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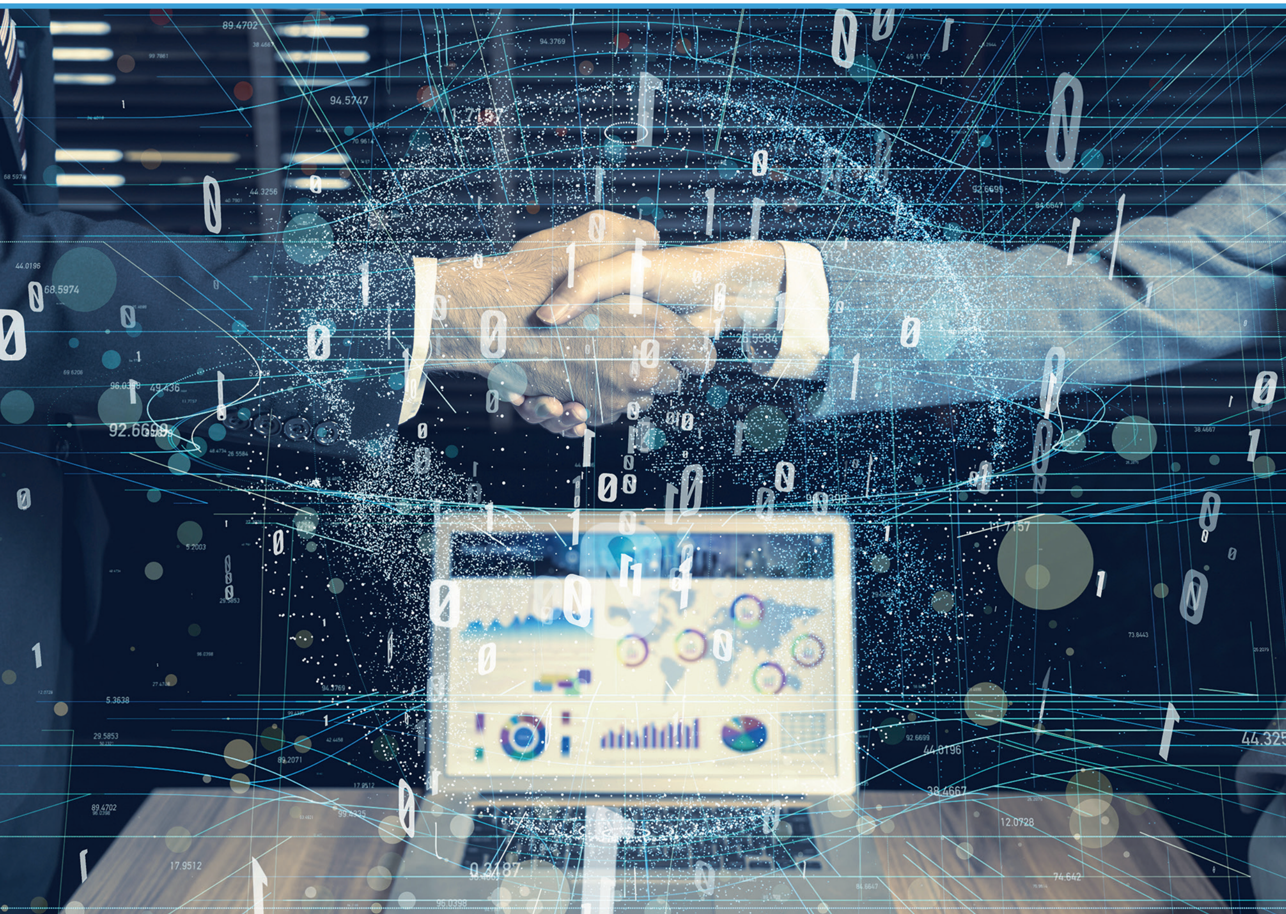
RIGA TECHNICAL UNIVERSITY

Ksenija Lāce

METHODS FOR SUPPORTING INFORMATION SYSTEM INTEGRATION IN THE POST-MERGER CONTEXT

Summary of the Doctoral Thesis



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RIGA TECHNICAL UNIVERSITY
Faculty of Computer Science and Information Technology
Institute of Applied Computer Systems

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Summary of the Doctoral Thesis

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DOCTORAL THESIS PROPOSED TO RIGA TECHNICAL UNIVERSITY FOR THE PROMOTION TO THE SCIENTIFIC DEGREE OF DOCTOR OF SCIENCE

To be granted the scientific degree of Doctor of Science (Ph. D.), the present Doctoral Thesis has been submitted for the defence at the open meeting of RTU Promotion Council on 23 October 2023 at 14.30 at the Faculty of Computer Science and Information Technology of Riga Technical University, 10 Zunda Krastmala, Room 102.

