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Potentials and Needs of Research References in Corporate Product Engineering

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Abstract: In product engineering, engineers take reference to already existing (socio-)technical systems or sub-systems to reduce development time and risk when developing innovations – successful new products. These references can originate from e.g., competitors, nature, or research. Especially research is a rich and potent source for references regarding knowledge and technologies on the edge in all disciplines. However, it is still neglected by many companies. Here we show the results of a survey with 31 participants from industry, academia, and funding agencies investigating the potentials and needs of using references from research facilities in corporate environments. The participants from industry see high potential for competitiveness, technological advances, and efficiency of development processes through better integration of research results as references. As one major challenge, they see searching for suitable references. We take these results as starting point for further research to support engineers in better using references from research.

Keywords: Product Engineering; Product Development; Innovation Management; PGE – Product Generation Engineering; Knowledge Management; Knowledge Transfer; Technology Transfer; Reference System; RSM – Reference System Management; Industry-Academia Collaboration

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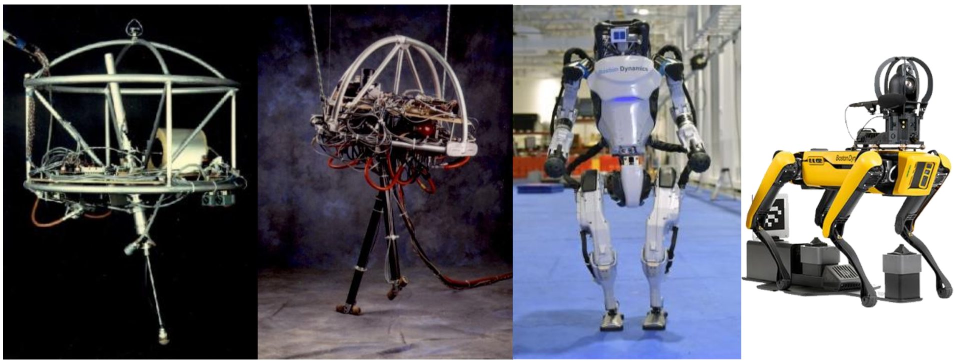
1 Introduction

Boston Dynamics (Boston Dynamics, 2022), a world-leading company in terms of autonomous and dynamic highly-mobile robots, is based on research conducted in a research facility. Precisely speaking, Boston Dynamics was founded in 1992 as a spin-off of the MIT, Massachusetts Institute of Technology. The founder Marc Raibert, an MIT Professor set up the knowledge and technologies he acquired and developed in the MIT Leg Lab to commercialize humanoid and animal-like robots as well as software for realistic human simulation. (Bora, 2018) Figure 1 shows prototypes of the MIT Leg Labs as well as current generations of Boston Dynamics robots as nowadays products based on these research results.



3D One-Leg Hopper (1983-1984) 3D Biped (1989-1995) Boston Dynamic Atlas Boston Dynamic Spot

Figure 1 Based on the knowledge and technologies developed in the MIT Leg Lab (e.g. the 3D One-Leg Hopper and 3D Biped (MIT Leg Laboratory)) Boston Dynamics robots (e.g. Atlas (Ngowi, 2021) and Spot (Boston Dynamics, 2022)) were developed.

This example shows, how taking reference to research results of universities or other research facilities can lead to innovations in competitive companies.

Generally speaking, using references such as already existing (technical) solutions, their documentation, or the experience of experts as the starting point for the development of new products can help to reduce the risk of failure as well as to decrease the development time (Eckert et al., 2004; Sivaloganathan and Shahin, 1999). Especially university research is a valuable source for such references since these are usually free to use as well as on the edge of knowledge and technology. While the example of Boston Dynamics represents the special case of a spin-off of a research facility, the knowledge and technology transfer to corporate applications in general needs improvement (Expertenkommission Forschung und Innovation, 2022). With this study, we aim on exploring and explaining the current role of references from university research in corporate product development projects. In our study, we are interested in the usage of research results of research facilities in corporate product engineering projects. Thus, we distinguish research as university research and research conducted by e.g., Fraunhofer Society, etc. from the activities conducted in R&D departments of companies.

2 References in Product Engineering

As shown in the example before, the development of new products does not start from scratch. New products are a mix of already existing successful designs with newly developed subsystems (Sivaloganathan and Shahin, 1999; Wyatt et al., 2009). Iyer et al. even state, that more than 75% of engineering activities are based on the reuse of engineering knowledge (Iyer et al., 2005).

Taking these findings into account, Albers, Bursac, and Wintergerst presented the Model of PGE – Product Generation Engineering to describe the basic principles of the development of new products (Albers et al., 2015). With this model, they enable research as well as the development of methodical support for product engineering. As illustrated in figure 2, within the model of PGE – Product Generation Engineering, the development of new products is described as the development of a new product generation G_n based on the corresponding reference system R_n. Hereby, "[R_n] is a system whose elements originate from already existing or already planned socio-technical systems and the associated documentation […]." (Albers et al., 2019) Product engineers develop G_n varying the reference system elements (RSE). Therefore, the model of PGE – Product Generation Engineering distinguishes three types of variation: carryover variation (CV), embodiment variation (EV), and principle variation (PV) (Albers et al., 2015). The sum of embodiment and principle variation forms the share of new development. In a principle variation, the solution principle of a reference system element is altered, while the solution principle is maintained, but the embodiment is changed in an embodiment variation. On the other hand, design changes are minimal in carryover variation (Albers et al., 2015).

