INTERNATIONAL DESIGN CONFERENCE - DESIGN 2010
Dubrovnik - Croatia, May 17 - 20, 2010.

DESIGN 2010

TRANSFERRING KNOWLEDGE OF PRODUCT CREATION – MOTIVATIONS AND CONSEQUENCES

M. A. Petermann, T. Meiwald and U. Lindemann

Keywords: knowledge transfer, interview study, qualitative approach, bottom-up analysis

1. Introduction

Most designing and manufacturing companies create their products within a network of suppliers. Those suppliers provide design or manufacturing tasks and thus competencies, capacities or cost structures desired by the purchasing company. In these ways, companies benefit from participating in supplier networks and have hence a strong motivation to do so. Yet, suppliers cannot perform the assigned tasks unless provided with the necessary knowledge of completing the involved task. So, the benefits of supplier networks come with the risk of providing suppliers with the product creation knowledge they need to reproduce unique features of the original products. Forced knowledge transfer is considered a major downside of supplier networks. Hopkins et al. (2003), Neemann (2007), Petermann et al. (2008) and Geiger (2008) give the most comprehensive descriptions of motivations and undesired consequences of knowledge transfer in the revised literature, but still stay on a very abstract level and mainly describe the point of view of the knowledge divulging party. In order to provide a more detailed understanding of the implications of transferring knowledge in product creation networks, we need a more detailed picture and the scope must be widened to knowledge receivers and knowledge users. In this paper we present first results of an interview study aiming at providing a deep insight in motivations and consequences of knowledge transfer for those who divulge, receive or use product creation knowledge. Therefore, data from 22 interviews within seven German industrial goods designers and manufacturers has been analysed.

2. Objectives (Research Questions)

In our research of the past years, we have been working in projects dealing with the consequences of undesired knowledge transfer and prevention of counterfeiting. Those projects mainly focused on negative consequences of knowledge transfer from original equipments manufacturers and designers (OEM) to suppliers or imitators, which are in many cases the same company. Eventually we found that our perception of the "whys" of knowledge transfer was biased by our strong focus on the OEM point of view and our exposure to "helping" OEMs prevent spreading their core knowledge and avoid imitations. An analysis of the state of the art (see introduction) revealed that this bias is present throughout the literature we reviewed. Evidence could not be found for a comprehensive understanding of the motivations and consequences of knowledge transfer for the most relevant groups of stakeholders, namely knowledge divulging parties, knowledge receivers and knowledge users (see Figure 1). Our motivation for this research is formalized in the following research questions that we try to answer:

1. Which are motivations of product creation knowledge transfer for all relevant groups of stakeholders on a detailed level?

2. Which are consequences of product creation knowledge transfer for all relevant groups of stakeholders on a detailed level?
3. How can detailed evidence of motivations and consequences be clustered?
4. How can motivations and consequences be distinguished in the context of this research?

Our approach for acquiring and analysing data for providing answers on these question are described in this paper. Data acquisition details are provided in chapter 3, data analysis details and study results in chapter 4.

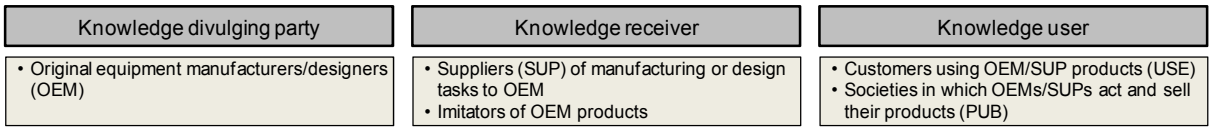

Figure 1. Relevant groups of stakeholders

3. Data acquisition

Our data acquisition scheme consists of five elements. Each of those elements is named and briefly described below, followed by the attributes defined for the purpose of this study (also see Figure 2):

Data requirements: Definition of relevant kinds of information

Situations where product creation knowledge is transferred between partners within product creation networks have to be investigated. The motivations for certain actions when transferring knowledge (or trying to avoid it) are of special interest; so are consequences of transferring the knowledge. Many different facets of product creation knowledge have to be considered in order to provide a broad understanding of motivations and consequences of transferring product creation knowledge. These facets include product definition, design and manufacturing as well as sales, marketing and sourcing.

Data sources: Definition of desired attributes and number of sources for required data

The authors' backgrounds are in industrial and design engineering. Thus focussing on industrial goods designers and manufacturers seemed to be appropriate to us. We assumed that different functions within such companies have different knowledge to divulge or to protect from suppliers, causing different consequences and having different motivations for doing so. So it was necessary to acquire data from various functions along the product creation chain: innovation management / product definition, engineering design / software design / control design, manufacturing, purchasing, manufacturing, sales and marketing, and intellectual property management. For keeping the backgrounds of data sources as similar as possible we decided to acquire data only from persons with engineering education. In order to avoid excessive biasing by single opinions or corporate singularities minimums of 20 data sources from five different companies were set.

