University of Pannonia

Doctoral School of Business and Management

Thesis summary

Modeling, planning and scheduling framework programs, and determining risks based on project portfolio management with matrix-based project planning technique

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1. Introduction

The relationships between strategy, project portfolio management, and project management are well-established and have been studied in the literature for more than two decades. In my dissertation, it is essential to study strategy because without it, there is no project portfolio management. This is because project portfolios running in the corporate environment are intended to achieve strategic objectives. On the other hand, in order to examine the organization of the projects of the framework programs as project portfolios, it is necessary to explore which type of strategy formation the projects involved can be likened to.

Project Portfolio Management (PPM) is considered one of the fastest-evolving concepts among researchers and professionals in the field of project management (Madic, Trujic és Mihajlovic, 2011; Levine, 2005). While initially based on the return-risk trade-off (Sebestyén, 2009; Blichfeldt és Eskerod, 2008; Devinney és Stewart, 1988), and used for financial purposes, nowadays the methodology has evolved with sophisticated criteria systems that encompass not only financial aspects (Csendes, 2017). At the core of PPM is the clear definition of the value of projects for the organization. It is important to highlight Petrović, Mihić és Obradović, 2006's assertion that PPM can be applied to all types of organizations, all types of projects, and all economic and non-economic areas.

Today, to enhance the feasibility of projects (Johnson és Mulder, 2020), traditional approaches to project management (TPM) are increasingly being replaced by flexible approaches (Wysocki, 2019; Özkan és Mishra, 2019; Ciric és tsai., 2018), as uncertainty becomes more inherent in everyday project environments (Hazır és Ulusoy, 2020). However, methodological tools and algorithms considering flexibility have mainly focused on the planning of single projects, with far fewer methods focusing on multi-level projects (Kosztyán, 2020; Kosztyán és tsai., 2022b) despite the growing demand for flexible tools for their efficient planning and scheduling (Kosztyán és tsai., 2023).

Regarding the use of methodological tools, in my dissertation, I cho-

se matrix-based project planning. I chose this technique because matrix-based project planning can be used for projects, managed both with traditional and flexible approach, allowing for consideration of deterministic or stochastic relationships between activities and their implementation importance/probability, thereby enabling the restructuring of project plans. Additionally, with its enhanced versions, it is possible to model, plan, and schedule concurrently running projects, programs, and project portfolios.

Throughout the development of my dissertation, I found it important to note that the analysis of the structure of a project portfolio is crucial for the success of both projects and the organization (Kaiser, El Arbi és Ahlemann, 2015). In a project portfolio, budgets, schedules, and risks can be better planned, concurrently running projects with shared resources can be managed more effectively, and programs can be designated if projects are substantively interdependent (Too és Weaver, 2014; Lock és Wagner, 2019). Based on these considerations, in my dissertation, I assume that by breaking down the projects of framework programs into elements forming a project portfolio, we can better uncover and understand the opportunities and risks related to the structure of European Union framework programs. Considering these factors is important because by applying methodological tools and evaluating the results, in the future, a better structure can be developed for framework programs, as well as other R&D programs that were not previously planned and managed as project portfolios. This would enable these programs to better meet the objectives of decision-makers.

2. Research objectives and research questions

In my dissertation, I aimed to develop and present a methodology that allows for more effective planning and scheduling of multi-level projects using a flexible approach compared to traditional project management techniques. In this regard, my first research question was formulated as follows:

R.Q.1. What methods and tools can improve the planning and

scheduling of flexible, multi-level projects?

My next objective, formulated within the framework of the third research question, was to extend the methodology developed in the first question - with adaptations for framework program characteristics - to framework programs. One reason for choosing framework programs is their undeniable role and expansion in the R&D activities of the EU and the world. Furthermore, an important scholarly and methodological novelty of the dissertation is the application of a structure and methodological tool for framework programs, which has not been used before to support their planning, scheduling, and risk analysis.

R.Q.3. Can the presented multi-level matrix-based project planning and scheduling algorithm be extended to framework programs?

A prerequisite for this methodological extension was applying the project portfolio implementation structure onto the projects of framework programs. Therefore, in connection with this, I posed my second research question:

R.Q.2. How can the implementation structure of projects within framework programs be modeled?

