Future Trends and key challenges in R&D Management – Results of an empirical study within industrial R&D in Germany

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This paper reports on the first results from an empirical study among R&D experts in German industry. As R&D is an investment in the future the outlook to future trends is certainly contributing to industrial orientation and prioritisation. To be prepared for trends and challenges for the R&D in the next 2-3 years, Fraunhofer IAO conducted a survey “R&D Fit for Future” among 162 companies mainly from advanced manufacturing, automotive and medical device industry. The objective of the research was to find relevant strategies and future trends in R&D management. Additionally, the key challenges in R&D for the next years from an industrial point of view were analysed. The survey was structured by the chapters of strategy, organisation, processes, methods & tools and R&D personnel.

The paper presents the communalities and differences of trends and challenges between the advanced manufacturing, automotive and medical device industry in the field of R&D-management. Based on this survey and on the results of a previous empirical study, also performed by Fraunhofer IAO in 2009, the most significant changes of priorities and new developments are pointed out and analysed. It concludes with some recommendations for more general trends in German industry.

1. Introduction and motivation

Industrial research and development (R&D) is subject to continuous change which is accompanied by discontinuities, technological trends and changes in the market environment. Industrial R&D is the term for systematically activity to generate new technical knowledge and to apply already existing knowledge new (Weule (2002), Bürgel et al. (1996)). To meet the ever growing and changing requirements, it is necessary to be prepared early to the changes and to identify opportunities and risks associated with strategic design options. The general challenges which industrial R&D departments are confronted today are known by the enterprises. Bullinger et al. (1990) and Werner (2002) note that these are for example shorter product development time and cycles as well as Time-To-Market. While the Fraunhofer IAO R&D study from the 90s called "F&E - heute" put the focus on the magic triangle of product development as well as the decoupling of the trilemma time, cost and quality (Bullinger et al. 1990), the presented solutions are no longer sufficient for the needs and requirements of today's industrial R&D. Challenges in R&D do not only increase in 2014, but are also characterised by growing complexity. In addition to the fundamental requirements to develop products, services and processes quickly, cost efficiently and in the right quality, new challenges also gain importance in the 21st century. Main challenges for R&D in enterprises are higher complexity of the products and systems, increasing development efforts, demands for a high level of innovation, focus on core competencies and collaborations, flexibility and ability to respond quickly, development of new markets, and enhanced pressure on the market because of prices. What are the
2. Research objectives and research methodology

The survey was conducted via web and mail among 162 companies mainly from German advanced manufacturing, automotive and advanced medical technology industry from June till October 2013. The main objective of the research was to find out trends and key challenges in the fields of R&D Management for the next 2-3 years. The survey addressed the following questions:
1. Which are the most relevant future trends of R&D management from an industrial point of view?
2. Which are the technology strategies and the most important corporate strategies?
3. Which are the most important objectives of industrial R&D fields?

The survey included R&D trends from the fields’ strategy, organisation, processes, methods and tools as well as R&D employees and concluded with some open questions on future trends.

Enterprise size and industry sectors

The participating companies have been asked to name their products or product types and the number of employees in their R&D department. With 70% the majority of the companies surveyed operate in the advance manufacturing sector, whereas 14% operate in the automotive sector, 7% in the medical technology sector and 9% in various other industry sectors. Figure 1 shows the distribution of employees in the R&D departments of the participating companies. The majority of the investigated R&D departments of the enterprises have less than 250 employees; most R&D departments have less than 20 employees.