Door opener: Concept for making identified information sources participate in study

This research is performed in a funded project environment (see Acknowledgements). One of the aims of the funded project is an evaluation of guidelines for the selection of anti-counterfeiting tools in case studies with industrial goods designers and manufacturers. Companies taking part in this evaluation process are provided with a list of anti-counterfeiting tools, suiting their individual requirements best. Companies are not charged for taking part in the evaluation process. So our approach is to ask them for the opportunity to acquire data from interesting sources (which turned out to be quite successful).

Data acquisition: Concept for extracting information from sources

As we aim for deeper understanding of a field, it is essential to bypass the researchers' mind-sets of the field in any data acquisition efforts [Sarantakos 1993]. This is assured by acquiring data through semi-structured interviews. Semi-structured interviews follow a list of open questions (interview guide) on topic related subjects as long as according information is provided by the data source in order to provide coverage [Blessing and Chakrabarti 2009]. Whenever a data source offers information on subjects that are not covered by the list, the new subject will be explored as far as the data source

would offer information. The list of questions will "grow" by adding questions leading posterior data sources to the newly discovered field each time such a field is uncovered. The list of questions deployed for this study consists of questions exploring the product creation process with emphasis on knowledge transfer and motivations/consequences of (not) divulging product creation knowledge when in contact with customers or suppliers. Different sets of questions were used for interviewing engineers from different functions in the company, each exploring typical knowledge transfer situation for the respective function. Interviews were scheduled for roughly 90 minutes duration each, though took between 45 and 125 minutes. This is owed to the semi-structured interview approach that allowed for data sources to provide detailed information wherever they considered it important.

Data storage: Concept for preserving a maximum amount of the acquired data for analysis

In order to ensure a maximum amount of acquired data to be preserved for analysis, interviews were always conducted by at least two researchers. One was guiding through the interviews, the other one took minutes of the most relevant data acquired from the data source. However, the protocols were just used as fall back documentation in case audio-taping failed. All interviews were audio-taped and subsequently transcribed into text files. A professional voice recording device was deployed therefore in order to provide reasonable sound quality for transcription. Audio-taping failed in two cases, in which minutes were used for further analysis.

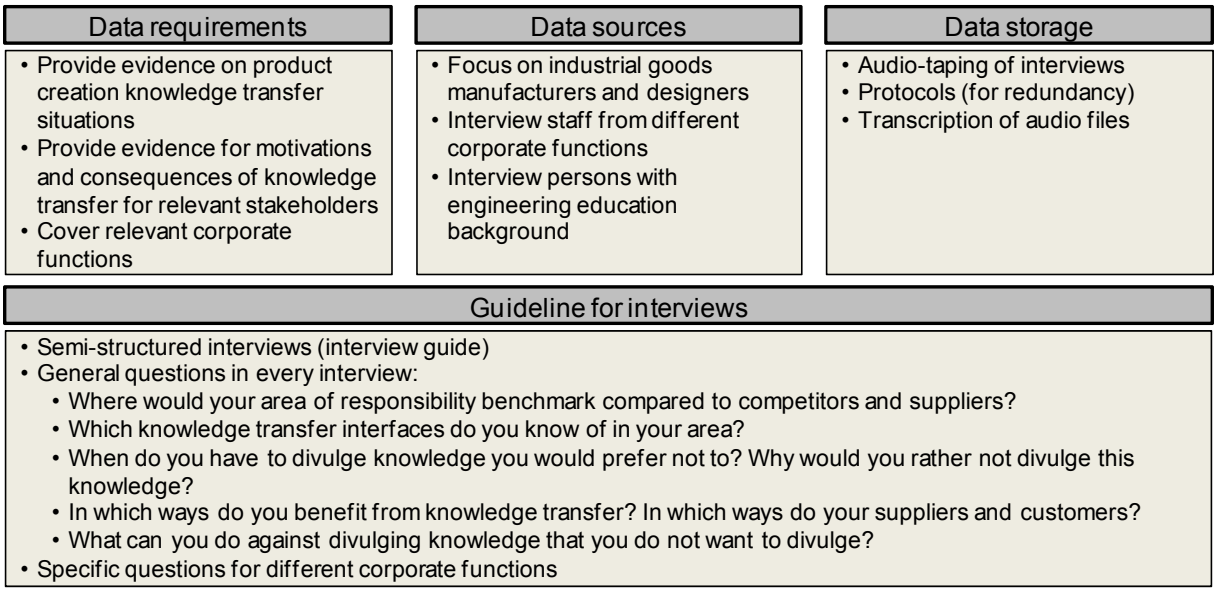

Figure 2. Data acquisition scheme

Data acquisition was conducted according to the descriptions given above. 45 persons working for seven different companies were interviewed in 37 interviews. The companies involved sell their products world-wide (one company does not serve Northern America) on markets that do not interfere with markets of one of the other companies. Details on the product range of the companies can be taken from Figure 3. The interviewed persons' functions in their companies varied according to the data requirements defined above, and are also depicted in Figure 3. The average length of the interviews is roughly 75 minutes, and the interview transcripts comprise about 240,000 words in total.

