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**ANALYSIS OF PRODUCT DEVELOPMENT  
PROCESS SUCCESS FACTORS**  
SUMMARY OF PHD THESIS

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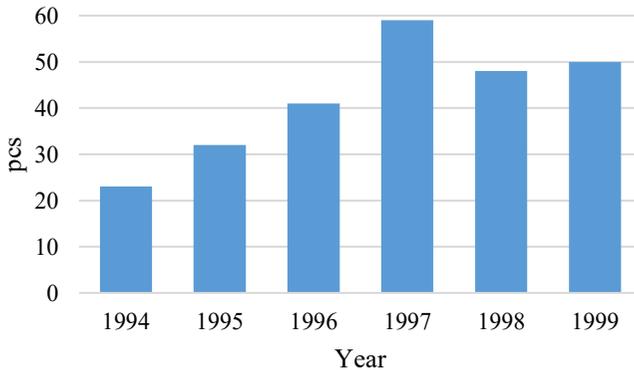
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# 1 INTRODUCTION

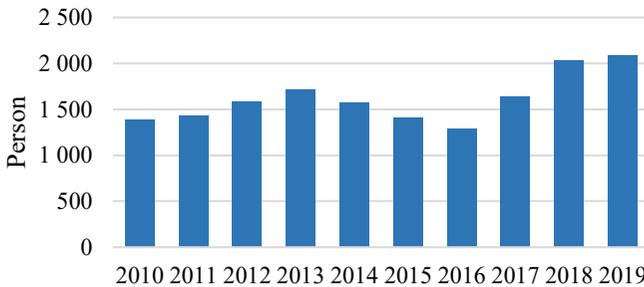
In history, continuous improvement, new ideas, and developments have been making people's life easier [1]. Newer and newer products, solutions, and processes are popping up to satisfy needs. The acceleration of diffusion of novelties throughout market needs and technology development appears as the compulsion of innovation [2].

Ernst's [3] analysis points to an increase in attention to the topic. Between 1994 and 1999, 250-300 publications were published (Figure 1.) examining the success of new products, some of these specifically focusing on the success of product development. There is a great interest in these studies of product development and the success of product development from the managers of companies to be able to compare their own activities with other market participants [3].



*Figure 1. Number of publications of success of product development [3]*

The strong research and publication activity in the second half of the 1990s on developing new products continued in the 2000s. Search for “New Product Development Success” in Google Scholar shows 5,200,000 results, narrowing the results to 637,000 from 2017 and 62,000 from 2020. Due to the screening algorithms, the number of hits is not entirely reliable – and not all directly related to my research – but there is definitely a remarkable amount of research results, which is a good indication of the widespread interest in the topic.



*Figure 2. Number of product development jobs at companies in Hungary  
(Source: KSH)*

In the everyday operation of industrial companies, it is essential to develop and improve continuously the products that work well in the market. In Hungary, more and more companies establish product development departments and centers. Over the past ten years, the proportion of product development professionals has visibly increased at companies (Figure 2.). These enhancements ensure that the product remains attractive towards the end of its life cycle. Due to the improvement, a new or “face-lifted” product is launched, which is just so new, different from the previous product, that consumers feel the need to replace the old product and buy a new product. Nowadays, customer demand for new products has become more and more intense. Because of technological development, newer and newer technical solutions and new functions appear on the market faster and faster, which in itself requires the further development of products and the provision of new functions. Customers are demanding new, innovative solutions quicker due to new features and new opportunities. Companies that cannot keep up with the requirements are leaving the market. To maintain or improve the market position, it is not enough to develop further existing products, but it will also be necessary to develop new products based on entirely new technologies [4]. Of course, the speed, the need for newer features, the introduction of newer products depends on the industry, but face-lifts only need to bridge the development time of a new product to temporarily satisfying customer needs.

Novák [5] points out that non-technical innovations play a crucial role in the success of the company level, as technical innovations can only be successful if they are implemented parallel with organizational, managerial, management, market innovations. To remain competitive, therefore, they need to renew their management approaches and methods fundamentally. Although the appreciation of organizational factors is important, in my opinion, the product and service remain a key element. Without these, organizational and organizational challenges cannot be answered; therefore, the product development process must be given special attention.