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DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted review to Riga Technical University for promotion to the scientific degree of Doctor of Science (Ph. D.) is my own. I confirm that this Doctoral Thesis has not been submitted to any other university for promotion to a scientific degree.

Name Surname: Ksenija Lāce (signature)
Date: 18.08.2023

The Doctoral Thesis has been written in Latvian. It consists of an introduction, 4 chapters, conclusions, 111 figures, 37 tables, and 8 appendices; the total number of pages is 175, including appendices. The Bibliography contains 202 titles.

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Definitions and Abbreviations

AMILI	Method for supporting informed decision identification.
AMILP	Method for supporting informed decision-making.
Blocking context factors	Limited knowledge, time and other resource constraints which adversely affect PMI IS integration decision identification and decision-making. The associated complications of decision identification and decision-making are referred to as the impact of blocking factors on PMI IS integration decisions.
M&A	Merger and acquisition. Mergers and acquisitions are growth strategies for organisations involving the consolidation of organisations and assets. In the Doctoral Thesis, the term “merger” refers to both merger and acquisition initiatives.
Support method	In the context of the Doctoral Thesis – a method for improving the awareness of the specialists involved in PMI IS integration.
Expertise	High-level knowledge and skills. In the context of the Doctoral Thesis – high-level knowledge and skills that facilitate decision identification and decision making in the domain of PMI IS integration.
IS	Information system.
Information model	The information model consolidates post-merger initiative concepts into a unified structure.
Decision identification	Identification of IS groups to be integrated requires the decision on the integration of their elements. Decision identification is the first phase in the extended decision-making approach.
Decision making	Evaluation and comparison of the integration options of IS included in the group to choose the most suitable integration option. For simplification of terminology in the context of the Doctoral Thesis, the evaluation, comparison, and choice of integration options is called integration option analysis. Decision-making is the second phase in the extended decision-making approach.
Model	In a general sense, a model represents existing or imagined reality. In the context of the Doctoral Thesis, a process and an information model are used in the support methods.
Determining context factors	Stated PMI goals, decisions on the business and information technology integration levels, and the specifics of the concrete PMI initiative, which PMI IS integration decisions should support. The degree to which PMI IS integration decisions support the determining context factors is the alignment between the decisions and the determining context factors.
Extended decision-making.	A decision-making approach for PMI IS integration in which the following three phases are distinguished – (1) identification of necessary decisions to be made, (2) decision-making, and (3) execution of made decisions.
PMI	Post-merger integration. One of the phases of merger initiatives during which the transformation process of the merging organisations takes place.
PMI IS integration	Post-merger integration information system integration. Part of the post-merger integration process in which the transformation of the merging organisations' information systems is carried out.
PMI context requirements	PMI context requirements define the properties or capabilities needed in the support method to be applied in supporting IS integration during PMI.
Process model	The process model defines the steps of the decision identification (in the AMILI method) or decision-making (in the AMILP method) process to be carried out.
Solution root research area	The research area where existing solutions for improving specialists’ awareness can be found which can be applied to PMI initiatives.
Specialist’s awareness	In the context of the Doctoral Thesis – method-based specialist’s awareness of the PMI domain and a specific PMI initiative, which compensates for the lack of expertise of the involved specialists in PMI IS integration.