4. Data analysis and study results

This research effort aims at providing a detailed understanding of a field that is so far mostly described by buzzwords and – owed to OEM focused points of views – often described in a biased and stereotypic way. Stereotypes range from "knowledge transfer is indispensable for cheaper sourcing" to "knowledge transferred to china is lost knowledge". Our goal is to provide first empiric bottom-up descriptions of motivations and consequences of product creation knowledge transfer – beyond these stereotypic descriptions and on a far more detailed level. Therefore, we established an analysis scheme

deploying coding and analysis methods taken from qualitative social research for analysing the interview transcripts. A software tool supporting this kind of analysis was deployed.

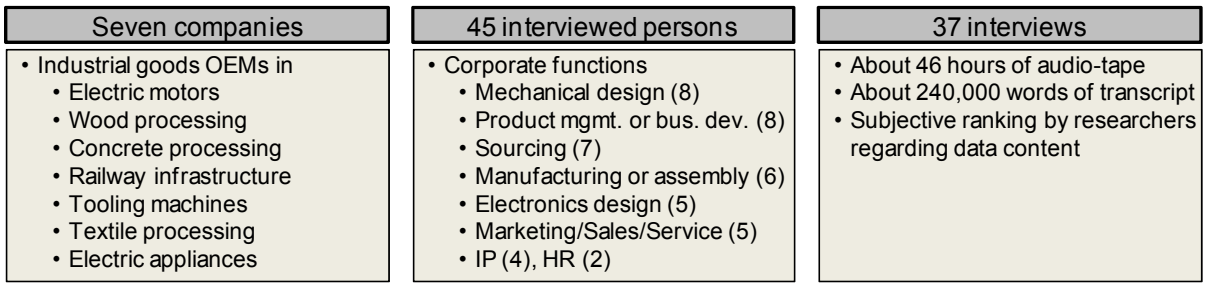

Figure 3. Data acquisition

4.1 Prerequisites

Bottom-up qualitative analysis is a highly iterative process, as the framework of results is not provided by the researchers in advance, but derives step by step through incorporation of yet another bit of empiric evidence. Not only the results framework but also certain contextual definitions of terms relevant for the meaning of results change and evolve during the course of analysis. Our research efforts were more iterative than suggested by the three step description below. We hope to contribute to better readability and understanding by only depicting the major iterations in the course of analysis. These major iterations were an adoption of a more detailed coding scheme along the way, generalisation/abstraction of quotes and introduction of contextual definitions of the terms "motivation" and "consequence". These terms have not been distinguished in the early phases of analysis, as they are used almost synonymously in every-day German language.
In this paper we offer the results of the over-all analysis of 22 of the 37 conducted interviews. Interview transcripts regarded most data prone by subjective judgement of the interview conductors (paper authors) were analysed first. In the course of analysis, we found that after analysis of about twelve interviews, new contributions to the results frame-work and terms understanding became infrequent and at roughly 20 interviews reached a level so sparse that we decided to publish first results. Analysis efforts leading to these first results are described below.

4.2 First step of analysis: Software supported rough coding

In the first step of analysis, interview transcripts were coded according to a very rough coding scheme. The coding scheme consisted of four codes, not distinguishing between motivations and consequences but between the different stakeholders in the field of transferring product creation knowledge. Four groups of stakeholders were identified: Original equipment manufacturers (OEM, or knowledge divulging party), suppliers (SUP, or knowledge receiver), customer/user of the product realized through knowledge transfer (USE, or knowledge user), and society (PUB, or knowledge user on an abstract level). So, four codes were assigned to relevant text passages/quotes (see Figure 4).
Coding itself in this first step was performed by the first author of this paper and by two senior undergraduate students of industrial engineering. This kind of researcher triangulation [Miles and Huberman 1994, Patton 1990] is difficult to handle as one has to make sure that all coding persons have very similar understandings of the codes to be assigned. This was an additional reason for keeping codes very rough at this step of analysis. To achieve the necessary level of common understanding, the first interview transcript has been jointly coded by all three researchers involved. The remaining interviews were coded by one researcher each. Normalized code density varied up to 65% between the three researchers. We took this as an indication for our coding training efforts to be insufficient. Re-coding efforts after additional joint coding training decreased the variation in code density to a maximum of 35%. This seems to be a reasonable value that can be explained by different interview situations in semi-structured interviews [Sarantakos 1993]. The first step of coding resulted in different numbers of quotes assigned to the different codes, as can be taken from Figure 4.

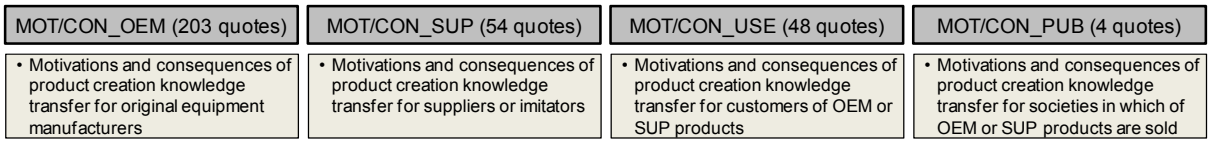

Figure 4. Codes for first step of analysis with number of assigned quotes

These quotes served as a basis for the second step of analysis described below. As can be seen in Figure 4, code MOT/CON_PUB has hardly been used and is thus merged with code MOT/CON_USE. The high number of quotes assigned to code MOT/CON_OEM seems to be reasonable considering all data sources work for companies that are OEMs in certain fields. However, all the companies contributing data to this study are also suppliers to their customers, and use the benefits of supplier networks in other fields. So quotes assigned to MOT/CON_SUP and MOT/CON_USE are considered first hand data.