Overall, due to the speed-up of the market, customer needs mean a higher level of requirements for faster product development processes and product to market. This higher speed of product development projects is not required beyond the customers by the investor or company management. A company that can be fast in product development can easily become a market leader because technologies and product made by that will be role models to follower companies. Otherwise, lead time to market and the speed of product development have a direct influence on profitability, return, and profit; maybe this topic is the most important to owners and investors. Metrics of today's companies are based on evaluation on a quarterly or a yearly level. That is why shorten time to market introduction of a product directly improve or late of product development project directly reduce the profit of a company. The Influence of that directly visible on rely on investors and sometimes on the stock market.

As a practicing professional, I have been working in the field of product development for 18 years. I gained experience in multinational companies. Due to my tasks, I have been able to form a comprehensive picture of product development practice, including the technical content as well as the project management challenges. Product development involves high risk and a high degree of uncertainty, and the process is typically managed as a project. In evaluating successes and failures, organizational issues and project management often proved to be more decisive than the technical content itself. Intensive coordination between project members plays an important role

in product development, providing sufficient potential for effective implementation [6]. The role of the project manager and the cooperation of the project members play a key role in product development also.

The recurring theme of the project closing and management meetings reviewing the results of the projects was to reduce the turnaround time of the developments, thus accelerating the launch of the new or improved product. The simultaneity of development activities can be a solution, but it is a big challenge. In order to meet the needs of customers is necessary to develop more and more complex technical systems, several sub-activities run in parallel (simultaneous engineering activities). While all of this can shorten lead times, it increases the need for coordination between different functions and areas of activity and the risk of errors due to redundant activities.

A company-level challenge that transcends the boundaries of individual projects is the opportunity to leverage experience and lessons learned. All of this should be part of daily practice.

## **1.1 RESEARCH QUESTIONS**

Product development processes used in multinational industrial and manufacturing companies work similarly regardless of the specifics of the industry or product [7]–[9]. For companies that place a great emphasis on the production of increasingly modern products and related technological solutions, the renewal of the development process itself - at the company level - is rarely on the agenda, the essential elements, main steps, and tools of the product development process have remained unchanged for decades. The performance and complexity of the products are constantly increasing while companies are looking for a solution using “old” organizational methods. In the changing social, economic and technical environment, in my opinion, also necessary to rethink and develop product development processes. The constant changes in customer needs, the economic environment, and the labor market require innovation, and increasing competition requires fast corporate reactions. The knowledge of project management is constantly expanding, the improvement of the long-term,

strategic cooperation of the project and the organization [10]–[13] is playing an increasingly important role, the application opens up new opportunities in product development.

My doctoral research is connected to the product development process; the aim is to explore the success factors of product development projects. In this way, I can contribute to the development of management solutions that support the enhancement of product development success. Product development is basically a challenge in the field of technical and mechanical sciences, but experience shows that the quality of management solutions has a fundamental impact on the outcome of the process and the operation of the company.

Careful design and development of product development processes are essential to reduce product development lead times, produce better, more valuable products, and control and manage the risks of new product launches to bring risk exposures to acceptable levels [14]. The presence or absence of a successful, efficient product development process is critical for industrial performance. A fast and innovative product development process gives a company a significant competitive advantage [15].

Despite the importance of product development processes, it is currently difficult for companies to plan, coordinate or select product development processes from the available wide range. [16], [17]. If companies misdevelop their processes, they jeopardize their products, their competitiveness, their efficiency, and even their survival in the market. Actually, there are no established criteria for comparing, selecting, or designing product development processes. Any product development process is ideal in all circumstances and for every company [7]. Although several different design models and design systems are available to support design activities at different stages of the design process, none are efficient enough for companies to design and develop their own products on their own. Companies should seek to identify the most customized product development processes that suit their own. They can achieve a competitive advantage over competitors or even remain at least on a standard level in the market only through these efforts.

In my research, I examine the critical points and development opportunities of the product development process from the perspective of technical management. The product development process is typically handled by companies as a project, as a time-limited effort to create a unique product, service, or result [10]. Project management has a detailed methodological background for planning process steps, tracking progress, measuring performance, and addressing emerging issues. The management and implementation of product development projects are given great emphasis during the evaluation; therefore, the management, project management, and company management must be given more weight in order to succeed, but without the appropriate technical content, the management efforts are not valuable.

I am looking for answers to the following research questions:

- What challenges does each product development process model answer?
  - Based on the review of product development models, I examined the key development areas in the projects. The historical review also shows where there are important areas that have less followed the change of market and corporate expectations.
- What internal (organizational and project level) factors influence the success of product development?
  - I examined the success factors by asking experts - in the framework of a workshop and by the survey. The study points to patterns of the opinion of those involved in different roles in the process. The difference of opinion shows the critical points of the management coordination tasks.
- How can the knowledge generated during product development projects be used for later developments?
  - Lessons learned from projects are an important issue for maintaining the success

of product development. Expert evaluation of the currently applied practical solutions helps to identify further development tasks.