Lastly, I investigated the time and cost risks associated with projects organized into different project structures, and the outcomes resulting from such implementations.

R.Q.4. How does increasing the proportion of projects implemented in multi-project - and program structures within the framework program's implementation structure affect costs, outcomes, and the time risk of the framework program?

3. Literature review and research assumptions

In the following, I highlight the scholarly findings on which I formulated my research assumptions.

In my dissertation, when defining the multi-level project management

environment, I relied on the definitions provided by Patanakul és Milosevic, 2009a, which state that the multi-level project management environment consists of project portfolios, single projects, concurrent projects, and programs. These categories are distinguished based on how closely the projects are related to each other (through shared goals or resources used for implementation) (Patanakul és Milosevic, 2009a). Project portfolio management encompasses all projects running within a company.

Concurrent projects are characterized by:

- potential temporal overlap of projects (Elonen és Artto, 2003),
- utilization of shared resources among projects (Cooper, Edgett és Kleinschmidt, 2000),
- and potentially differing objectives for each project (Elonen és Artto, 2003).

Structurally, these projects are characterized by partially or fully parallel implementation methods, and due to resource sharing, they typically require shared organization or ownership structure (Cooper, Edgett és Kleinschmidt, 2000). Another important characteristic of these projects is their similar volume (Boyette és Fang, 2012).

Regarding the structure of programs, unlike concurrent projects, projects within programs may not necessarily overlap in time, but since they share a common goal (Patanakul és Milosevic, 2009b), subsequent projects build upon the results of preceding projects (Hans és tsai., 2007). Thus, the most important task here is to synchronize the goals and scheduling of projects.

The flexible project management approach is increasingly playing a significant role in both single and multi-level project planning and implementation (Gil és Tether, 2011; Hertogh, 2014; Jalali Sohi, Bosch-Rekveldt és Hertogh, 2020; Kaiser, El Arbi és Ahlemann, 2015; Cooper, Edgett és Kleinschmidt, 2000; Doerner és tsai., 2006; Kavadias és Loch, 2003; Zuluaga, Sefair és Medaglia, 2007; Olson és tsai., 2010; Ghassemi és Amalnick, 2018). An effective and widely used methodological tool for planning and scheduling projects

with flexible project management approach is the matrix-based project planning technique (Kosztyán és Kiss, 2011). Matrix-based project planning has managed to overcome numerous methodological obstacles that traditional methods were unable to represent, model, or manage (Kosztyán, 2013). Furthermore, the multi-level matrix-based project planning procedure allows for the modeling, planning, and scheduling of concurrent projects, programs, and project portfolios (Kosztyán és tsai., 2022b; Kosztyán, 2020). Based on these, I formulated my first assumption and utilized the matrix-based project planning technique in practical examinations to improve the planning and scheduling of projects within a corporate flexible project management environment.

A.1. The use of matrix-based project planning can improve the feasibility and scheduling of flexible, multi-level projects.

Taking advantage of the latter possibility of matrix project planning, as well as the characteristic that framework programs - just like project portfolios - consist of a set of projects, I aimed at structuring framework programs as project portfolios and describing the possibility of matrix planning. The projects of framework programs modeled as project portfolios can be organized into single project -, multi-project -and program structures.

A.3. The matrix-based planning and scheduling algorithm applied to multi-level, flexible projects can be extended to framework programs after determining the execution structures.

In the context of my dissertation, an important characteristic of EU framework programs is that they are not planned or scheduled in practice. Essentially, the projects within framework programs comprise a set of project plans without coordination, and their risk management is very deficient, lacking management support as well. It's worth noting this because, as Mikkola, 2001 pointed out, treating R&D&I projects that run parallel, build on each other, or are independent but part of a project portfolio can yield numerous advantages.

During the classification as project portfolios, it's important to clarify

that we defined the project structures based on the project categories of the multi-level project management environment as defined by Patanakul és Milosevic, 2009a. Accordingly, projects and project pairs were classified as single project structures, multi-project structures, and program structures.