4.3 Second step of analysis: Fine coding and quote generalisation

For the second step of analysis, we introduced a distinction of positive and negative motivations and consequences. So each of the first step quotes was divided into two codes: MOT/CON_[...]_POS and MOT/CON_[...]_NEG (see also Figure 6). Quotes were assigned to one or more of these codes. The assigned quotes were also slightly abstracted. An abstraction was necessary since the number of original quotes was too high to be reasonably accessed. By slightly abstracting quote after quote, eventually we were able to assign several analogous quotes to one and the same abstraction. By that, this slight abstraction/generalisation also served as a first level of generalisation. Still, with the abstractions being linked to each original quote assigned, motivations and consequences stay accessible on the very detailed level aimed at. In the course of the second step of analysis, further levels of abstraction/generalisation were added for two reasons:

1. Allow for a comparison of the motivations and consequences found with those described in the state of the art
2. Allow for reasonable accessibility of specific detailed level motivations and consequences

An example of motivations and consequences on different levels of abstraction is given in Figure 5.

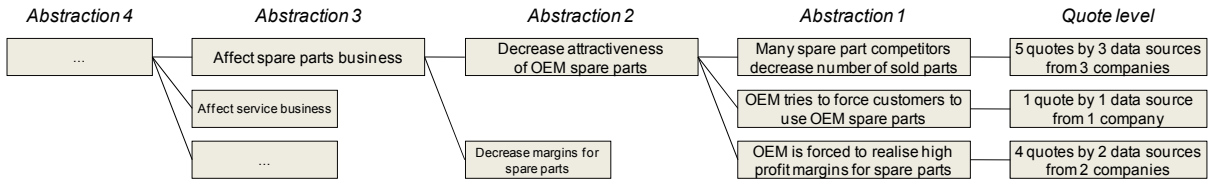

Figure 5. Example of motivations and consequences on different levels of abstraction

The second step of analysis was performed by one researcher, even though it was very time-consuming and could have been completed faster if undertaken by more than one researcher. Yet, our experiences with researcher triangulation in the first step of analysis led us to the conclusion that it would take even more time to build up shared mental models for acceptably similar abstractions of quotes.

Up to five levels of abstraction were derived from the 309 original quotes taken into account, resulting in a lesser number of more generalised motivations and consequences for each additional level of abstraction. Outcome was one generalised top level statement for each of the codes. These statements are depicted in Figure 6.

4.4 Third step of analysis: Distinction of motivations and consequences

For the third step of analysis, we derived contextual definitions of the terms “motivation” and “consequence” during our first and second step analysis efforts. Those definitions are deliberately not influenced by dictionary definitions:

- Motivation: A factor that affects decisions regarding certain actions in the future. Motivations can lead to taking or declining action. Example: The ability to source a part cheaper is a good motivation to divulge knowledge to suppliers.
- Consequence: The outcome of a past event that is beneficial or unbeneficial for a person, a corporation or a society. Consequences can be good or bad. Example: The necessity to divulge knowledge to a supplier is a bad consequence of the need to source this part cheaper.
- Relation between "motivation" and "consequence": Motivations are anticipations of consequences.

The examples stated above are intended to show the initial difficulties in distinguishing the terms motivation and consequences.

Statements on all levels of abstraction found in the second step of analysis were assigned to being consequences or motivations of product creation knowledge transfer according to the definitions above. All quotes and generalisations are indeed consequences, with some of them also being motivations. This finding suggests that motivations quoted display very well the consequences desired or feared.4.5 Results

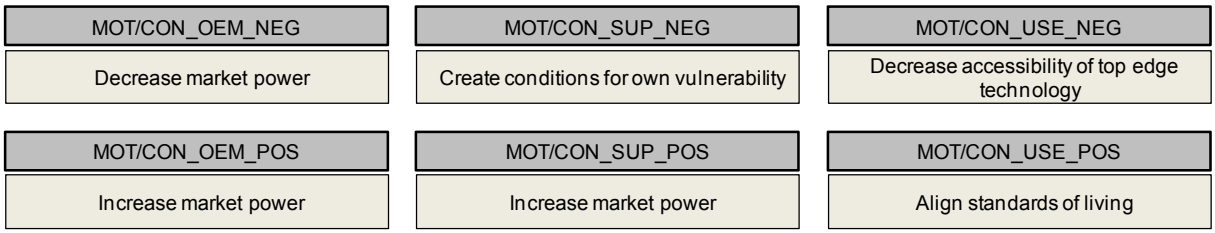

Figure 6. Codes for second step of analysis with top level abstraction

Thus, we were able to derive hierarchical lists of consequences of product creation knowledge transfer on various levels of abstraction, containing evidence of consequences that are also motivations of product creation knowledge transfer. Each consequence (and motivation) in these hierarchical lists is described by the quote or abstraction itself, and three attributes: involved stakeholder, perception of benefit, importance and "weight" of statement through numbers of assigned quotes, data sources and companies (see Figure 7). Our intention for offering values for these attributes is to allow for some basic judgement regarding the relevance of a statement by providing this kind of "weight" of single statements. However, this can just give an impression and is not meant to serve as a robust criterion of relevance.