## **2 RESEARCH METHODS**

### **2.1 USED RESEARCH METHODS**

I used both qualitative and quantitative methods [18]–[20] to answer the research questions:

- I examined the research issue related to the development of product development process models by analyzing literature sources.
- To verify my research question on project and organizational level factors of product development success and my hypotheses on the evaluation (hypothesis H2) and performance (hypothesis H3) of related success factors, I organized an expert workshop to determine the possible range of success factors.
- My survey was the most important tool in examining my research question on the organizational utilization of knowledge generated during product development projects. The questionnaire was prepared in Hungarian and English in Microsoft Forms software. I used Microsoft Excel and IBM SPSS software to statistically process the responses and display the results. In performing the statistical analysis, I relied on the work of Babbie [18], Sajtos and Mitev [21], Barna and Székely [22], and Wagner [23].

The process of applying the methods is summarized in (Figure 4.).



Figure 4. Applied research methods

## 2.2 ANALYSIS OF PRODUCT DEVELOPMENT PROCESS MODELS

Various management system standards typically play an important role in the operation of product development companies. The quality management standard (ISO 9001) deals specifically with the issue of product development, requiring the development and implementation of a process that focuses on meeting external and internal customer requirements. The standards and guidelines of project management, which provide support for the systematic management of processes, must also be highlighted. Both quality management and project management guidelines can provide a framework for the planning, executing, and administering product development projects, but the content of success factors, due to their general nature, is less prominent in them.

During the literature review, I cover the development of the approaches and models of the product development processes discussed in the technical literature. With their evaluation, I sought answers to the most important tendencies along which the success factors related to the topic can be determined and systematized. A review of the general and product development literature on project success and background literature need to answer the research questions (utilization of experience, stakeholder goals, importance-performance evaluation) were processed in the relevant chapters.

## 2.3 ANALYSIS OF SUCCESS FACTORS

Boncz [24] points out that quantitative studies are suitable for proving research hypotheses in many areas but do not provide an opportunity for a deeper understanding of the underlying

relationships. The literature presents a large number of success factors that can cause a double risk to my research. On the one hand, the quantitative assessment of a large number of factors is time and resource-consuming; on the other hand, factors relevant to product development projects may be omitted or marginalized.

The main task of the qualitative research in my work was to prepare a survey, highlighting the relevant elements to the success, understanding, and improvement of product development projects. In addition to compiling a list of success factors, I also considered qualitative research in defining issues related to the product development process, internal communication, and the utilization of experience.

Qualitative research methods include observation, experiment, in-depth interview, expert interview, focus group, case study [24]. Susánszky [25] presents expert solutions that can also be used for research purposes, and the supporting methods of quality management [26]–[28] are also suitable for supporting the answers to research questions. The advantage of using these is that, as part of the quality management systems, the methods and tools often used by the company and familiar to the experts can be used effectively in the research.

Qualitative research was managed between March and May 2020, mainly in the form of online meetings due to the coronavirus pandemic (Figure 5).



Figure 5. Timeline of qualitative research

The methods of the workshop were as follows:

- Casual discussion on the actual challenges of the product development process and the experiences of experts. The purpose was to tune in to the topic.
- Brainstorming was used to determine a pool of critical success factors. Susánszky [29] emphasizes that Osborne's brainstorming method - compared to a traditional conference - does not require long preparation, the activity of the participants is sustainable, time can be saved, and possible to take all opinions into account. The moderator and administration tasks were performed by me.
- Based on the ideas collected during the workshop, we used the mind mapping method to systematize the success factors considered relevant by the experts to be taken into account for the questionnaire surveys. Mind mapping was originally an individual method that depicts a documented and orderly pattern with the association of ideas [26], and usable in teams [30].
- The flexibility and efficiency of the focus group method [18], [31] could also be exploited in the workshop, although the number of participants was lower than the proposed 12-15 people. The discussion on some of the topics planned for the questionnaire research (project triangle, forms of utilization of lessons learned, usefulness of project meetings) was also utilized in the wording of the questions and in setting up the hypotheses.