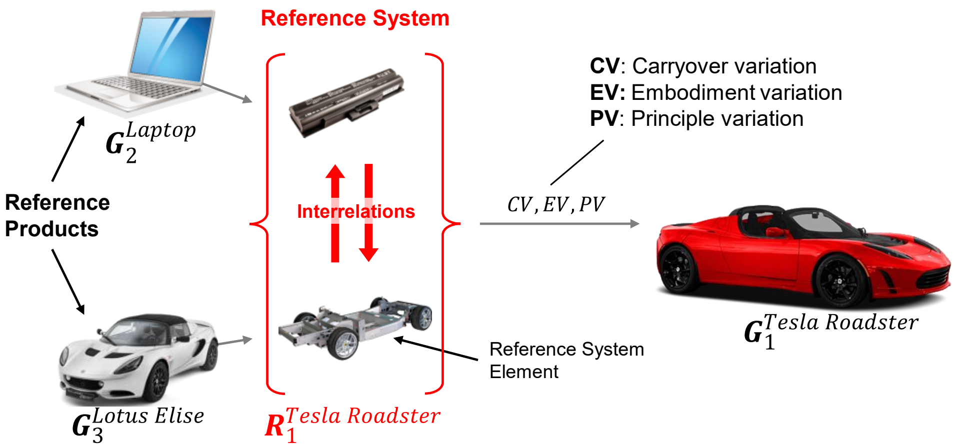


Figure 2 The Model of PGE – Product Generation Engineering describes the development of a new product generation G_n based on the variation of reference system elements (based on (Albers et al., 2019)).

The development of the reference system is a complex task in itself. Starting from the definition of the reference system as presented before, elements can originate from various sources. Hajialibeigia distinguishes four classes as possible sources for reference system elements (Hajialibeigi, 2021):

- "vertical class: suppliers, private clients, public clients

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- horizontal class: competitors
- societal class: consultants, government, private research institutes, professional associations
- specialized class: universities, conferences, scientific journals"

As shown in figure 3, the *reference system element identification atlas* considers 12 knowledge spaces from the point of view of a corporate product engineer. Reference system elements can originate from four different categories. These are the same branch, other branches, research, and society/ nature. In all of these categories, the elements can either be corporate knowledge already, part of the total accessible knowledge for the engineer, or part of the globally existing knowledge. In addition to the knowledge spaces as sources for reference system elements, the reference system identification atlas classifies 30 methods and tools to identify reference system elements to the respective knowledge spaces. (Kempf et al., Manuscript submitted for publication)

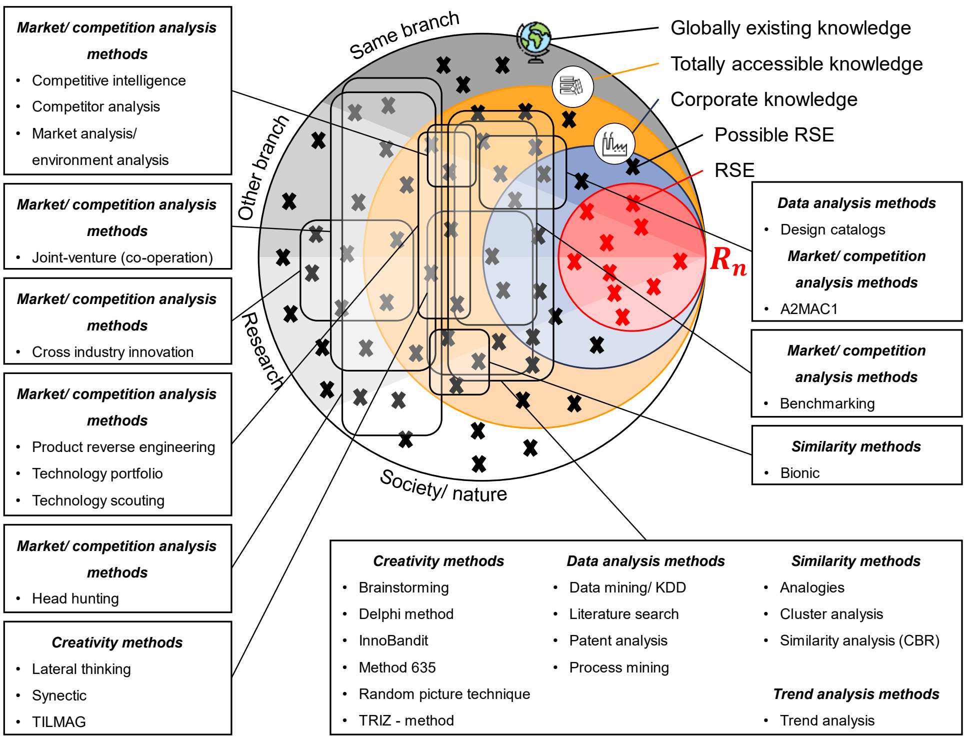

Figure 2 The reference system identification atlas classifies 30 methods and tools to the respective knowledge spaces to identify reference system elements (Kempf et al., Manuscript submitted for publication).

Hereby, the importance of knowledge and technology transfer of research results to companies is growing. The usage of research results in corporate product development is said to be one significant aspect of keeping up innovativeness. (Expertenkommission Forschung und Innovation, 2022; Frank et al., 2007; Wissenschaftsrat, 25.05.2007)

3 Research Profile

Aim of Research

The main goal of this contribution is the exploration of the actual role of research results as reference system elements in corporate product engineering projects. Therefore, we want to determine the awareness of corporate product engineers for the benefits of these reference system elements. This is represented in our first research question.

> *Research Question 1: How do corporate product engineers see the importance and potential of using reference system elements from research in corporate product engineering projects?*

Following, we want to assess the status of this knowledge and technology transfer by addressing the need/ potential for improvement of the integration of reference system elements from research in corporate product engineering projects. This is addressed in the second research question.

> *Research Question 2: Do corporate product engineers see a need to improve the usage of reference system elements from research in corporate product engineering projects?*

Lastly, we want to compare the point of view of corporate product engineers to researchers and representatives of funding agencies.