3. Results: Future trends and key challenges of industrial R&D

The survey investigated the relevance of 34 trends in the areas management, organisation, processes, methods and tools and employees. On a scale from 1 (no to very low) to 5 (very high), experts rated which degree of significance each trend will have in the next 2-3 years. Afterwards responses have been evaluated by comparing average values from all industries. Respondents of all industries rated the following 10 out of 34 trends as the top trends for their R&D:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Trend</th>
<th>Average Value</th>
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<tbody>
<tr>
<td>1</td>
<td>Development of customer specific products</td>
<td>4.1</td>
</tr>
<tr>
<td>2</td>
<td>Target-oriented competence development of R&amp;D employees</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>Stronger involvement of customers</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Increase of R&amp;D effectiveness</td>
<td></td>
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<tr>
<td></td>
<td>Structured observations of new trends and technological developments</td>
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<tr>
<td>4</td>
<td>Increase of consistency and efficiency of all R&amp;D processes</td>
<td>3.7</td>
</tr>
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<td></td>
<td>Systematic use of sources of knowledge</td>
<td></td>
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<tr>
<td></td>
<td>(Further) development of expert / project management career paths</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lean processes in development</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Development of strategies for overcoming the skills shortage</td>
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The survey results show that there are only slight differences in the mean values which we have rounded to one decimal place. Thus, rank 2 and rank 3 is placed by 3 and 4 trends that have identical average values for degree of significance. Furthermore, it can be seen that some of the most relevant trends address similar topics. Therefore, for this paper we have structured the top 10 trends in 4 topics which are briefly introduced in the following:
Customer orientation in R&D
We name the first topic customer orientation in R&D which includes also the highest rated trend Development of customer specific products and the trend on rank 3, Stronger involvement of customers.

Employees in R&D
The second topic contains the trends Target-oriented competence development of R&D employees, Development of R&D expert/project management career paths and Development of strategies for overcoming the skills shortage.

R&D strategy and effectiveness
The third topic deals with choosing the right projects as well as with the realisation and exploitation of new technologies. The topic is addressed by the trends Increase of R&D effectiveness, Structured observations of trends and technological developments and Systematic use of sources of knowledge.

Efficiency and lean processes
The fourth topic is about accelerating R&D. Trends that address this topic are Increase of consistency and efficiency of all R&D processes and Lean processes in development. This paper will show a first analysis of the topics with detailed survey results which include the top trend ratings with regards to industries. In the following sections the ratings for each trend will be presented.

1.1 Customer orientation in R&D

Stronger focussing on the customer is a known trend in the R&D area for quite a long time and R&D experts from different industries still think that it will be a very important topic in the future. The results of the surveys most significant trend Development of customer specific products (Customizing) according to the scale from 1 (no to very low) to 5 (very high) are presented in Figure 2. Results show that this trend is highly rated from respondents of all industries. More than 80% of the advanced manufacturing and automotive companies think that it is of high (4) or very high importance (5).

The main objective of Stronger involvement of customers through approaches like customer co-development or customer co-design is increasing the customer involvement in development processes. The distributions of the ratings in Figure 3 show that the trend has most significance for advanced manufacturing and other industries. For the medical technology industry customer involvement is rather less important compared to other industries.

1.2 Employees in R&D

The most significant trend in the field of human resources management (HR) or competence management in R&D is Target-oriented competence development of R&D employees which implies the development and ensuring of strategic relevant expertise see Figure 4. In contrary to most other top trends the result show a different distribution of ratings in caused by a notable quantity of high significance rates (4), whereas the top rate was placed to a lesser extent. It is also notable that distributions of advanced manufacturing and automotive industry are almost equal and that results from medical technology industry and other industries lead to exactly the same distribution. Results for the trends Development of R&D expert/project management career paths and Development of strategies for overcoming the skills shortage are presented in Figure 5 and Figure 6 respectively.
While expert career paths give experts the opportunity to start a career as proven specialists in strategic important research topics within the company, project management career paths offer a perspective for project managers in line with the growing complexity and increasing size of their projects. In view of the fact that companies suffer from skill shortage it can be assumed that career management and incentive systems for R&D will be even more important in future (Bauer et al. 2014).

