organization of knowledge flows and innovative success*) and the case study results (*knowledge transferring mechanisms*). The final section concludes our findings (*conclusion*).

THEORETICAL EXPECTATIONS

Knowledge characteristics

Innovation ultimately creates a substantial part of firm performance and ever more so with increasing degrees of technological change. The normative prediction of just producing more innovations is problematic, because of the cost of performing R&D, the uncertainty in the discovery process and the path dependency aspects of creating new competencies. One way around these problems is to engage in inter-organizational relationships. The expected success of knowledge exchange depends on the stage in the innovation process; at earlier stages like idea generation supplementary knowledge may fit better with the mindset and support the process, whereas complementary knowledge is more likely to trigger diverse or unrelated ideas and thus not fit within the current context. Oppositely both types of knowledge may fit later in the process 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. Earlier views have merely dealt with the difference between supplementary and complementary knowledge exclusively see e.g. Dussauge and Garette (2000) paying no attention to where in NPD the knowledge was needed. Access to complementary knowledge resources may enable the creation of new competencies more easily and supplementary knowledge may result in a shortening of development times through utilisation of this knowledge. The first two expectations relate the knowledge characteristics to innovative success:

Absorption of *supplementary* knowledge at both early and late stages of the R&D process has a positive effect on the innovative success

Absorption of *complementary* knowledge at early stages in the R&D process has a negative effect on the innovative success, whereas absorption later in the process has a positive effect on innovative success.

Organizing knowledge flows

The creation of general experience with inter-organizational relationships is one argument that is usually given for achievement of successful knowledge flows (Child and Faulkner 1998). That is irrespective of the type of alliance, creation of agreements, management of alliances and frequent interaction with external partners are all ways of gaining relational experience (Kale, Singh et al. 2000 and Kale, Dyer et. al. 2002) that may be used in later relationship formations.

Participation in strategic alliances in general has a positive effect on innovative success.

And in a similar vein, it can be expected that:

Collaboration on product innovation has a positive effect on innovative success.

Moreover the success of inter-organizational knowledge flows may depend on the type of partner with which the knowledge is exchanged. For instance is it often mentioned that universities and public and private research institutes focus on more fundamental research projects with longer development duration and thus less likely immediate payoffs. On the other end of the extreme, customer involvement ensures highly application-oriented development projects with shorter duration. Suppliers may deliver invaluable insights into the integration of new modules and items that may have a very positive influence at early stages of the R&D process, whereas inputs at later stages may appear as a disturbance into the completion of the innovation. On the one hand, competitors may supply supplementary knowledge of high quality and immediate potential outcome, but why should they? In case knowledge flows are seen between competitors at later stages of the R&D process the effect is expected to be positive as the exchange is expected to be well-suited for the purpose and may thus lead to shorter development periods providing quicker access. Joint R&D projects between competitors at early stages of the R&D process are less likely as the contribution with knowledge for idea generation is a give away. Finally, the role of consultants is less clear; they provide technical knowledge for tailored projects and most often act as additional work force. A positive impact should thus be expected.

This leads to the following expectations:

Absorption of knowledge from *customers and consultants* are expected to give a positive effect at all levels of the R&D process

Absorption of knowledge from *universities and public and private research institutes* are expected to give a negative effect at all levels of the R&D process

Absorption of knowledge from *suppliers* is expected to give a positive effect at early stages and negative effect at later stages of the R&D process

Absorption of knowledge from *competitors* is expected to give a negative effect at early levels of the R&D process and a positive effect at later stages of the process.

In the following paragraph, a review of three characteristic organizational forms are presented. As these are surveyed using case studies exact hypotheses are not established; instead the general barriers or mediators of knowledge flows are discussed.

The *functional* form is based on functional grouping of similar activities under major functional managers with many layers of hierarchical control. The scope and flexibility of the knowledge absorption is rather limited whereas the advantage lies in the efficiency attained from economies of scale and skills. In relation to R&D these limited skills in knowledge absorption leads to problems for the production of new knowledge based partly on external knowledge sources.

The *disintegrated divisional form* highlights a certain degree of independence of the R&D unit from the other divisions. The R&D division is in itself flexible organised allowing for teams to be set up in response to new projects. It is expected that the problems of knowledge transfer primarily lies between the divisions, whereas knowledge flows from external relationships are facilitated. Moreover smooth follow up an evaluation through strict knowledge management procedures must be ensured. Finally, the collaborative form is strongly focused on existing relationships and the maintenance of these relations. The channels are well established and knowledge flows are therefore facilitated by trust, mutual working practices etc. However, the anticipated problems lie in the establishment of new relations and associated knowledge flows.

METHODOLOGICAL CONSIDERATIONS

The survey of European manufacturing industry on innovation related knowledge flows (Know) was carried out during 2000. Ten follow up case studies were subsequently carried out based on the preliminary survey results. To uncover the nature of knowledge flows in particular in inter-

organisational relationships the analyses draw on both data sources. The survey 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, 32, 64 and 72) and firms of size between 10 and 999 employees. In total the cleaned data set contains 558 firms. The organizational forms in the survey are based on the degree of reliance on cooperative relationships in the innovation process. To discuss the survey results in more depth the paper draws on 3 Danish case studies, which allows for identification of three organisational forms in R&D and the respective mechanisms for knowledge flows.