> *Research Question 3: What are the differences and similarities in the perception of the role of reference system elements from research in corporate product engineering projects of researchers and representatives of funding agencies compared to corporate product engineers?*

Research Methodology

To answer the formulated research questions, we designed an online survey using the tool LimeSurvey. To address both groups, corporate product engineers as well as researchers, and representatives of funding agencies, the survey was designed in two versions. All questions are attached in appendixes A and B. To keep the survey simple, we avoided too scientific terms such as reference system elements in the survey and gave examples of what we consider research results in the beginning:

- Technological results: e.g. new energy storage systems (battery systems), fiber composites for lightweight construction applications, or AI algorithms for autonomous driving
- Processual results: e.g. new working models, or efficiency-increasing elements
- Methodological results: e.g. new creativity methods, methods for structure/shape optimization, or problem-solving methods

While we asked corporate product engineers for information on the company’s size and their background of working in a scientific environment, researchers and representatives of funding agencies could start with the main questions directly. In the first section of the main part, we asked for the following:

- Frequency of using reference system elements from research
- Involvement of engineers of the company in the research projects where the used reference system elements were developed
- Simplicity of identifying relevant reference system elements in research

To answer these questions, we offered a closed set of answers.

In the second section of the main part, we used a five-point Likert scale for the participants to rate the following statements:

- Research generates results that are relevant for product engineering in companies
- In my company, there is potential for improvement in the integration/ consideration of research results
- To develop more innovations, the integration/ consideration of research results should be improved in my company
- To accelerate technological progress, the integration/ consideration of research results should be improved in my company
- To increase competitiveness, the integration/ consideration of research results should be improved in my company
- To create a more efficient engineering process, my company should make greater use of research results
- I would like to use research results in my work more often
- I know what I have to consider when integrating/considering research results
- I receive sufficient support when searching for results from research

The Likert scale ranged from total disagreement to total agreement.

While the presented statements are formulated for participating corporate product engineers, the statements for researchers and representatives of funding agencies were asking for their perception of the usage and potential of reference system elements from research in corporate product engineering projects.

In the end, we asked every participant for their work experience and highest qualification. Additionally, we asked the corporate engineers for an allocation to their sector.

Research Environment

We conducted this study within nine collaborative projects of industry and academia. Each of these projects has a consortium of scientific and corporate partners working together in the field of advanced systems engineering. These projects are all part of the PDA_ASE program and are funded by the German Federal Ministry of Education and Research. (ASE, 2022)

We started the survey on August 25th in 2022 and closed it on September, 30th in 2022 and was conducted in German.

We are aware, that all participants being part of a research project might impose a light positive bias on the answers because of their affinity to research.

4 Results

In the following, we present the results of our online survey (for all result see appendices A and B). In total, 90 participants started the survey but only 31 completed it and will thus be considered in the following presentation of the results. These 31 participants split up into 22 corporate product engineers and nine researchers. Six of the researchers are working at universities, while the other three indicated to be working for other research facilities. Even though one representative of the funding agency is allocated to each of the nine PDA_ASE projects, none of these representatives did participate in the survey.

Having a closer look at the participating corporate product engineers, figure 3 shows their segmentation regarding different sectors. While most participants are working in mechanical and plant engineering (9), medical technology (4), electrical engineering (3), and consulting (3), only one person from the sectors of software, and automotive engineering participated. One person did choose *other* as their allocation.

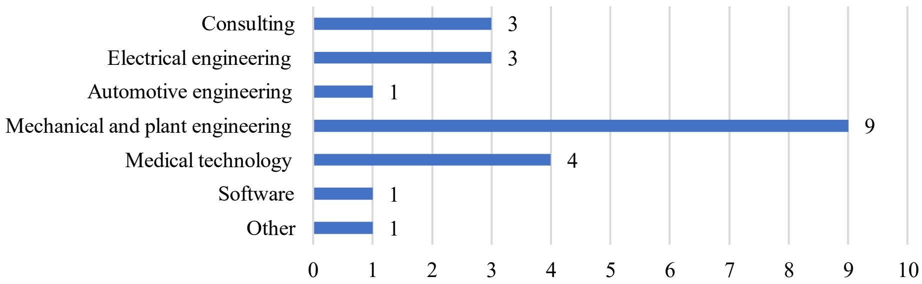

Figure 3 Segmentation of the participating corporate product engineers

All of the 22 corporate product engineers do have a scientific background. Two of them have a bachelor's degree, ten have a master's degree or diploma, nine have a doctoral degree, and one is a professor. Hereby, the professor and eight of the nine engineers with doctoral degrees as well as five of the ten engineers with master's degrees have been working for a research facility before their current job. Thus, the two engineers with bachelor's degrees, five with master's degrees, and one with a doctoral degree do not have experience working in research.

As figure 4 illustrates, 16 of the 22 corporate product engineers use reference system elements from research in their daily work at least monthly. Only two stated to never use reference system elements from research while two could not answer this question. Ten of the corporate engineers stated, that they or their colleagues were involved in the research projects where the reference system elements were created in more than 50% of the cases.

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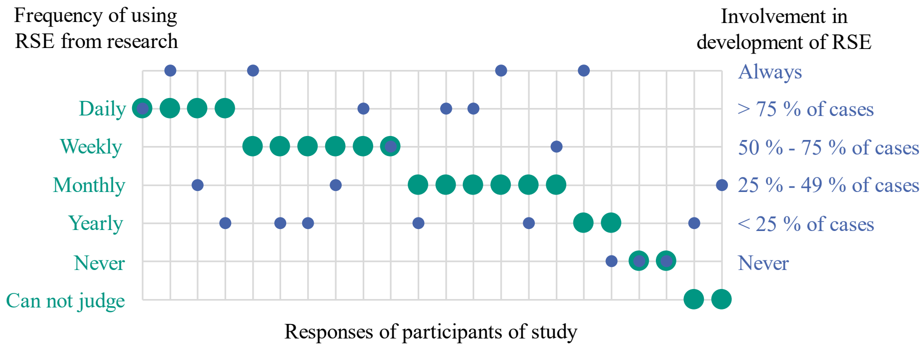

Figure 4 Frequency of usage of reference system elements from research of the participating corporate product engineers in corporate product engineering projects and the involvement of the participating corporate product engineers or their colleagues in the development of these reference system elements in research projects. The responses are sorted by descending frequency of usage of reference system elements from research.