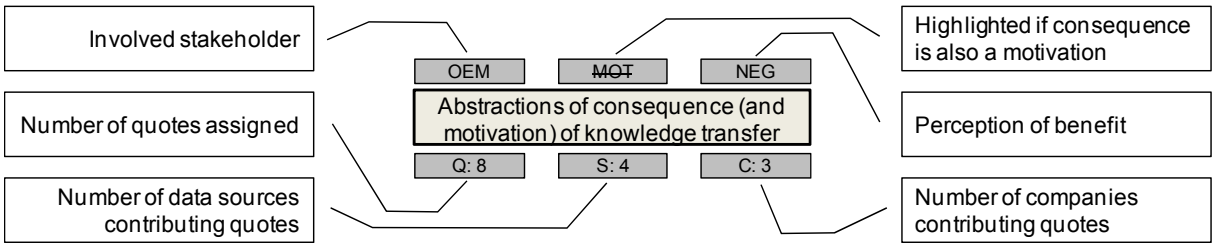

Figure 7. Graphical representation of consequences of product creation knowledge transfer

We generated six lists according to the codes displayed in Figure 6, starting with the top level statements going down the applied levels of abstraction until reaching the original quotes. By deploying this hierarchical way of presenting motivations and consequences of product creation knowledge transfer, we are able to provide results beyond stereotypic description and on a very detailed level, but still comparable to the state of the art. We hope to contribute to readability but still give the most interesting findings of this research by displaying only the top three abstraction level in these figures. The list of negative consequences for knowledge divulging parties (OEMs) is depicted in Figure 8. The consequences found are mostly market, revenue and cost oriented. Only a few of the consequences have also been stated in the interviews as motivations to restrain from product creation knowledge transfer.

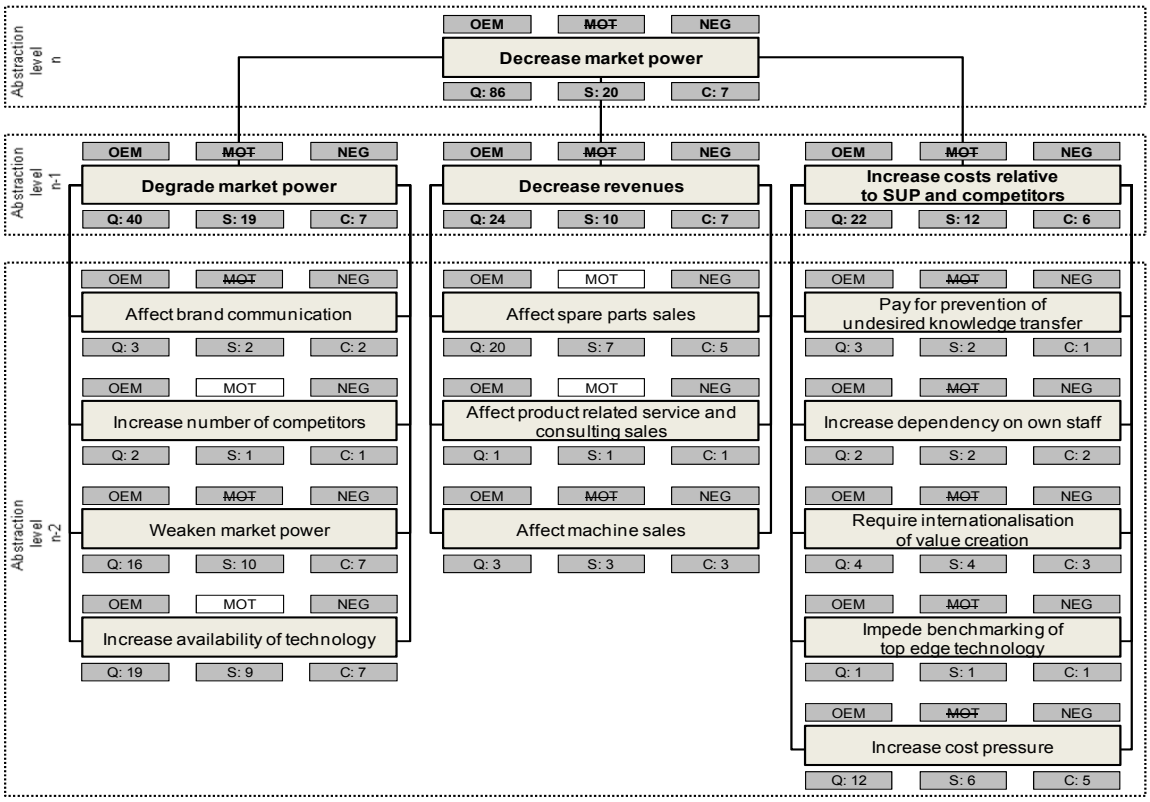

Figure 8. Negative consequences and motivations for OEMs

The list of positive consequences for knowledge divulging parties (OEMs) is depicted in Figure 9. This list also shows a focus on market implications but with stronger emphasis of customer relation and technology issues. Many of the consequences are also stated as motivations to transfer product creation knowledge.