ORGANIZATION OF KNOWLEDGE FLOWS AND INNOVATIVE SUCCESS

In the following table the results of the stepwise backward regression analysis is presented. The purpose of the stepwise regression is to select from a large number of independent variables a subset of variables that account for most of the variation in the dependent variable. The cut-off points were set at 0.05 for inclusion into the model and 0.10 for exclusion from the model. The dependent variable[1] is innovative success measured as the percentage of a firms total sales that was caused by the most important innovation. Second, R&D intensity (RDintHR) measured as the share of employees in R&D to total number of employees and the science share (SCIENCE) measured as the number of employees with an engineering or natural sciences degree to the total number of employees are both included and expected to give a positive impact on the innovative success.

The results give support to a number of the stated hypotheses above. First of all, a general difference between the two models, idea generation and completion of innovation is clear. Especially for the completion of the innovation only few relationships are important; namely with competitors (positive) and suppliers (negative). Moreover both exchange of supplementary and complementary knowledge has a positive impact on innovative success. The final stage of the NPD process should therefore focus on finalising the innovation alone with only few contacts. For the original idea more diverse relationships are seen as important for innovative success.

[1] The dependent variable had a missing value rate of 41%, which is very 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%

Regression results: organizational forms and innovative success

	Original idea		Completion of innovation	
	Stand. coeff.	Sign.	Stand. coeffi.	Sign.
Constant		.044		.001
Participation in strategic alliances	-	-	-	-
Collaboration on product innovation	0.971	.043	-	-
Supplementary knowledge	1.001	.026	1.074	.023
Complementary knowledge	-4.768	.036	0.663	.021
Competitors	-5.210	.031	0.619	.015
Suppliers	5.194	.034	-0.861	.014
Customers	5.640	.035	-	-
Uni's or PRI's	-0.975	.039	-	-
Consultants	-2.520	.033	-	-
Science share	-	-	1.411	.003
RD intensity (HR)	1.055	.037	-	-
Adj. R^2	0.999		0.88	
F	999.94		15.681	

- : not included in stepwise regression analysis
All coefficients are significant at 5% significance level (cut-off point is 10%)
Calculations based on Know-survey

First of all, competitors, universities and PRI's and the exchange of complementary knowledge have a negative impact on the innovative success as expected. Surprisingly enough though consultants also have a negative impact on innovative success. The causes for this result cannot be clarified with the present data material. Another surprising result is the lack of importance of the general relationship competence (illustrated by 'participation in strategic alliances). We expected this competence to have a positive impact on the innovative success but this did not appear so and should be investigated in more detail in later research. Finally, it should be noted that both measures of human capital namely the SCIENCE and the RDintHR variables showed up positively although only one in each model.

significance level. This means that for all the other variables the usage of the dependent variable was not statistically problematic and thus has been included in the analysis.

These overall results supported the general ideas of the hypotheses namely that inter-organizational knowledge flows and the relative importance of different relationship types did in fact have an impact on the innovative success. Moreover, the type of knowledge that was exchanged and the stage in the innovation process that the knowledge was to be utilised in also had an impact on the success of the NPD process. However, none of the above results could pinpoint the mechanisms that enabled the knowledge flows. To uncover some of these burdensome processes the following section incorporates some illustrative case results.

KNOWLEDGE TRANSFERRING MECHANISMS

Three cases are in utilised in this section, each of them is different with regard to the organization of the R&D process within the firm. In the following each case is presented and the mechanisms for knowledge transfer and absorption are presented.

Case A: Functional form

Firm A is a large telecom equipment manufacturer with core competencies within optics. A total of 10.7% are employed in R&D of a total of 280 employees. The most important innovation was invented within the core competencies and is a new combination of existing technologies. In 1999 the top manager was replaced with the present contact, which lead to drastic changes in the organisation. First of all, the manager brought in a network of international contacts and experience from international operations; practically this has lead to an opening up towards strategic collaborations with app. 40% of the innovations being carried out in collaboration with external partners. The organizational form is traditional in its hierarchical set-up with a flow of inventions being converted into innovations through production, sales and marketing. The bottleneck is frequently appearing in the link between the development and production stages. The problems of knowledge flows are obvious here, since no cross-functional teams exist to ensure the smooth shift from prototypes to production. At present the organization is planning to incorporate rotation mechanisms but they have not yet been initiated. Furthermore, the R&D department is more interested in developing new ideas than following the old ones through the value chain and no incentive systems have so far been erected. The external relationships are in the early stages with universities and in the later stages with suppliers and customers, the latter being the most important. The knowledge absorption processes have been under tight control demanding written documentation of the transferred knowledge even though the transfer took place face to face. The

very complex knowledge that was received has become quite important to the department but has proven very difficult to turn into new products. Even though the knowledge was of complementary type no problems with absorption were registered. The smooth process of knowledge absorption can be seen as a result of the high training share (more than 75% of the staff are on courses each year) combined with the close cooperation throughout the knowledge transfer process.