1. INTRODUCTION

1.1. Doctoral Thesis motivation

Information system (IS) integration is essential to a collaboration between organisations and a single organisation's functioning (Land and Crnkovic, 2007; Litan et al., 2011). It is even more important in mergers and/or acquisitions (Brunetto, 2006; Baker and Niederman, 2014), considered in this Doctoral Thesis as the context of IS integration. Despite the popularity of the merger and acquisition (M&A) strategy (Hossain, 2021), studies of the results of these initiatives show that only half of them achieve the set goals (Peta and Reznakova, 2021). The main idea behind M&A is to create a new organisation by combining several existing organisations. This organisation must be able to achieve the goals stated for M&A, which could not be achieved by each of the merging organizations separately (Hossain, 2021; Galpin, 2021). A transformation process, often called a post-merger integration (PMI), creates a new organisation (Bodner and Capron, 2018; Henningsson et al., 2018; Teerikangas and Thanos, 2018). Successful IS integration is cited as one of the five most important factors contributing to PMI success (Brunetto, 2006; Baker and Niederman, 2014). IS integration is vitally important in many industries (Hasselbring, 2000), and is studied from various perspectives, including data integration and quality (Noy et al., 2005; Ziegler and Dittrich, 2007), process and workflow integration (Risimic, 2007; Soomro and Hasnain Awan, 2012), and from technology and technical aspects viewpoint (van der Aalst et al., 2006; Vale et al., 2016; Ghofrani and Lübke, 2018; Nath et al., 2018; Mathijssen et al., 2020). In the PMI context, this process becomes more complex as it requires understanding and integrating at least two separate organisations' systems, where specialists from one organisation are unfamiliar with the other organisation's ISs (Vieru and Rivard, 2014; 2018). This could involve dozens or hundreds of separate systems supporting various business processes and user groups. Furthemore, IS integration occurs parallel to other PMI activities and related changes in merging organisations' business units and their functions (Toppenberg and Henningsson, 2013; Henningsson and Toppenberg, 2020). In studies on a single organisation's IS integration, the most commonly addressed issue is how to technically integrate systems (Jain et al., 2010), but in PMI initiatives, before tackling this problem, it must first be determined which specific ISs are to be integrated (defining the groups of IS to be integrated) (Baker and Niederman, 2014). Moreover, respecting the origins of the systems to be integrated, in PMI initiatives, there is a potentially large number of possible integration options for the selected groups of IS, and therefore, additional difficulties in selecting the best option (Eckert et al., 2012). Thus, to successfully integrate ISs in the PMI context, a broader view is required that considers the specific challenges of this context. IS integration can be perceived as the sequence of integration decisions and decision implementation activities (Henningsson and Carlsson, 2011). In the scope of this Doctoral Thesis, integration decisions are perceived not only as a choice between possible IS integration options but also as a question about which ISs integration option should be selected. Therefore, this Doctoral Thesis uses the approach described by Ahmed and Omotunde (2012) and Lunenburg (2021), which proposes the following three phases of extended decision-making – (1) identification of the necessary decisions to be made, (2) decision-making, and (3) decision execution. The Doctoral Thesis is focused on the first two phases. In the context of PMI IS integration, the result to be achieved in the decision identification is identifying IS groups that require the integration decision (Freitag et al., 2010; Dameri, 2013). On the other hand, the result to be achieved in decision-making is a specific integration option selected for a group of ISs as an outcome of the analysis of possible integration options (Eckert et al., 2012).

PMI IS integration decision identification and decision-making depend on the PMI context. Decisions must support stated M&A goals and decisions on other PMI levels, such as business and information technology integration levels (Carlsson and Henningsson, 2006; Henningsson and Carlsson, 2011; Henningsson et al., 2018). In this Doctoral Thesis, stated goals, decisions on the other PMI levels, and specifics of the concrete PMI initiative are referred to as the determining context factors. The degree of how PMI IS decisions support M&A goals and decisions on other PMI levels is referred to as the alignment between the findings and the determining context factors. In the context of PMI, IS integration decision-making is often adversely affected by the organisation's limited knowledge of the PMI domain and of concrete PMI initiative specifics, as well as time and other resource constraints (Henningsson and Kettinger, 2016b; Henningsson et al., 2018). Limited knowledge, time, and other resource constraints in this Doctoral Thesis are referred to as blocking context factors. The associated complications of decision-making are referred to as the impact of blocking factors on PMI IS integration decisions. According to Henningsson and Yetton (2013) and Henningsson (2015), organisations with experience (of their employees) in several different PMI initiatives in PMI IS integration decision identification and decision-making can achieve better alignment with determining context factors and lower impact from the blocking context factors. Organisations can accumulate expertise and use it in future PMI initiatives (Henningsson and Yetton, 2013; Henningsson, 2015).