European framework programs are not "traditional" project portfolios; hence, they lack official definitions and structuring based on the complexity of their single projects, concurrent projects, and programs. Therefore, we can consider them as "unstructured project portfolios." In my dissertation, I assume that the structure of framework programs can be reconstructed using available public data, and the classification into defined project structures can be performed based on the literature characteristics of the project structures highlighted above.

A.2. Possible execution project structures can be derived from the literature characteristics of the defined project structures and the information available on framework program projects.

Regarding the risk analysis of framework programs, when formulating assumptions and sub-assumptions for my fourth research question, I took into account the literature characteristics that emphasize the risks of projects running under the defined project structures and the benefits arising from the implementation mode. Overall, I assumed that:

A.4. By applying complex execution structures, costs can be reduced, and project outcomes can be improved, but in this case, an increase in the time risk of the framework program is expected.

Wei és tsai., 2020 demonstrated that the mutual dependence between projects can influence the benefits of project portfolios. Projects related within a program may achieve greater/better results (in this case, scientific results characterized by the number of publications) because the centrally coordinated management of the group of projects related to a goal can more effectively achieve strategic objectives (Ferns, 1991).

A.4.a. Increasing the proportion of program structures in the project execution structure of the framework program increases

the portfolio-level total project time, thus increasing the time risk of the framework program; however, it results in higher publication performance.

If concurrently running projects do not share a common goal but are managed by the same organization, their resources need have to be shared among the projects. Resource sharing may lead to relatively lower costs for each project, but scarce resources can cause delays (Fricke és Shenbar, 2000).

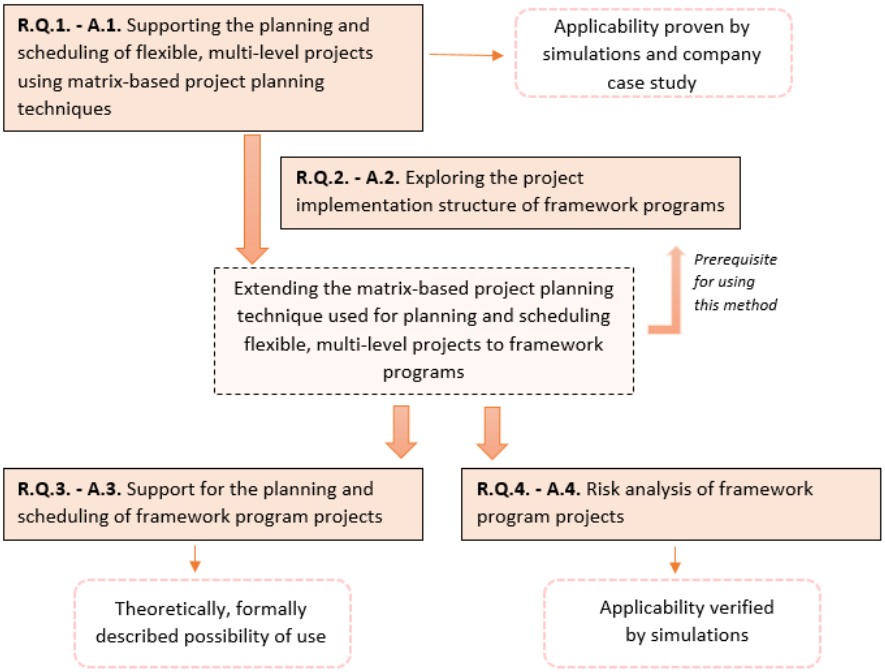
A.4.b. Increasing the proportion of multi-project structures in the project execution structure of the framework program leads to resource overload and hence greater time risk; however, resource sharing among concurrently running projects results in more cost-effective implementation.

4. Research Findings and Theses

Figure 1 illustrates the relationships between the research questions formulated in my dissertation and the the results obtained for these research objectives.

My first research question is addressed by the matrix-based project planning technique, specifically by the multi-level matrix-based project planning and scheduling algorithm (MPR). The MPR algorithm, in conjunction with the hybrid project management approach, provides answers to the management of multi-level projects, allowing for visually intuitive modeling of projects in a multi-level project environment. The multi-level matrix-based scheduling algorithm has been proven to find optimal solutions that meet decision-makers' needs. The application of this method has revealed that in a flexible multi-level project management environment, significantly more acceptable solutions are found, indicating fewer unsuccessful implementations of multi-level projects.