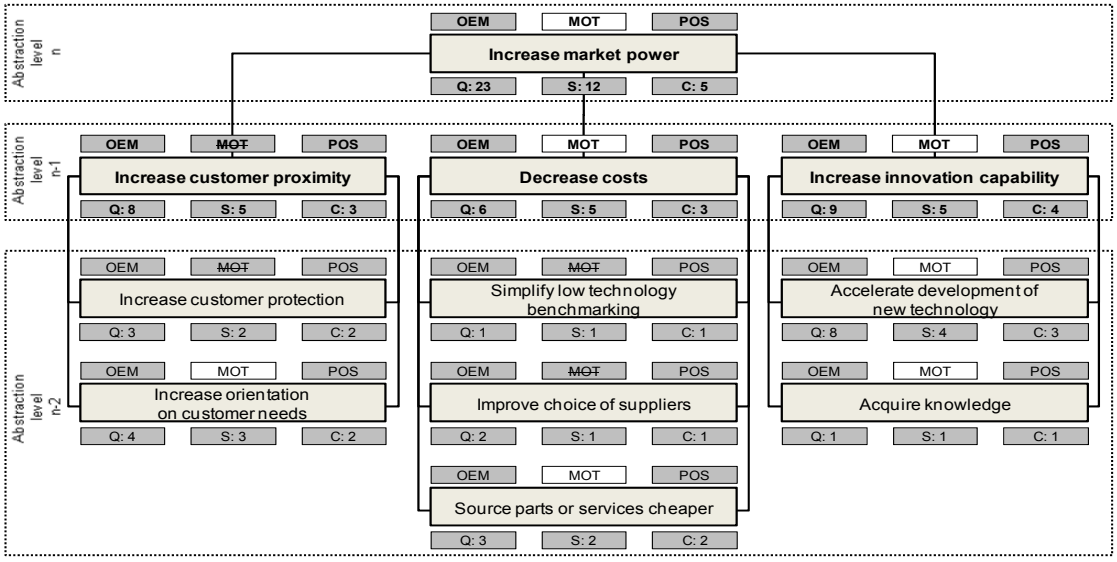

Figure 9. Positive consequences and motivations for OEMs

The list of positive consequences for knowledge receivers (suppliers and imitators) is given in Figure 10 and shows many of the typical elements of early phases of competition, when a "new player" in the field tries to close the gap to the well-established company. Many of the stated consequences are also referred to as motivations for facilitating knowledge transfer.

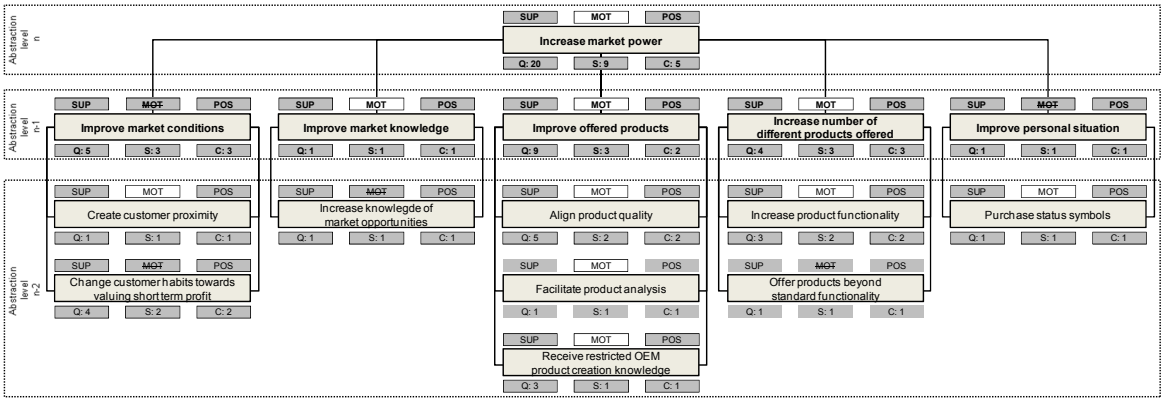

Figure 10. Positive consequences and motivations for suppliers and imitators

The list of negative consequences for knowledge receivers (suppliers and imitators) is backed by very few quotes compared to the lists for the other codes. However, the quotes assigned imply that knowledge receivers by their competitive demeanour provoke strong antagonistic tendencies in the knowledge divulging parties, resulting in some "fighting back" (see Figure 11). There is no evidence of consequences also stated as motivation.