This Doctoral Thesis is focused on the problem that organizations new to PMI lack expertise in PMI IS integration. In the context of this Doctoral Thesis, the expertise is regarded as high-level knowledge and skills that facilitate decision identification and decision-making in the domain of PMI IS integration (Salas et al., 2009). The lack of expertise means that, in terms of IS integration decision identification and decision-making, these organisations need help to achieve as good alignment with the determining context factors and low impact from the blocking context factors as organisations with PMI experience do. To compensate for the lack of expertise, it is necessary to improve the awareness of the involved professionals about the PMI domain and the specific PMI initiative. But currently, there are no methods that would methodically help organisations without PMI experience to implement PMI IS integration decision identification and decision-making with their own internal resources without involving external expertise, i.e., there are no scientifically proven methods to compensate for the lack of expertise. In the scope of this Doctoral Thesis, the methods for supporting the identification of groups of ISs to be integrated (decision identification) and analysis of integration options (decision-making) in the PMI initiatives were developed. The developed methods are aimed at compensating for the need for more expertise in PMI IS integration.

1.2. The research question and goal of the Doctoral Thesis

The Doctoral Thesis aims to answer the following question: What methods can help specialists without expertise in the PMI IS integration to achieve results comparable to the results of experts (specialists with expertise).

Accordingly, *the Doctoral Thesis aims* to develop methods for supporting the identification of groups of IS to be integrated (decision identification) and analysis of integration options (decision-making) in PMI initiatives.

Tasks set to achieve the goal are the following:

1. Develop a concept of support for IS integration in PMI initiatives.
2. Implement the support concept as two methods: the method supporting informed identification of groups of ISs to be integrated (decision identification) and the method supporting analysis of integration options (decision- making) in PMI initiatives.
3. Verify the usability of the developed methods in the context of IS integration in PMI initiatives.

1.3. Research object and subject

The object of the research is the integration of ISs in the context of M&A initiatives.

The subject of the research is support for the informed identification of groups of ISs to be integrated (decision identification) and analysis of integration options (decision-making) in PMI initiatives.

1.4. Hypothesis of the research

The following *hypothesis* is put forward in the study: Specialists without expertise in the PMI IS integration with the support method can achieve results comparable to the results of experts in the (1) identification of groups of ISs to be integrated (identification of decisions to be made) and (2) analysis of integration options (decision-making)".

Based on the available scientific works (Henningsson, 2015), the study assumed that "specialists without expertise in the PMI IS integration without additional support achieve different results than experts". However, given that the related studies were conducted in the broader context of PMI IS integration, this assumption was additionally tested as part of the validation phase of the study (a detailed description is available in Chapter 5).

1.5. Research process

As prerequisites to start the research process, the Doctoral Thesis problem was defined, a literature analysis was performed to verify the relevance of the problem, the Doctoral Thesis question and goals, the research object and subject were defined, and the research hypothesis was put forward. The research process is based on design science research principles (Johannesson and Perjons, 2014; Wieringa, 2014) and is briefly illustrated in Fig. 1.1.

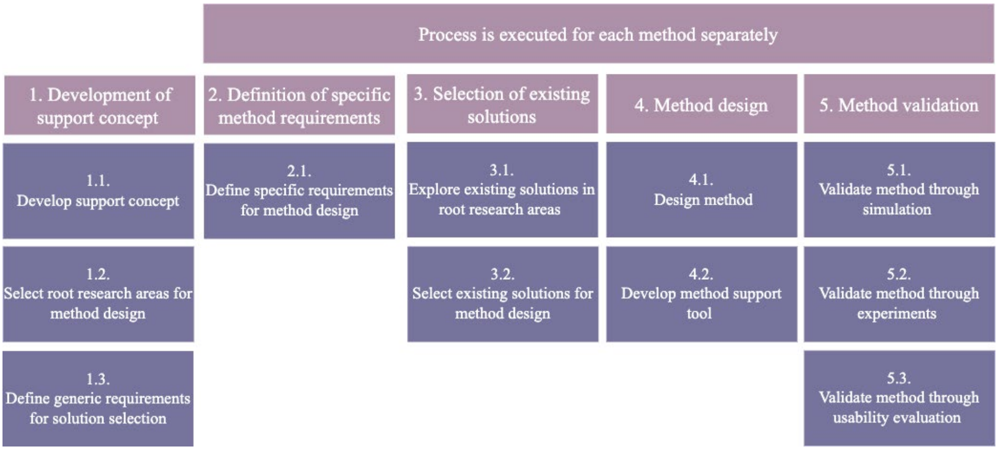

Fig. 1.1. Research process.