The simulations presented in my dissertation have successfully confirmed the assumption posed by the first research question: that considering flexibi-



1. figure. Connections of the results of the dissertation (My own editing)

lity and employing a matrix-based multi-level project planning method can improve the feasibility and scheduling of multi-level projects compared to traditional approaches. Table 1 summarizes the efficiency of scheduling with MPR compared to the method following traditional approaches Beşikci, Bilge és Ulusoy, 2015. (The values in Table 1 represent the results of the MPR algorithm concerning the boundary conditions; the percentage differences are relative to the results of the method by Beşikci, Bilge és Ulusoy, 2015.)

In the highlighted case, the objective function was to minimize the total project time, whereby the proposed method reduces the duration time for parallel projects and programs compared to the method based on traditional scheduling Beşikci, Bilge és Ulusoy, 2015. Thus, it has been demonstrated that the method can improve the scheduling of multi-level projects by better exploiting opportunities for reducing duration. However, this improvement comes at the cost of increased costs. The point values, which characterize the implemented content, also decrease even for parallel projects and programs,

1. table. Comparison of the effectiveness of scheduling with MPR using the Beşikci, Bilge és Ulusoy, 2015 method (My own editing)

Comparison of the effectiveness of scheduling		
Objective ->minimize TPT		
	Paralell projects	**Programs**
Duration	- 11,1%	- 27,2%
Costs	+ 11,2%	+ 15,1%
Scores	- 3,3%	- 11,2%
Resource needs	+ 1%	+ 3%

while it is interesting that resource requirements only slightly increased. This can be explained by the fact that for information technology projects, which inherently execute many activities in parallel, there is little opportunity for further parallelization. Therefore, if we want to shorten the project, it can only be achieved with additional cost increases and content (score value) reduction. However, this phenomenon is not uncommon and is often discussed in project management literature as the time-cost-quality trade-off problem, which also follows from the general definition of the project management triangle. Of course, in a project plan where there are typically fewer parallel activities or projects (for example, in a research and development project), the method has more facility to parallelize activities, thus it is possible to reduce the time requirement without additional cost increases or content reduction. These opportunities, options can be effectively exploited by the multi-level matrix-based project scheduling algorithm, providing an optimal solution according to the objective functions, thus offering an effective solution to improve the feasibility and scheduling of flexible multi-level projects.

T.1. I have demonstrated that the developed multi-level matrix-based project planning and scheduling algorithm (MPR) is a method capable of finding multiple feasible solutions in a flexible multi-level project management environment, providing an optimal implementation mode according to the objective functions, and reducing the number of infeasible projects.

The application of the algorithm to the selected software development

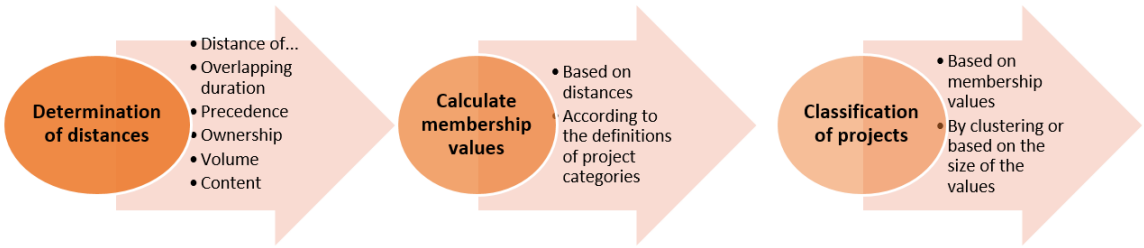
projects resulted in improved feasibility by considering flexibility and improved scheduling by reducing duration times. The simulations have shown that despite some deterioration of boundary conditions, the method has achieved the set goal, namely, finding a solution with lower total project time compared to a traditional multi-level project plan while retaining the given constraints, thus promoting improved scheduling.

To support the successful application in everyday real-world flexible multi-level project management environments, I present a case study in my dissertation.