Importance and potential of using reference system elements from research in corporate product engineering projects

Looking at the importance of reference system elements from research in corporate product engineering projects, figure 5 shows the agreement or disagreement of the participating corporate engineers to respective statements. About 73% agree to the general relevancy of research results for corporate product engineering at least partly. 73% see a positive relationship between using reference system elements from research and the development of innovations. Regarding the technological progress and competitiveness of the companies 82% respectively 77% see a positive relationship. 68% agree on a positive relationship between the use of reference system elements from research and the improvement of engineering processes.

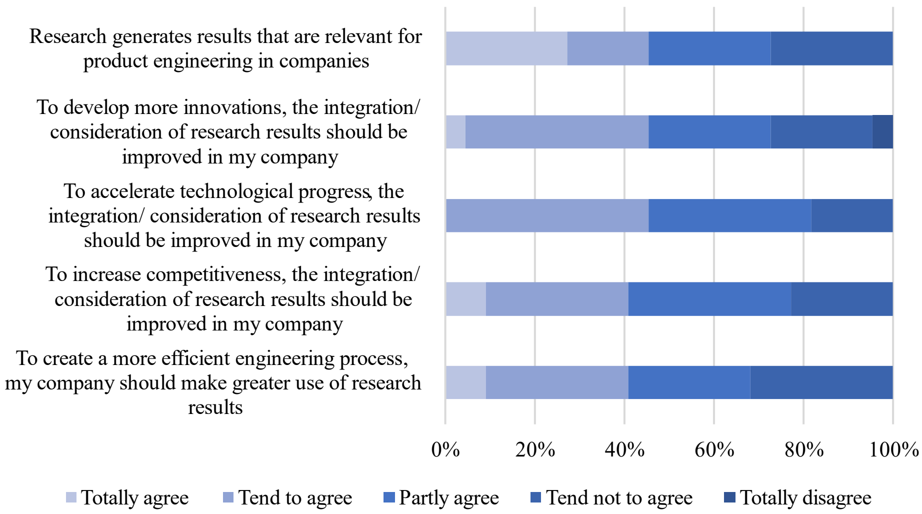

Figure 5 Agreement of corporate product engineers to the statements regarding the importance of using reference system elements from research in corporate product engineering (n = 22). The responses show a general awareness of the corporate product engineers of the importance of reference system elements in corporate product engineering.

As illustrated in figure 6, 91% of the participating corporate engineers agree that their companies have potential in improving the integration/ work with reference system elements from research. On the other hand, 82% of the corporate engineers would like to work with reference system elements from research in their daily work, more often.

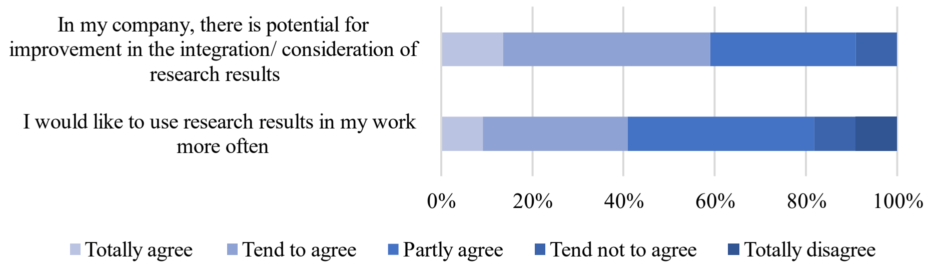

Figure 6 Most participating corporate engineers see potential for improvement in the integration/ consideration of reference system elements from research in corporate product engineering projects. The majority would like to work with reference system elements from research more often (n=22).

Need to improve the usage of reference system elements from research in corporate product engineering projects

However, as figure 7 shows, 48% state that finding suitable reference system elements in research is only possible with great effort while 52% think it is possible with reasonable effort – none states, it would be easy. According to the results of the study, using the reference system elements from research in a corporate environment is even harder. 57% of the participating corporate engineers stated it is only possible with great effort.

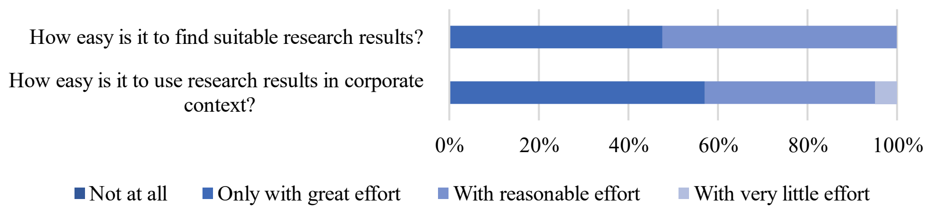

Figure 7 According to the participating corporate product engineers, finding reference system elements in research and using them in corporate product engineering requires great effort (n=21).

As presented in figure 8, only 14% think they are supported sufficiently, when searching for reference system elements in research. Furthermore, only 32% know what has to be considered when working with reference system elements from research in corporate product engineering projects.

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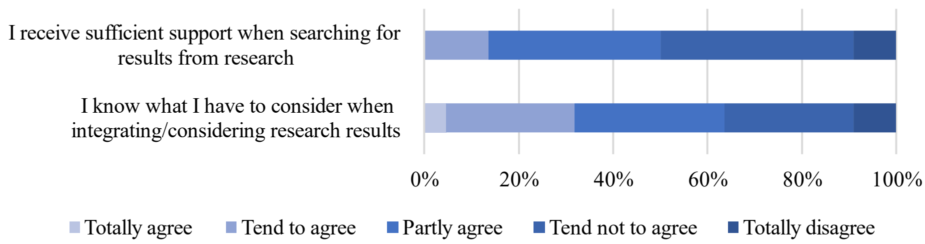

Figure 8 Only a minority of corporate product engineers think they are supported in the search for reference system elements in research, sufficiently or know what has to be considered when working with reference system elements from research in corporate product engineering projects (n=22).