### 1.3 R&D strategy and increasing effectiveness

Strategic orientation and effectiveness are central future topics of R&D Management. This has been underlined by the survey results for the trends **Increase of R&D effectiveness** (see Figure 7), **Structured observations of trends and technological developments** (see Figure 8) and **Systematic use of sources of knowledge** (see Figure 9). The basis of strategic orientation and effectiveness is a careful formulation of an R&D strategy which includes at least main strategic objectives and their contribution of R&D to corporate strategy. In addition to the R&D strategy a supportive process for choosing the right projects should have various process steps considering market and financial criterias as well as feasibility. A good overview over technological developments is the bases for observing and recognising new technologies at an early stage. Additionally companies have the chance to utilise a rising number of information sources with IT-tools for strategic orientation and effectiveness. While the highest degree of significance (AVG 4.2) for **Structured observations of trends and technological developments** is found in the advanced manufacturing industry, the highest rating for **Increase of R&D effectiveness** is found in medical technology industry (AVG 4.2). For **Systematic use of sources of knowledge** there are no notable differences with regard to average values by different industries.

![Target-oriented competence development of R&D employees](image1)

![Development of expert/project management career paths](image2)

![Development of strategies for overcoming the skills shortage](image3)

![Increase of R&D effectiveness](image4)
Figure 8: Structured observations of new trends.

Figure 9: Systematic use of sources of knowledge.

Figure 10: Increase of consistency and efficiency of all R&D processes.

Figure 11: Lean processes in development.

1.4 Efficiency and lean processes

According to the survey among industrial experts, "Increase of consistency and efficiency of all R&D processes" is one of the most important trends of R&D management. Principles like the second Toyota paradoxes from "Toyota production System" (Morgan and Liker 2006) can be transferred to R&D in order to shorten development times and reducing costs. Lean development is an approach which is focussing on rising effectiveness and paying attention to make higher efforts in the early phases. In the following phases lean development aims at increasing efficiency and no changes and iterations are approved. More than 60% of the surveyed experts from advanced manufacturing and automotive industry think that both trends aiming at increasing efficiency are of high or very high importance (see Figure 10 and 11).

4. Comparison of survey results

One of the main goals of this paper is to analyse the most important trends also considering their relevance with regards to changes over time. Similar information from previous comparable surveys can help to identify general trends and changes. Therefore data from the different surveys have to be comparable to achieve this goal. In 2009 a comparable R&D management survey was performed at Fraunhofer IAO (see also Wagner and Finger 2009). The survey was conducted via web and mail among 100 companies mainly from German advanced manufacturing and automotive industry. The main objective of this research was to find out key challenges and trends in the field of R&D Management for the next 5-6 years. While the structure and the design of the survey have been identical, there are relevant differences that need to be considered which are briefly listed in the following:
• Respondents are not all the same persons in both surveys but all have comparable expert levels and positions such as CEO, CTO, R&D directors, etc.

• Respondents of 2009 survey were from two industries: Advanced manufacturing industry and automotive industry. In 2013 additionally data from medical technology industry and other industry has been surveyed.

• Number of survey respondents is different; 100 survey respondents in 2009 and 162 survey respondents in 2013.

• Number of pre-selected trends was 22 in 2009 and was 34 in 2013.

While keeping these aspects in mind we have analysed survey results of the most relevant R&D trends of the survey in 2013 and results for these trends of the survey carried out in 2009. In Table 2 the top trends of the updated survey are listed with their according average values in 2009 and 2013 as well as the value difference. Average values of new trends are not listed for 2009 because there is no data available due to the fact that they were not included as pre-selection in the former questionnaire.

Comparison of the results shows that the majority of the top trends have remained likewise important during the last 4 years. Nonetheless there are notable relevant trend directions:

The most important trend Development of customer specific products (Customizing) has gained little more significance compared to the last survey.

HR trends in R&D are becoming more and more relevant in industrial R&D. The most significant trend in this area Target-oriented competence development of R&D employees has gained more importance more than any other trend. Furthermore there are other HR trends in the top list which were not listed in 2009.

Although organizational trends in R&D are not listed in the list of the most important 10 they are still important and achieved high rank positions in the overall rating. The most significant organizational trends are in the order of significance Cooperation with external partners, Flexibility in R&D and Integration of R&D with other areas like production. There is a rising awareness in all industries that cooperation in R&D is essential for future success in particular when corporate R&D aims at radical innovations. Cooperation offer new opportunities for thinking out of the box and overcoming existing boundaries in habitual thinking. Also in industry areas that are characterized by interdisciplinary teamwork of different expertise such as medical technology the cooperation in R&D is a relevant key challenge.