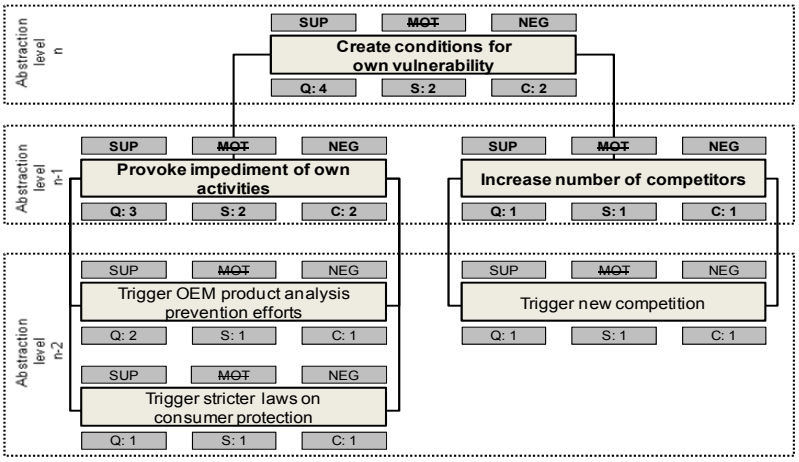

Figure 11. Negative consequences and motivations for suppliers and imitators

The list of negative consequences for knowledge users (customers and society) is depicted in Figure 12 and offers as most stunning finding that knowledge transfer seems to decrease to a certain degree the world-wide availability to top edge technology. None of the consequences is mentioned as a motivation.

The list of positive consequences for knowledge users (customers and society) depicted in Figure 13 shows evidence of positive effects of knowledge transfer on standards of living, economic growth and technology development. Many of the consequences are also named as motivations.

5. Discussion

Our research provides evidence for motivations and consequences of knowledge transfer on very different levels of abstraction. Original quotes by 22 interviewed engineers ensure a picture of the field much more detailed than stated so far in the revised literature. By iteratively abstracting the original quotes, generalised statements have been derived, hopefully reflecting empirical data much more than the researchers' mind-sets. Still, with the abstraction of quotes comes the danger of biasing empiric data with mind-sets of the researchers. However, we put effort in limiting these influences by deploying many small abstraction steps and thus staying closer to the original meanings of the quotes.

Even though we are convinced that our proposed motivations and consequences of product creation knowledge transfer are less stereotypic than the ones described in the state of the art, the final consideration must stay up to the reader. Widening the state of the art scope from just the point of view of the knowledge divulging party to knowledge receivers and knowledge users in our opinion contributes to a better understanding of the societal implications of knowledge transfer.
The generalised results we provide vary very much in the number of assigned quotes, persons and companies. Even though our research aimed at uncovering new findings rather than at proving their legitimacy, we would have liked to provide more evidence at least for those high level abstractions relying on very few quotes, persons or companies. We assume the reasons for this unsatisfactory empirical foundation is in a too high emphasis on negative consequences in the interviews. Whether this emphasis is caused by our choice of interview questions or by interviewed persons using their freedom in choice of topics stays unclear at this point of research. However, we expect to provide a more solid foundation by analysing the last 15 interviews that have already been transcribed. Still, we assume to offer a solid basis for discussion on the motivations and consequences of knowledge transfer by publishing first results at this stage of research.