Differences and similarities in the perception of researchers and representatives of funding agencies compared to corporate product engineers

Looking at the responses of the participating researchers, figure 9 shows that 78% think research produces relevant results for corporate product engineering. 89% agree with the three statements, that the usage of reference system elements from research is beneficial for the development of innovations, increased competitiveness, and set up of more efficient engineering processes at least partly. Furthermore, all participating engineers expect a positive relationship between using reference system elements from research and the technological progress in companies.

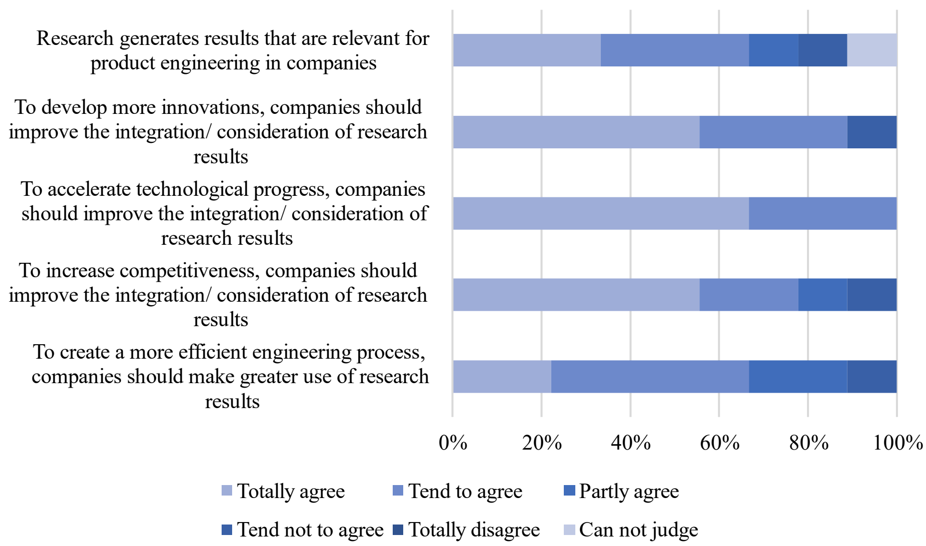

Figure 9 Agreement of researchers to the statements regarding the importance of using reference system elements from research in corporate product engineering (n = 22). The responses show an awareness of the researchers of the importance of reference system elements in corporate product engineering (n = 9).

Figure 10 illustrates that all researchers (only one could not judge) believe that there is potential for companies to improve the work with reference system elements from research. Furthermore, all but one agree at least partially that reference system elements from research should be used more often in corporate product engineering.

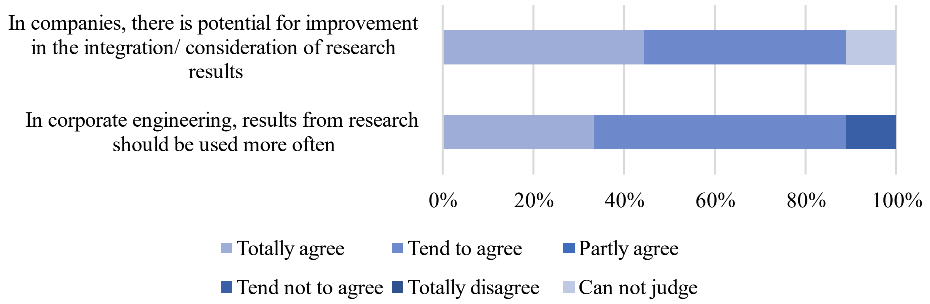

Figure 10 The researchers see potential for improvement in the integration/ consideration of reference system elements from research in corporate product engineering projects and believe these reference system elements should be used more often (n = 9).

Looking at the simplicity of finding reference system elements in research and using them in a corporate context, figure 11 shows that researchers see challenges. 44% state that finding suitable reference system elements in research is only possible with great effort while only 33% believe it is possible with reasonable to little effort (22% could not judge). Applying these reference system elements in a corporate context, even 66% think it is only possible with great effort. Again, 22% could not judge.

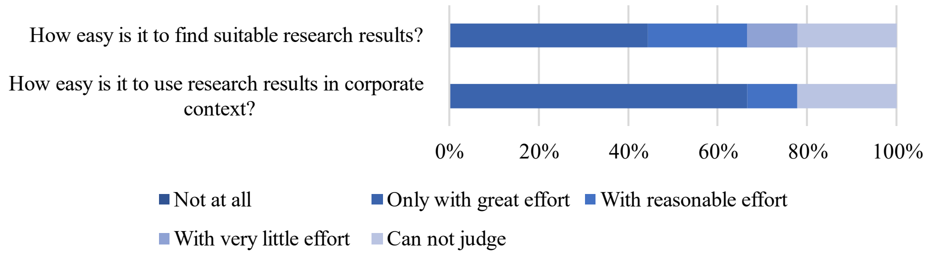

Figure 11 According to the participating researchers, they expect finding reference system elements in research and using them in corporate product engineering requires great effort (n = 9).

Looking at figure 12, 66% of the participating researchers believe that corporate engineers are not supported, sufficiently when searching for reference system elements in research. Only 11% believe they are supported sufficiently, while 22% could not judge. Furthermore, all researchers but one (could not judge) believe that corporate engineers do not know all that they have to consider when working using reference system elements from research in their corporate environment.

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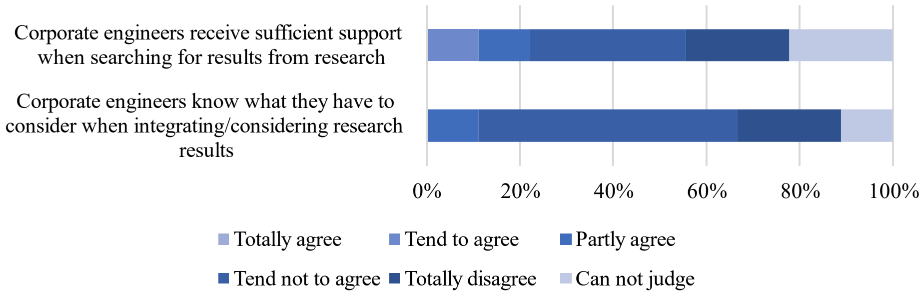

Figure 12 Only a minority of researchers think they are supported in the search for reference system elements in research, sufficiently or know what has to be considered when working with reference system elements from research in corporate product engineering projects (n = 9).