In addressing the second research question of my dissertation, I explored how to model the execution structure of projects within a framework program. This step was necessary to answer the third and fourth research questions, as both objectives required an understanding of how the projects within the seventh framework program were executed from a project portfolio perspective (see Figure 1).

In addressing the second research question, I present the project categorization as described in our study (Kosztyán és tsai., 2022a). Using data extracted from CORDIS containing information about the seventh framework program, we estimated the membership value of projects based on the specific characteristics of portfolio elements. We found that projects within the framework program can be classified according to the temporal overlap duration, subproject precedence, ownership, volume, and content (description) based on the distances defined in my dissertation. The membership values of single projects — indicating to what extent a framework program project exhibits program or parallel project characteristics — can be estimated using the distance matrices presented in my dissertation (see Figure 2).

These results provide empirical evidence for the classification of projects forming the project portfolio of the Seventh Framework Programme, thus structuring the projects within the Rramework Programme as single project structures, multi-project structures, and program structures.



2. figure. Steps for creating the project execution structure of the framework programs (My own editing)

T.2. With the developed method, it is possible to identify single project -, multi-project -, and program structures within the project execution structure of project portfolios modeled as Framework Programme.

The results show that more than half of the projects (13,555) within the Seventh Framework Programme's execution structure are single projects. It is worth noting that the proportion of programs within the project structure of the Seventh Framework Programme is very low, including both the 106 programs and the additional 742 projects, which can be considered either projects of programs or parallel projects.

These findings shed light on the real structure of the project portfolio derived from the European Union's Seventh Framework Programme and the distribution of different types of projects within it. Additionally, this result provides new insights into policy implications. Despite the European Union's primary goal of increasing collaboration among organizations through financing projects within Framework Programmes (Decision No 1982/2006/EC; European Parliament (2006)), the presented results indicate that the project portfolio of the Seventh Framework Programme primarily consists of standalone, single projects (Kosztyán és tsai., 2022a).

Overall, it can be concluded, and I have verified through calculations, that with the presented method, the execution structure of a naturally, without manual intervention, developed unstructured project portfolio can be accurately mapped using minimal, often publicly available data.

In addressing the third research question of my dissertation, I aimed to extend the method developed within the first research question to be effectively applicable to Framework Programs in a corporate, flexible multi-level project management environment. I presented two possible uses of the FPM (Framework Precedence Matrix) algorithm developed by me:

- I discussed how the model could be used already in the project selection phase of Framework Programme projects if the necessary data were available. With this, not only risk analysis of framework program projects but also support for their planning and scheduling could be realized.

- I demonstrated the applicability of the model to risk analysis of framework program projects at the project portfolio level. The model was used in simulations for matrix representation of framework program projects, consideration of membership values in the matrix, and calculation of duration times. Simulations were conducted for risk analysis of the Seventh Framework Programme, which aimed to answer the fourth research question of my dissertation.

Through the research work on the development of the FPM algorithm, I explored the differences between projects running in everyday project portfolio environments and framework program projects, demonstrated what the differences and similarities are in the matrix representation of a traditional project portfolio and a framework program, what we consider as the unit of analysis, and how the relationships between projects in the case of framework programs and between activities in the case of project portfolios can be interpreted (see Table 2). Furthermore, in my dissertation, I also discussed how different defined project execution structures can be represented in matrices, how the total project time, expected value, and risk of projects included in them can be calculated.

T.3. By extending the multi-level matrix-based project planning and scheduling algorithm, I have developed a method that,

2. table. Comparison of projects running as part of a project portfolio and projects of framework programs (My own editing)