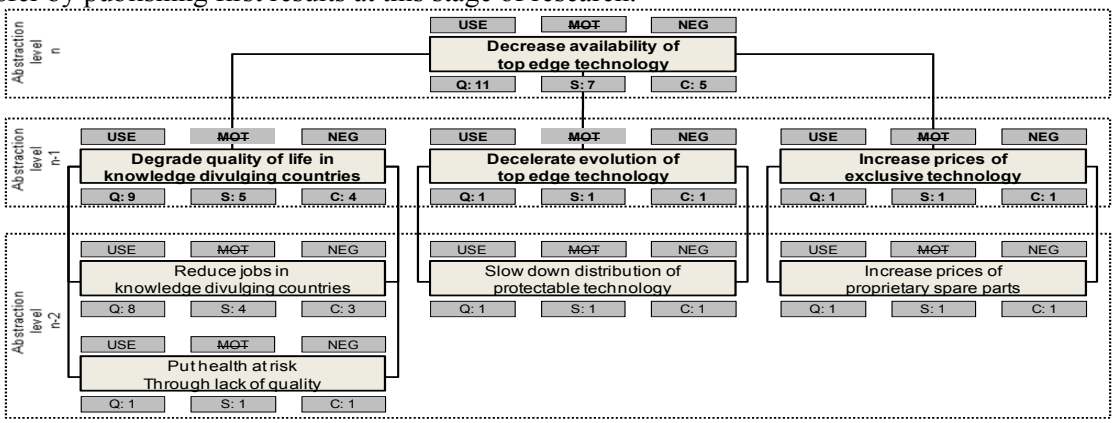

Figure 12. Negative consequences and motivations for customers and society

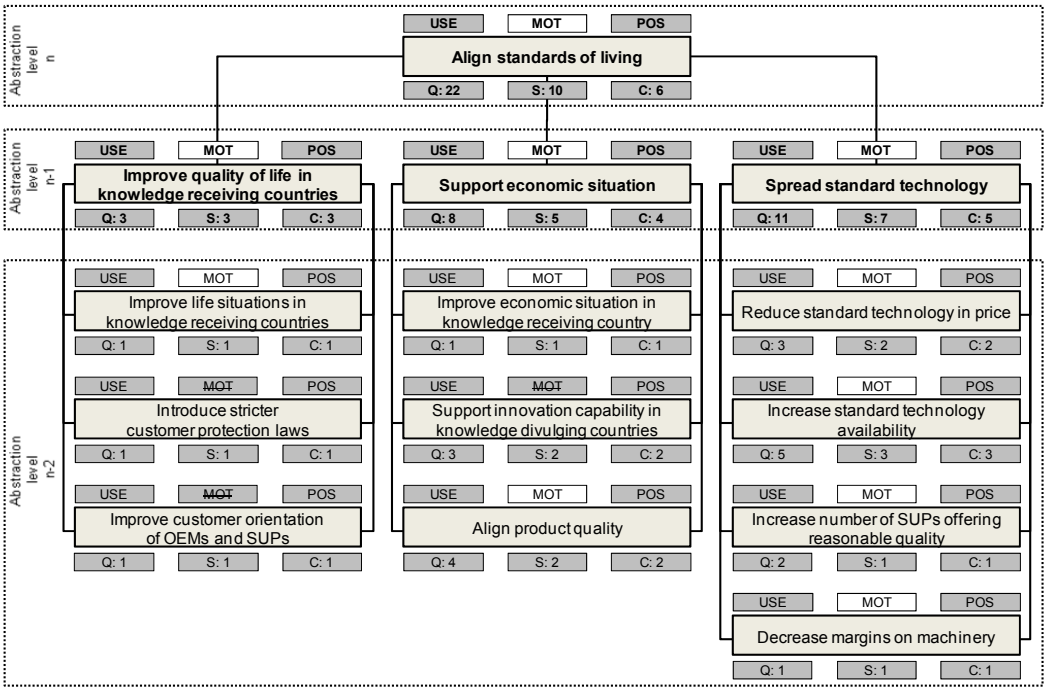

Figure 13. Positive consequences and motivations for customers and society

6. Conclusion and recommendations

Hierarchical lists of consequences of product creation knowledge transfer have been derived for OEMs, for suppliers and customers/public (see research question 2). Consequences that are also motivations have been highlighted in these lists (see research question 1). Through their hierarchical structure, those lists provide evidence on a very detailed level as well as on a generalised level by stepwise abstraction of original quotes from the 22 analysed interviews. Generalised statements also provide the clustering of motivations and consequences asked for (see research question 3). The term "motivation" in the context of this research describes factors that affect decisions on whether to take or decline certain actions; the term "consequence" has been contextually defined to beneficial or unbeneficial outcomes of past events (see research question 4).

Advantages and disadvantages of our data acquisition and analysis approach have been discussed in chapter 5. First future work could – and will – be in analysing the last 15 interviews that have already been transcribed. The discussions ignited by this publication will contribute to refinement and additional foundation of the findings. Anticipated opportunities for further research include quantitative evaluation of the finding of this bottom-up qualitative research effort as well as research into the implications of the findings for decision making in knowledge transfer situations. The question of whether to divulge certain knowledge or not is one of the most vital questions in an industrial goods industry, where knowledge is the only real competitive advantage left [Nonaka and Takeuchi 1997, Schilcher 2006].

Acknowledgements

We want to thank all involved persons for their commitment and support, especially the persons and companies spending their time and resources as interview partners. The interviews conducted within this research effort have been partly funded by the German Federal Department of Education and Science in the "Contra Imitatio (ConImit)" research project (funding reference number: O2PU1070) and attended by Projektträger Karlsruhe.

References

Blessing, L. T. M., and Chakrabarti, A., "DRM, a Design Research Methodology", Springer London, 2009.

Geiger, R., "Piraterierisiken: State-of-the-Art und eine Systematik zur Identifizierung", International Performance Research Institute Stuttgart, 2008.

Hopkins, D., Kontnik, L., and Turnage, M., "Counterfeiting Exposed - Protecting Your Brand and Customers", John Wiley & Sons Hoboken, New Jersey, USA, 2003.

Miles, M., and Huberman, A., "Qualitative Data Analysis: An Expanded Sourcebook." Sage Thousand Oaks, 1994.

Neemann, C. W., "Methodik zum Schutz gegen Produktpiraterie", Shaker Aachen, 2007.

Nonaka, I., and Takeuchi, H., " The knowledge-creating company: how Japanese companies create the dynamics of innovation", Oxford University Press, 1995.

Patton, M. Q., "Qualitative Evaluation and Research", Sage Newsbury Park, 1990.

Petermann, M., Meiwald, T., and Lindemann, U., "Factors Influencing the Vulnerability of Manufacturers to Product Imitations", DESIGN 2008 - PROCEEDINGS, Dubrovnik, 2008 of Conference.

Sarantakos, S., "Social Research", MacMillan Education South Melbourne, 1993.

Schilcher, C., "Implizite Dimensionen des Wissens und ihre Bedeutung für betriebliches Wissensmanagement," Ph.D. thesis, Technische Universität Darmstadt, 2006.

Dipl.-Ing. Markus Alexander Petermann
Research Assistant
Technische Universität München, Institute of Product Development
Boltzmannstr. 15, 85748 Garching, Germany
Telephone: +49.89.289.15129
Telefax: +49.89.289.15144
Email: petermann@pe.mw.tum.de
URL: http://www.pe.mw.tum.de