Case B: Disintegrated divisional form

Firm B operates in computer service market supplying IT infrastructure solutions based on standard products. A total of 360 are employed of which 19.4% are employed in R&D. The most important innovation is the integration of the internet in the existing solutions. The integration can both relate to the broader use of the internet as well as distribution media of new software as well as updates. In 1999 firm C was taken over by a large group, which has lead to drastic changes in the organisation, both regarding strategy and customer relationships. The most important innovation can be traced to development projects before the acquisition. The company is organised according to the figure below based on a divisional form:

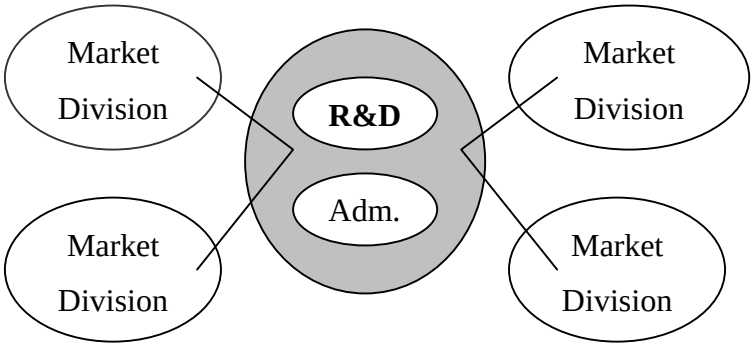

Figure 1: The organisation of firm B

The R&D department is organised such that approximately 50% of R&D costs should be covered through customer related projects and the remaining 50% is devoted to development projects of a broader character like development of new methods etc. The R&D department serves as an independent unit that must be partly self-financed. In principle the typical R&D project is initiated by one of the market divisions that act on request from customers feeding the idea into the R&D department. R&D then appoints a team of employees with the necessary competencies. The team is then placed in the division and works there for the duration of the project in cooperation with the customer and the market division. The advantage of this structure is that teams can be organised

according to the specified needs and they are in close contact with the customer. Drawing on common methodologies allows the teams to be assembled across the members of the department according to the needs. The disadvantage of this form is that some start-up cost of setting the team up and getting to know each other must be incorporated. However these seem to outweigh the close relationship with the contractor for the project and the cross-disciplinarity that can be drawn from.
To ensure smooth knowledge flows and feedback into the system a very structured project evaluation process is initiated at the end of each project. The loosely coupled organization with the ad hoc teams creates a need for tight knowledge management control to ensure that experience is passed on in the system.

Case C: Collaborative

The last firm is small and established in 1994. Originally the firm has been a distributor of entertainment and telecom products, but has to an increasing degree started to develop own products. Only very small shares of turnover are still coming from this product but the expectation is that it will rise to become the most important source of profits. The particular feature of this firm is the organisation of the R&D department. The innovation is developed in cooperation with an Asian firm where the division of labour is particular in the following sense. The Asian firm possesses all the core technological competencies but has no manufacturing, sales or marketing functions, these are placed in the Danish company. The Danish firm, on the other hand, does not have the competencies to start their own development from scratch, but is responsible for the development of the applications to the product. Thus, even though the two firms are independent their relationship is based on mutual dependence. The knowledge flows are primarily undertaken through email and internet, but frequently especially the Asian engineers stays in Denmark for longer periods to work there. Thus periods of close personal interaction are followed by periods of only electronic contact. The knowledge flows have so far been unproblematic since the relationship is characterised by trust, openness and high competence levels at both sides. Thus, no problems of transferring or absorptive bottlenecks have been experienced.

As can be seen from the above cases each of the organizational forms sets different requirements for the knowledge transfer processes. In the first case, incentive systems had to be built which would motivate the development team to follow up and participate in taking the innovation to production. In the second case a clear team based organization required massive follow up and systematising to

ensure that experience would be shared. Finally, the last situation was a pure collaborative relationships where the value primarily came through open and trust-based relationships. Clearly, trust was not built over night, but was supported by the mutual dependence between the two firms.

CONCLUSION

This paper has demonstrated coherence in the set-up by combining survey results on the organization of the R&D process with case based insights on the mechanisms enabling knowledge transfer. The clear relationship between the two empirical sections has allowed for the discovery of the importance of relationships combined with the type of mechanisms that were incorporated to ensure the knowledge flows. The results indicated that especially in the early phases of the R&D process the external impulses through knowledge flows were important for the success of the innovation. However, later on the relationships were much less important. These results highlight the type of relationships that can be selected and de-selected for the development of new products. Moreover the case studies revealed a clear relationship between the organizational form and the requirements for the successful knowledge flows within the organization. These results must of course be tested further, but as a first attempt they highlight some important lessons for managers of R&D.

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