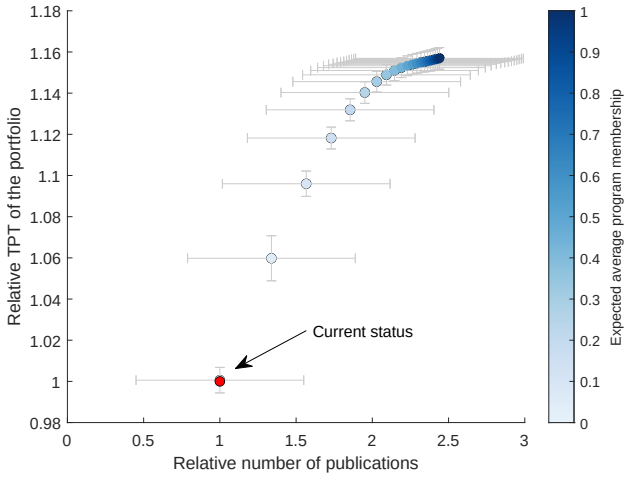
	Project portfolio environment	**Framework programme**
Unit	Activity	Project
Connection	Dependency relation between activities	Possible logical connection between projects
Structures	- Single project structure - Multi-project structure - Program structure	- Single project structure - Multi-project structure - Program structure

considering the characteristics of framework programs, is suitable for planning, scheduling, and risk analysis of framework programs.

To answer the fourth research question, we run simulations to examine the sensitivity of costs (the risk of delays and the relative costs of projects) and publication outputs to changes in the distribution of parallel projects and programs within a given project portfolio composed of projects from the Seventh Framework Programme.

The results indicate that programs are more sensitive to outputs (i.e., publications) than to the TPT of project portfolios. For example, numerically, increasing the expected average program membership value from close to zero to 0.5 results in approximately a twofold increase in the number of publications, while the total duration only increases by about 1.15 times (see Figure 3). It is important to note that due to the 7-year limitation of framework programs and the average TPT of projects within a framework program being 1.5 years, only 3-5 projects can be initiated within a framework program; therefore, the impact of delays is much smaller compared to the increase in the number of publications. This result has significant policy implications, as supporting programs at the expense of single projects results in a significant increase in publications (performance), while the increase in TPT is only minimal, meaning that there is a lower increase in temporal risk at the framework program level.

T.4.a. I have confirmed that – considering the limited number of projects that can be interconnected due to the financing period

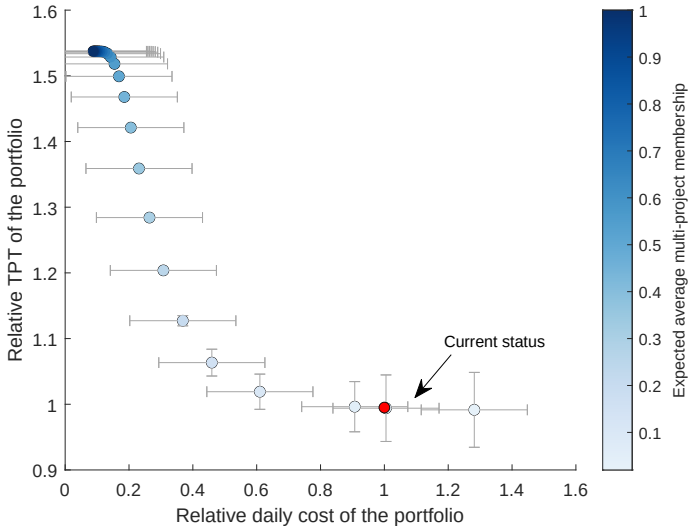


3. figure. The effect of increasing the program membership value on the number of publications and the TPT of the project portfolio (My own editing)

of the framework program – incentivizing the implementation of framework program projects in program structures leads to a much greater increase in publication performance than the increase in temporal risk of the framework program.

Regarding parallel projects, it can be observed that projects within a multi-project structure are more sensitive to relative daily costs than to TPT up to an expected average multi-project membership value of approximately 0.3. Beyond the value of 0.3, projects within a multi-project structure become more sensitive to TPT than to relative daily costs. This implies that incentivizing the implementation of framework program projects in a multi-project structure increases the temporal risk of the framework program to a lesser extent up to an expected average multi-project membership value of 0.3 than the cost reduction achieved. However, beyond an expected average multi-project membership value of 0.3, the temporal risk of the framework program becomes higher than the potential cost reduction.

Highlighting an example, increasing the expected average multi-project membership value from close to zero to 0.2 results in approximately a 40% decrease in relative daily costs, while the TPT of the project portfolio inc-



4. figure. The effect of increasing the multi-project membership value on the daily cost of projects and the TPT of the project portfolio (My own editing)

reases by less than 5% (see Figure 4). This indicates that incentivizing implementation in a multi-project structure is only worthwhile as long as the resulting benefits can be exploited without significant increases in TPT.