5. Conclusions

Within this paper, the authors elaborated on selected trends in the fields of industrial R&D. The answers from 162 respondents of the advanced manufacturing, automotive, medical technology and other industries revealed the industrial significance of 34 different trends in the areas of R&D-strategy, -organization, - processes -methods and tools as well as -people.

The four most significant trends and key challenges found in the survey can be summarized as enhanced customer orientation in R&D, HR and competence management in R&D, R&D strategy and effectiveness, and efficiency and lean processes.

While customer orientation and involvement in R&D is getting more important in B2B and B2C markets there are several options for open R&D available. Potential options (Dahan & Hauser 2002; Harzer 2013) include observations (“listen in on the customer domain”), responding (“ask customers”) and active participation (“build with customers”), e.g. via toolkits for user innovation (Franke and Piller 2004), idea competitions (Piller and Walcher 2006; Ebner et al. 2009; Neyer et al. 2009), lead-user workshops (Lilien et al. 2002), or firm-hosted innovation communities (Blazevic and Lievens 2008; Jeppesen and Frederiksen 2006). While co-creation sparks interaction, increases engagement, and generates additional value, customer involvement in the entire value chain suggests new forms of co-creation by transforming traditional corporate practices (Prange and Ates 2010).

The second most relevant topic of the survey is employees in R&D, mainly with trends in the area of competence management which can be explained by
the increasing global competition. Many German companies see their ability to innovate as success factor and thus the competences of their employees. The challenges in competence management also include the high degree of digitalisation in an interconnected world and the still ongoing war for talents. Currently employees face the challenge to systematically develop competencies and contacts to relevant partners. Companies are struggling with questions how to support their employees and use their know-how for company. New impulses are offered by Internet technologies like Web 2.0 with various interactive formats. But there are still open questions in the organisational and social issues like what motivates experienced employees to handover expertise to their younger colleagues.

R&D strategy and effectiveness is another key challenge in R&D especially for small and medium enterprises (SMEs) that have limited availability of financial sources and where long-term planning and strategic technological orientation are mainly performed by solitary persons on the basis of their acquired experiences. For sustainable success of the company it can be helpful to formulate strategic goals and instruments for choosing and deciding on R&D projects and building responsibilities for monitoring relevant technology fields. Furthermore no company should miss the opportunity to use an increasing number of information sources and IT tools for a better strategic orientation and effectiveness in R&D.

The last of the four topics derived from the most important R&D trends and key challenges of the survey is efficiency and lean processes in R&D. To increase the efficiency in processes different approaches and methodologies can be applied, for example lean development or agile development. While lean development is an approach originally from manufacturing area, agile development was not accepted by manufacturing industries for a long time and is currently mainly used by software developers. Nowadays agile development gains for a second time more and more attention from companies which are typically used to traditional product development processes. Agile approaches are focused on adding value for customers and the most popular called Scrum is particularly interesting for complex development projects (Maximini 2013). Agile elements or combinations thereof can be integrated in existing development processes in order to increase efficiency. Some best practices show their potential.

With our research we will further elaborate on these key challenges as well as some trends we have identified by the open questions in the survey like new technologies such as 3D printing and new materials. Also the potentials of further digitalisation including so called intelligent products and production networks which are addressed by the German strategic initiative “Industrie 4.0” focussing on cyber-physical systems for manufacturing are quoted as important trends by industrial R&D. Besides of technological challenges one of the most important questions is how to manage the paradigm shift in manufacturing during operation conditions in existing factories. Therefore, strategies, methodologies and tools for the transformation towards the factories of the future still need to be developed and are addressed in current research projects (MetamoFAB 2014). Further statements of the respondents show that globalisation and new markets are also among the important trends in R&D management, while the most prominent trend found was around “Low Cost Innovation” (Wagner et al. 2010) and will be addressed in further studies at Fraunhofer IAO.

9. References