An online survey was a central element of my research to determine the product development project's critical success factors and explore development opportunities (H2 hypothesis). In addition to the general advantages of a survey, such as the ability to collect a large number of responses relatively easily, and the good statistical processing [18], [32], convenience, low cost, fast execution, fast availability of results are the main advantages of online solution [33]. To identify the dominant success factors, I compiled a list of success factors for product

development projects using the results of literature review and qualitative research.

Evaluating the corporate performance related to the success factors appears in Hypothesis H3. The survey included questions that ask respondents to rate the corporate performance related to them.

## **2.4 INVESTIGATION OF PROJECT TRIANGLE PREFERENCES**

Based on the experience of the workshop, I addressed the change in preferences related to the success factors of the project in the survey (Hypothesis H4). I simplified the studies to the success factors according to the project triangle. Already from the wording of the scale questions [18], I considered it more appropriate to rank the factors directly in the case of the topic. I asked the experts to prioritize the importance of timing, budget, and specification (project result) in two phases - when the product development project is adopted and any changes are made. I examined the rankings, distribution, and correlation between evaluations based on the overall sample and the role of the experts in the project.

## **2.5 INVESTIGATION OF LESSONS LEARNED**

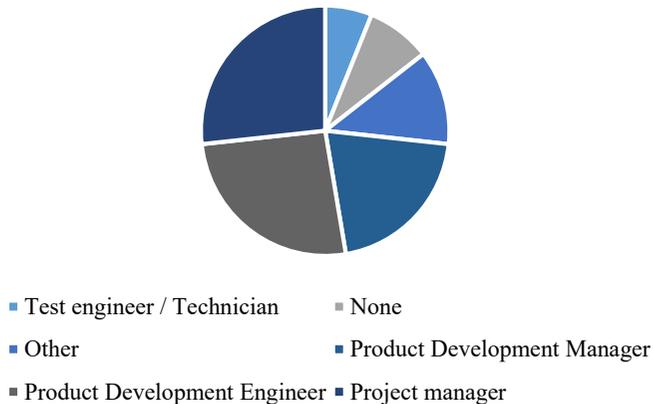
The practice of dealing with lessons learned (Hypothesis H5) is a critical issue in my research as it can ensure that product development projects and company-level success are maintained. The task of the survey was to explore the solutions used by respondents to share experiences (lack thereof, shared files and drives, emails, databases, and records). In addition, on a 5-point scale (with non-typical and fully characteristic endpoints), I asked to evaluate the form and frequency of use (adding, extracting information) and the usefulness of the solution used (utilizing information in daily work, regulation, documentation).

## 2.6 SAMPLE COMBINATION

To fill the survey, I contacted potential respondents electronically via email and social media (LinkedIn, Facebook). The questionnaire was received by the experts in June 2020 and was completed in June and July. I did not make any personal inquiries due to restrictions of the coronavirus pandemic.

The survey participants are still active professionals, most of whom work for a company on product development projects. Basically, this is lucky for the research, as their up-to-date knowledge of the current regulations in force, as well as their experience of the processes, contribute to the exploration of real problems and opportunities for improvement.

A total of 131 responses have received by the survey. In the case of some analysis, the number of items in the sample may be smaller, depending on the applicability of the question for the respondent.



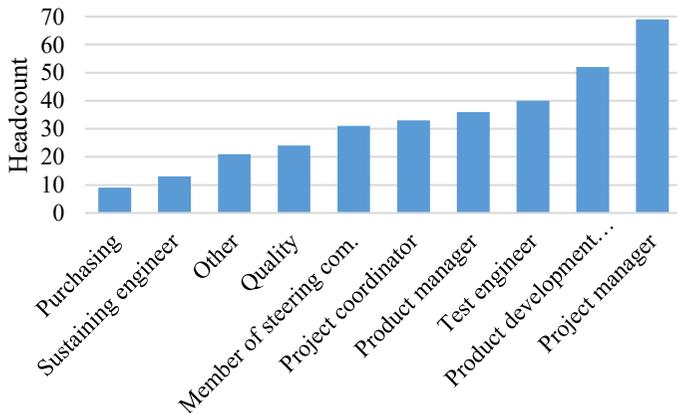
*Figures 6. Spread of participants according to their present job (Data in headcount)*

The questionnaire asked whether the respondent was Hungarian or of another nationality, but the statistical analysis did not show any significant difference according to this criterion, so I did not take this aspect into account in the

analyzes. Considering the large-scale globalization of our time, as well as the fact that most of the Hungarian product development experts also work in an international environment on international projects, the need for non-discrimination was an expected result.