T.4.b. I have highlighted that incentivizing the implementation of framework program projects in a multi-project structure increases the temporal risk of the framework program to a lesser extent up to an expected average multi-project membership value of 0.3 than the cost reduction achieved. However, beyond an expected average multi-project membership value of 0.3, the temporal risk of the framework program becomes higher than the potential cost reduction.

In summary, concerning the increase in the ratio of programs and parallel running projects, it can be observed that the Seventh Framework Programme has an exceptionally high proportion of single projects. In the revealed execution structure, projects running within multi-project or program structures accounted for approximately 10% of all projects. However, my findings shed light on the fact that the relative cost and outputs (number of publications) of

a project portfolio consisting of a large number of single projects from framework programs could be improved by moderately increasing the proportion of projects running in parallel or as part of programs, achieving significant improvements without a significant increase in time risk.

T.4. I have confirmed that increasing the ratio of multi-project and program structures in a project portfolio consisting of framework program projects - taking into account the characteristics of the framework program - results in lower time risk than the cost reduction and increase in publication performance resulting from restructuring.

These results offer a new perspective on the implementation of projects within the Seventh Famework Programme, which policymakers should consider in the planning and implementation of future framework programs.

5. Summary

In my dissertation, I examined flexible project portfolios running in a corporate environment, and the Seventh Framework Programme structured as project portfolios. For their planning, scheduling, and risk analysis support, I applied matrix-based project planning techniques. To validate the MPR algorithm, the basis of the matrix-based project planning method extended to framework programs, I presented a case study. Additionally, to demonstrate effective applicability, simulations were conducted both in a corporate software development multi-level project environment and for projects within the Seventh Framework Programme. The FPM algorithm developed by me was utilized for risk analysis in the Seventh Framework Programme, and theoretically, I demonstrated the usability of the algorithm to support the planning and scheduling of framework programs. Practical examinations were not conducted because data for all projects submitted for support were not available, and the extension of the algorithm in this direction would be usable in the pre-award phase, before the decision on support is made. Si-

mulations were carried out for the risk analysis of the Seventh Framework Programme, revealing the benefits arising from the exploration and consideration of the implementation structure of the framework program as project portfolios, such as the opportunity for increased publication output and cost reduction due to restructuring, considering the evolution of time risks in the framework program.

5.1. Contribution to the literature

In my dissertation, I presented a project planning and scheduling methodology suitable for multi-level projects in a corporate environment with a flexible approach, which effectively supports the planning, scheduling, and modeling of multi-level, flexible, and traditional projects. The methodology represents an important novelty in both literature and methodology in the field of multi-level project planning.

By applying the portfolio approach and planning methods to framework programs, I highlighted the diverse opportunities inherent in the concept of project portfolio management. I drew attention to the fact that there are numerous areas in everyday business, scientific, R&D environments where this type of project division, although not traditionally used, can be effectively applied and can be a source of many advantages. Furthermore, a literary novelty is evident in that - to the best of my knowledge - the project execution structure of framework programs, or other R&D programs, has not been previously examined and explored based on literature on project portfolio management.

Conducting risk analysis on framework programs structured as project portfolios also represents a novelty in the literature, as simulations conducted according to multi-project and program structures shed new light on the relationship between the time risk, cost, and outcome implications of the framework program and the implementation mode of the projects.

5.2. Practical applicability

The primary objective of my dissertation was to extend a multi-level, matrix-based model supporting traditional and flexible project management approaches, applicable in a corporate environment, to framework programs. The underlying multi-level, matrix-based project planning and scheduling algorithm also allows for the allocation of shared resources between projects and takes into account deterministic/stochastic relationships between projects. The results presented demonstrated that the MPR algorithm is capable of providing optimal solutions for multi-level projects and finding multiple feasible solutions in a flexible project management environment, thus reducing the risk of unsuccessful implementation of multi-level projects.