5 Discussion

The results show that the participating corporate engineers in general agree on the importance of reference system elements from research in corporate product engineering projects (compare figure 5). Only 27% tend to disagree with this statement. Hereby, between 41% and 45% of the participating corporate engineers see a high potential in terms of developing more innovations, accelerating technological advances, increasing competitiveness, and increasing the efficiency of the engineering process by improving the work with reference system elements from research in their companies. On top of these engineers, another 27% to 36% expect a potential in some cases.

Comparing these findings to the point of view of the participating researchers (compare figure 9), a mismatch becomes evident. Between 78% and 100% of these researchers see a high potential for companies to develop more innovations, accelerate technological advances, and increase competitiveness by improving the work with reference system elements from research. 67% see a high potential to increase the efficiency of the engineering process. Summing up all participating researchers that see a potential to improve these four factors at least partially, 89% and more agree with this statement. We expect these higher numbers are partly reasoned by the different point of view of researchers towards their research as well as less knowledge of the researchers about corporate boundary conditions and requirements. But since these numbers are significantly higher than for the corporate engineers, we conclude that the corporate engineers are unaware of many valuable potential reference system elements from research. This can have two reasons. First, the engineers cannot see or evaluate the potential of many research results as reference system elements. This again can have multiple reasons. For example, it might be that the researchers did not describe the potential benefits, application areas, or boundary conditions for their results. Furthermore, there can be e.g., communication issues due to different terminologies, etc. Second, the corporate engineers do not know relevant reference system elements from research because they could not find them.

In general, both groups of participants see potential to improve the work with reference system elements in corporate product engineering projects (compare figures 6 and 10).

Therefore, the principal willingness and wish of the participating engineers to use research results more often is a valuable premise.

On the other hand, the participants identified searching for reference system elements in research and using them in a corporate as challenging (compare figures 7 and 11). About 50% of the participating corporate engineers stated both would only be possible with great effort. Here we discovered, that all engineers that stated finding suitable reference system elements in research and using them in the corporate context require reasonable effort are working with such reference system elements regularly at least monthly. The perception of the participating researchers is even more negative. They rated the effort for searching quite similar and for using the reference system elements significantly higher. The majority of the participating researchers expect great efforts to use reference system elements from research in corporate product engineering projects. However, it has to be considered that it is hard for the participating researchers to judge the effort of corporate engineers. Thus, two researchers each were not able to judge the efforts.

These challenges are stressed by the lack of support for the participating corporate engineers (compare figure 8). 86% state that they do not get sufficient support in searching for reference system elements in research. This perception is stressed by the participating researchers (compare figure 12). Following up, 68% of the participating corporate engineers state that they do not know all that is necessary to use reference system elements from research in their corporate environments.

6 Conclusion and Outlook

Based on the presented results, we conclude that research results play an important role as reference system elements in corporate product engineering. Both participating groups, corporate engineers, and researchers agree with this statement.

Thus, we can answer the first research question concerning the perception of the importance and potential of reference system elements from research in corporate product engineering. Most corporate engineers expect a beneficial influence on developing innovations, accelerating technological advances, getting competitive advantages, and improving the engineering processes in their companies through improved usage of reference system elements. Furthermore, we conclude, that corporate engineers not only see potential in the improved usage of reference system elements from research but are also willing to reach out to research results more often. This is an important finding since this lowers the barriers to increasing and improving the usage of reference system elements from research in corporate product engineering. No mindset change seems necessary.

Looking at the second research question concerning the needs to improve the usage of reference system elements from research in corporate product engineering, the participating engineers confirmed that searching for such reference system elements and using them in a corporate environment are relevant challenges and need to be improved. We conclude that the search for reference system elements in research needs to be supported. Furthermore, we discovered that there is a lack of knowledge in terms of applying or using reference system elements from research in corporate product engineering environments. This finding is stressed even more since most of the participating corporate engineers are working with reference system elements from research in their daily work regularly.

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Last, regarding the third research question considering the differences and similarities between the researcher's point of view compared to the point of view of corporate engineers, we conclude that they are on the same page. In the results, we saw that their opinion is a bit more homogenous compared to the participating corporate engineers'.

To set these findings into relation it is important to consider the limitations of this study. We are aware that due to the selection of participants we do have a bias in our results. Since the participating corporate engineers are all members of collaborative projects with research we have to anticipate that they are more research affine. 73% of these corporate engineers do use reference system elements from research in their daily work regularly at least monthly. Only 9% of the participating corporate engineers stated to never use reference system elements from research. We conclude that this does not necessarily represent corporate engineers in general. In the same way, the awareness for the potential of reference system elements from research for innovation, technological progress, competitivity, and efficiency of engineering processes could be less pronounced in a set of corporate engineers that are less research affine. This would not change the interpretation of the importance of reference system elements from research for corporate product engineering but pose the challenge of increasing the awareness of corporate engineers for the matter. Since our set of participants is involved with research, they are more likely to judge the potential of such reference system elements.

Due to the limited number of participants from the industry, no branch-specific conclusions can be drawn. Similarly, no one from funding agencies participated. Thus, we are not able to consider their view and by this mean the point of view of politics in this matter. However, from the state of research presented, we conclude that in general, politics as well see a need to improve the transfer of knowledge and technologies from research into corporate engineering.

We take these results as a starting point for further research. After corporate engineers confirmed a need to improve and increase the work with reference system elements from research, we will conduct a study to understand more about the different types of research results. Thus, we want to find different classes and categories of research results. Consecutively, we intend to derive the measures necessary to consider and undertake when searching and using reference system elements from research specifically to the different categories.

To understand, when corporate engineers use reference system elements from research, we will investigate reasons and triggers in detail. Furthermore, we will explore the barriers and challenges corporate engineers have to face when searching for reference system elements in research and using them in a corporate context.