Sampling is not probabilistic, the representativeness of the survey results is not checked. Respondents started from their own circle of acquaintances, on the principle of snowball [34], asking them to suggest additional potential respondents. At the same time, the sample members are all with significant experience, experts in their field, and therefore provide reliable data and are therefore able to draw conclusions.

We find all the important jobs in terms of product development among the experts (Figure 6.); several of them have 10-20 years of experience, during their internship, they could turn in several jobs (Figure 7.). Experts participating in the questionnaire survey were able to provide their answers anonymously. In the case of self-administered surveys, the willingness to answer is generally low, but due to the wide involvement of experts, specifically due to geographical constraints, I used this solution, taking into account its limitations.



Figures 7. Scope of research

### **3 SUMMARY OF NEW SCIENTIFIC RESULTS**

New scientific results of thesis value, the elaboration of which was part of the doctoral research, are formulated below.

#### **3.1 THESIS 1.**

I reviewed the models of product development processes, the changes, and the underlying conditions according to their temporal appearance in order to identify developing trends and new challenges. Based on the evaluation of the literature, I concluded that the determining element of the development of product development processes is the integration of participants such as production, finance, technology, procurement, and suppliers and customers. The other significant determining element, in addition to integration, is the pursuit of cooperation, an increase of motivation, the formation of a people-centered organization. The research confirmed hypothesis H1. My related thesis:

T1: Development directions of product development models:

- creating integration with other functional areas, external project participants,
- the appreciation of human factors, the increase of their weight in order to improve the success and lead time of development.

Related publications: [35]–[38]

#### **3.2 THESIS 2.**

My questionnaire survey covered the success factors of product development projects. Studies have shown the importance of some difficult-to-quantify success factors (active attention of the project leader, project team collaboration), but these are no more important than well-quantifiable success factors (defining project goals, adhering to project plans, developing and reviewing written regulations). Building in the past experience into new projects is not one of the most

important success factors. I rejected hypothesis H2. Success factors of product development projects:

- define clear project goals, recording them in writing,
- cooperation of project team,

T2: The dominant success factors of product development projects are the setting of clear project goals related to the company's strategic goals, as well as the cooperation of the project team.

Related publications: [39]–[43]

### **3.3 THESIS 3.**

The questionnaire examination of the success factors of the project included, in addition to the importance of the success factors, also the assessment of their performance. Hypothesis H3 assumes that well-quantifiable success factors (defining clear project objectives, adhering to project plans, developing and reviewing written regulations) are not a bottleneck, while product development projects are less satisfied with the performance of hard-to-quantify factors later in development. Thus, future support for product development processes should focus on these.

The results of the research did not confirm my H3 hypothesis. Among the well-quantifiable factors, the clear definition of project goals, the availability of written regulations, and especially to keep project plan, their performance remain significantly behind their importance.

T3: In the product development project, the related corporate performance is weaker against of importance of it; at the same time, the performance is also lagging behind the importance of the well-quantifiable factors. Enhancing success should not be limited to developing areas of success factors that are difficult to quantify.

Related publications: [43]–[45]

### **3.4 THESIS 4.**

Based on the survey results, I examined the opinions of those working as development engineers, project managers, and product development managers about the success factor of the product development project from several aspects.

The experience of the related studies is that the majority of the interviewed experts ranked the specification in the first place, but in case of changes in it, the cost and time factor increases but only the order of adherence to the schedule and the cost plan changes based on the average rankings.

T4: During the execution of the product development project, as a result of changes in the project result adherence to budgets increases against the specification but does not become a primary preference. The order of preference of the development engineers is not; the order of preference of the project managers and product development managers change significantly in the importance of keeping the project budget.

Related publications: [46]–[48]

### **3.5 THESIS 5.**

In the area of product development, knowledge management, experience gathering, management, lessons learned are essential and provide a significant advantage to the teams that use them against those who do not. While the accelerating market changes and the corporate environment require faster product development, there are no evidence for solutions dealing with lessons learned emerged from the survey, which would be decisive for clusters describing patterns of usage patterns. Email is the most popular form of adding information but searching shared files is most effective by experts.

However, the results show that colleagues with more experience in product development are less likely to share and use such information than those with less experience. My related thesis:

T5: Experts with less experience in product development are more active in sharing and using lessons learned in product development projects, regardless of the technical solution used for the task. The solutions considered appropriate for sharing and using information are different.

Related publications: [40], [49]

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