Furthermore, the effectiveness of the model was confirmed in practice through a multi-year case study. After identifying the shortcomings of template-based planning used by the company, the proposed method was implemented. This successfully reduced the TPT and cost of projects in the multi-level project management environment and achieved an important goal of minimizing resource overload. The practical benefits of application in a corporate environment also include the model's ability to identify subprojects through matrix clustering and model shared resource requirements.

Since an important prerequisite for extending the model to framework programs was the exploration of the project portfolio structure formed by framework program projects, before presenting the formal description and application possibilities of the model, we defined the possible logical structures based on the literary characteristics of elements of multi-level project management environments and classified the projects won in the tender into these structures.

The structuring of the Seventh Framework Programme in project portfolio perspective revealed that the structure of an "unstructured" project portfolio, developed without human intervention, can be very accurately mapped with little, often publicly available data, such as dependencies between projects, ownership, volume, and content. This result may be interesting for

other framework programs or other programs that have not previously been managed and planned as project portfolios.

Although in my dissertation, the applied and extended methods and simulations were presented through data from the Seventh Framework Programme, the developed method is not limited to the presented framework programme. The only requirement for projects is that we know at least the following 5 characteristics of each project: budget, duration (including start and end dates of the project), project output (in this case, the number of publications), project ownership, project description (content). Thus, not only the collaboration network of the framework program but also the structure and relationships of the projects can be revealed.

The presented results highlight that the literary findings regarding the time, cost, and outcome implications of single projects, concurrent projects, and programs are also valid in the case of a originally unstructured project portfolio (such as the Seventh Framework Programme).

The results presented provide a new perspective on the Seventh Framework Programme and on the compromises inherent in all framework programs, which should be considered in the planning and execution of future framework programs. The aim of EU framework programs is to increase cooperation between organizations, but the results show that this objective could be achieved more effectively than was the case with the Seventh Framework Programme. Furthermore, an important advantage, also supporting the objectives of the EU, is that the number of publications and other research results could be significantly increased - with minimal impact on costs and duration - by restructuring the project implementation structure of the framework program, which requires the practical introduction and application of project portfolio approach and methodology.

The examinations carried out in my dissertation support the idea that decision-makers responsible for EU framework programs should consider framework programs as project portfolios and apply at least basic project portfolio management tools to them. It would be advisable to establish a ma-

nagement structure for framework programs that not only more accurately defines objectives and scope but also places much greater emphasis on organizing project structures before projects are launched. However, it should be noted that publicly funded R&D programs are often not predictable in advance, as they are implemented by networks that are built from the bottom up.

Regarding the results, it is important to highlight that all Python code is available, allowing for the free variation of ratios of single projects, concurrent projects, and programs, thus enabling testing of desired or optimal project portfolio structure characteristics, parameters, cost, duration, and outcome data.

6. Publications

Publications in hungarian and international refereed journals:
Publication related to the exploration of the implementation structure of framework programs and the risk analysis of the projects contained therein:

- Kosztyán, Zs. T., Katona, A. I., Kuppens, K., Kisgyörgy-Pál, M., Nachbagauer, A., & Csizmadia, T. (2022). Exploring the structures and design effects of EU-funded R&D&I project portfolios. Technological Forecasting and Social Change, 180, 121687. URL: https://www.sciencedirect.com/science/article/pii/S0040162522002141

Publication presenting matrix-based project planning techniques supporting the planning and scheduling of projects in a flexible multi-level project management environment, along with the MPR algorithm, validated through simulations and case studies:

- Kosztyán, Zs. T., Sebrek, Sz. S., Csizmadia, T., & Kisgyörgy-Pál, M. (2022). Rugalmas, többszintű projekttervezési és ütemezési technikák. Szigma, 53(1), 33-71. URL: https://unipub.lib.uni-corvinus.hu/7700/1/document-3.pdf

The publication of the developed FPM algorithm supporting matrix-based planning, scheduling, and risk analysis of framework program projects will take place in the future.

Conferences:
Presentations given on the exploration of the implementation structure of framework programs and the risk analysis of the projects contained therein:

- Kisgyörgy-Pál, M. (2023). Európai Uniós keretprogramok strukturális jellemzőinek feltárása projekt portfóliók vizsgálatával. New Trends and Challenges in Management Conference, 2023. Debrecen, University of Debrecen

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