Combining these aspects, we will develop a descriptive model that explains the relations and dependencies of different types of research results as references system elements to different reasons and triggers as well as the expected barriers and challenges. Among others, this will allow us to formulate trifold recommendations. First, we can formulate recommendations for researchers to lower the barriers for corporate engineers when looking for and using their results. Second, we intend to provide recommendations to politics/ funding agencies to foster the applicability of research results as reference system elements in corporate product engineering. And third, we will give recommendations for corporate engineers to overcome the challenges due to the different natures of academia and industry.

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Appendix

A – Results of Online Survey: Industry

Response ID	Participant from:	Size of company	Have you previously worked in a research institution?	How often do you use* results (technological, process, methodological) from research in your work?	Were you or colleagues from your company involved in the research projects that produced the research results?	How easy is it to find suitable research results?	How easily can research results be used in a corporate context?	Research generates results relevant to product engineering in companies.
19	Company	50 - 249 Employees	No	Weekly	Always	Only with great effort	Only with great effort	Totally agree
30	Company	250 - 5000 Employees	No	Weekly	25 % - 49 % of cases	With reasonable effort	Only with great effort	Totally agree
33	Company	250 - 5000 Employees	No	Weekly	> 75 % of cases	With reasonable effort	With reasonable effort	Totally agree
37	Company	50 - 249 Employees	Yes	Monthly	Always	With reasonable effort	With reasonable effort	Partly agree
41	Company	50 - 249 Employees	Yes	Yearly	Always	Only with great effort	Only with great effort	Tend to agree
43	Company	10 - 49 Employees	No	Weekly	50 % - 75 % of cases	With reasonable effort	With reasonable effort	Partly agree
44	Company	> 5000 Employees	No	Monthly	< 25 % of cases	With reasonable effort	With reasonable effort	Tend to agree
46	Company	50 - 249 Employees	Yes	Yearly	Never	Only with great effort	Only with great effort	Tend not to agree
48	Company	250 - 5000 Employees	Yes	Monthly	50 % - 75 % of cases	With reasonable effort	Only with great effort	Partly agree
52	Company	< 10 Employees	Yes	Daily	> 75 % of cases	With reasonable effort	With reasonable effort	Totally agree
56	Company	10 - 49 Employees	Yes	Monthly	< 25 % of cases	Only with great effort	With reasonable effort	Partly agree
58	Company	10 - 49 Employees	Yes	Monthly	> 75 % of cases	With reasonable effort	With reasonable effort	Partly agree
59	Company	10 - 49 Employees	Yes	Weekly	< 25 % of cases	Only with great effort	Only with great effort	Tend to agree
61	Company	10 - 49 Employees	Yes	Daily	Always	Only with great effort	Only with great effort	Tend not to agree
65	Company	50 - 249 Employees	No	Can not judge	< 25 % of cases	Only with great effort	Only with great effort	Tend not to agree
71	Company	> 5000 Employees	No	Daily	25 % - 49 % of cases	With reasonable effort	Only with great effort	Tend to agree
79	Company	250 - 5000 Employees	Yes	Monthly	> 75 % of cases	With reasonable effort	With very little effort	Totally agree
89	Company	250 - 5000 Employees	Yes	Weekly	< 25 % of cases	Only with great effort	Only with great effort	Tend not to agree
92	Company	250 - 5000 Employees	Yes	Never		Only with great effort	Only with great effort	Tend not to agree
97	Company	250 - 5000 Employees	Yes	Can not judge	25 % - 49 % of cases	Can not judge	Can not judge	Partly agree
101	Company	250 - 5000 Employees	No	Never		Only with great effort	Only with great effort	Totally agree
107	Company	> 5000 Employees	Yes	Daily	< 25 % of cases	With reasonable effort	With reasonable effort	Tend not to agree

In my company, there is potential for improvement in the integration/ consideration of research results.	To develop more innovations, the integration/ consideration of research results should be improved in my company.	To accelerate technological advances, the integration/ consideration of research results should be improved in my company.
Partly agree	Tend not to agree	Tend to agree
Totally agree	Tend to agree	Tend to agree
Partly agree	Tend not to agree	Partly agree
Partly agree	Partly agree	Partly agree
Partly agree	Tend to agree	Tend to agree
Partly agree	Partly agree	Tend to agree
Tend to agree	Partly agree	Partly agree
Totally agree	Totally agree	Tend to agree
Tend to agree	Partly agree	Partly agree
Tend not to agree	Tend not to agree	Tend not to agree
Tend to agree	Tend to agree	Partly agree
Tend to agree	Tend not to agree	Tend not to agree
Tend to agree	Partly agree	Partly agree
Tend not to agree	Totally disagree	Tend not to agree
Partly agree	Tend not to agree	Tend not to agree
Tend to agree	Tend to agree	Tend to agree
Tend to agree	Tend to agree	Tend to agree
Tend to agree	Tend to agree	Tend to agree
Tend to agree	Tend to agree	Tend to agree
Partly agree	Partly agree	Partly agree
Tend to agree	Tend to agree	Tend to agree
Totally agree	Tend to agree	Partly agree

To increase competitiveness, the integration/consideration of research results should be improved in my company.	To design a more efficient engineering process, more research results should be used in my company.	I would like to draw on research findings more often in my work.
Tend to agree	Totally agree	Tend to agree
Partly agree	Partly agree	Totally agree
Partly agree	Tend not to agree	Totally disagree
Partly agree	Partly agree	Tend not to agree
Tend to agree	Tend to agree	Tend to agree
Tend to agree	Tend not to agree	Partly agree
Tend not to agree	Totally agree	Partly agree
Totally agree	Tend to agree	Totally agree
Partly agree	Tend to agree	Tend to agree
Tend not to agree	Tend not to agree	Partly agree
Tend to agree	Tend to agree	Tend to agree
Tend not to agree	Tend not to agree	Partly agree
Partly agree	Partly agree	Partly agree
Tend not to agree	Tend not to agree	Tend to agree
Tend not to agree	Partly agree	Tend not to agree
Tend to agree	Tend to agree	Tend to agree
Partly agree	Tend to agree	Partly agree
Totally agree	Partly agree	Tend to agree
Tend to agree	Tend to agree	Partly agree
Partly agree	Partly agree	Partly agree
Tend to agree	Tend not to agree	Partly agree
Partly agree	Tend not to agree	Totally disagree

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I know what to consider when integrating/ considering research findings.	I am adequately supported in seeking results from research.	Sector	Sector [other]	How many years of work experience have you gained?	What is your highest qualification?
Partly agree	Tend not to agree	Mechanical & plant engineering		1 - 4 Years	Master/ Diploma
Partly agree	Partly agree	Electrical engineering		> 10 Years	Bachelor
Tend to agree	Tend to agree	Mechanical & plant engineering		> 10 Years	Master/ Diploma
Tend to agree	Tend not to agree	Other		> 10 Years	Doctor
Partly agree	Tend not to agree	Mechanical & plant engineering		> 10 Years	Doctor
Tend to agree	Partly agree	Mechanical & plant engineering		1 - 4 Years	Master/ Diploma
Tend not to agree	Tend not to agree	Mechanical & plant engineering		> 10 Years	Master/ Diploma
Totally disagree	Totally disagree	Consulting		1 - 4 Years	Master/ Diploma
Partly agree	Partly agree	Medical technology		> 10 Years	Professor
Tend to agree	Tend to agree	Medical technology		> 10 Years	Doctor
Partly agree	Tend not to agree	Consulting		> 10 Years	Master/ Diploma
Tend to agree	Tend to agree	Electrical engineering		5 - 10 Years	Doctor
Tend not to agree	Tend not to agree	Software		5 - 10 Years	Master/ Diploma
Tend to agree	Partly agree	Consulting		> 10 Years	Doctor
Totally disagree	Totally disagree	Medical technology		> 10 Years	Doctor
Tend not to agree	Tend not to agree	Automotive engineering		> 10 Years	Bachelor
Partly agree	Partly agree	Mechanical & plant engineering		1 - 4 Years	Doctor
Tend not to agree	Partly agree	Mechanical & plant engineering		> 10 Years	Doctor
Tend not to agree	Tend not to agree	Mechanical & plant engineering		5 - 10 Years	Doctor
Partly agree	Partly agree	Electrical engineering		< 1 Year	Master/ Diploma
Tend not to agree	Tend not to agree	Medical technology		> 10 Years	Master/ Diploma
Totally agree	Partly agree	Mechanical & plant engineering		5 - 10 Years	Master/ Diploma

B – Results of Online Survey: Not Industry

Response ID	Participant from:	How often do corporate engineers use* results (technological, process, methodical) from research?	Do the research results used originate from research projects involving the employees of the respective company?	How easy is it to find suitable research results?
26	Other research facility	Weekly	50 % - 75 % of cases	Only with great effort
63	University reserach	Can not judge	< 25 % of cases	Only with great effort
66	University reserach	Yearly	> 75 % of cases	Only with great effort
67	University reserach	Can not judge	< 25 % of cases	Can not judge
69	University reserach	Can not judge	Can not judge	Can not judge
70	Other research facility	Daily	> 75 % of cases	With very little effort
76	University reserach	Daily	50 % - 75 % of cases	With reasonable effort
81	University reserach	Can not judge	> 75 % of cases	Only with great effort
96	Other research facility	Can not judge	Can not judge	With reasonable effort

How easily can research results be used in a corporate context?	Research generates results relevant to product engineering in companies.	In companies, there is potential for improvement in the integration/ consideration of research results.	To develop more innovations, companies should improve the integration/ consideration of research results.
Only with great effort	Partly agree	Tend to agree	Totally agree
Only with great effort	Totally agree	Tend to agree	Tend to agree
Only with great effort	Tend to agree	Totally agree	Tend to agree
With reasonable effort	Totally agree	Totally agree	Totally agree
Only with great effort	Tend not to agree	Totally agree	Tend not to agree
Can not judge	Tend to agree	Tend to agree	Tend to agree
Only with great effort	Totally agree	Can not judge	Totally agree
Only with great effort	Can not judge	Totally agree	Totally agree
Can not judge	Tend to agree	Tend to agree	Totally agree

To accelerate technological advances, companies should improve the integration/consideration of research results.	To increase competitiveness, companies should improve the integration/consideration of research results.	To create a more efficient engineering process, companies should make more use of research findings.
Tend to agree	Totally agree	Partly agree
Tend to agree	Tend to agree	Tend to agree
Totally agree	Tend not to agree	Tend to agree
Totally agree	Totally agree	Tend to agree
Totally agree	Partly agree	Tend not to agree
Totally agree	Totally agree	Tend to agree
Totally agree	Totally agree	Totally agree
Totally agree	Totally agree	Totally agree
Tend to agree	Tend to agree	Partly agree

In corporate work, results from research should be used more often.	Corporate engineers know what to consider when integrating/ considering research findings.	Corporate engineers are adequately supported in their search for results from research.	How many years of work experience have you gained?	What is your highest qualification?
Tend to agree	Tend not to agree	Tend not to agree	1 - 4 Years	Master/ Diploma
Totally agree	Tend not to agree	Partly agree	5 - 10 Years	Master/ Diploma
Tend to agree	Tend not to agree	Totally disagree	5 - 10 Years	Master/ Diploma
Tend to agree	Totally disagree	Totally disagree	1 - 4 Years	Master/ Diploma
Tend not to agree	Tend not to agree	Can not judge	> 10 Years	Master/ Diploma
Tend to agree	Can not judge	Can not judge	> 10 Years	Master/ Diploma
Totally agree	Tend not to agree	Tend not to agree	5 - 10 Years	Master/ Diploma
Totally agree	Totally disagree	Tend to agree	1 - 4 Years	Doctor
Tend to agree	Partly agree	Tend not to agree	> 10 Years	Master/ Diploma