In the first phase of the process, the support concept was developed, the solution root research areas were selected to identify existing solutions, and the general requirements for method design were defined. The following phases of the process were executed separately for each method. The specific context requirements were defined in the second phase of the research. In the third phase of the research, solution root research areas were inspected, and existing solutions satisfying specified requirements were selected. Based on the defined requirements and selected solutions, a method was designed in the fourth research phase, and a method support tool was developed. In the fifth research phase, the use of the method with the help of its support tool was validated through simulation, experiments, and usability evaluation.

The research methods used in the research process are summarised in Table 1.1.

Table 1.1

Research Methods Used

Research process step	Research method
Development of concept	Systematic literature review (Biolchini et al., 2005)
Definition of specific requirements	Systematic literature review (Biolchini et al., 2005)
	Qualitative data analysis (evaluation of existing solution) (Lacey and Luff, 2007; Graue, 2015; Grbich, 2022)
Selection of existing solutions	Qualitative data analysis (incorporation of existing solution into solution) (Lacey and Luff, 2007; Graue, 2015; Grbich, 2022)
Method design	Process and data modelling (Becker et al., 2000; Knapp and Störrle, 2005)
Method validation	Case study (Meyer, 2001; Johansson, 2007; Baxter and Jack, 2015)
	Experiments (Dean et al., 2017)
	Survey (Glasow, 2005; Schwarz, 2007; Stern et al., 2014)
	Descriptive statistics (Byrne, 2007; Nick, 2007; Fisher and Marshall, 2009; Stapor, 2020)
	Hypothesis testing (Byrne, 2007; Bettany-Saltikov and Whittaker, 2014; Stapor, 2020)
	Qualitative data analysis (Lacey and Luff, 2007; Graue, 2015; Grbich, 2022)

1.6. Scientific novelty

The main scientific innovations of the Doctoral Thesis are as follows:

1. A concept of support has been developed to compensate for the lack of expertise in PMI IS integration.
2. Based on the developed support concept, a support method has been developed for the informed identification of IS groups to be integrated into the context of PMI IS integration. The method is rooted in the following research areas: requirements engineering, enterprise architecture and knowledge management.
3. Based on the developed support concept, a support method has been developed for the informed analysis of integration options in the context of PMI IS integration. The method is rooted in the following research areas: multi-criteria decision-making, knowledge management, synchronisation of PMI levels, and the impact of PMI context factors.

1.7. Practical significance

The practical significance of the Doctoral Thesis is the following:

1. Support method for the informed identification of groups of IS to be integrated, and its support tool can be used in practice to identify groups of IS to be integrated within the context of the specific PMI initiative.
2. Support method for the informed analysis of integration options and its support tool can be used in practice to choose between possible IS integration options within the context of the specific PMI initiative.
3. The methods can be used independently or in combination. For combination, in the support method for the analysis of integration options, the input data is obtained as the output data of the method for identifying groups of ISs to be integrated – the identified ISs to be integrated.

Organisations can use the methods and their supporting tools without experience in PMI IS integration to compensate for the lack of expertise. The developed methods and tools can also be used in organisations with PMI IS integration experience – for the scalability of their PMI initiatives by involving fewer experts and more specialists without experience in PMI IS integration. Additionally, methods and tools can potentially be used to address issues related to human resource turnover and related decrease of expertise in PMI IS integration.

1.8. Approbation of results

The results of the doctoral thesis are reflected in 9 publications. Ksenija Lāce is the sole author of three publications. In the publications developed together with the scientific supervisor, Ksenija Lāce's contribution is approximately 90 % of their content:

1. Lace, K., Kirikova, M. Importance of IS in mergers and acquisitions. **In:** *Proceedings of the workshops co-organized with the 13th IFIP WG 8.1 working conference on the*

Practice of Enterprise Modelling (PoEM 2020). Ceur-ws.org, Volume 2749. 2020, pp. 127–132 (***Scopus***).

2. Lace, K., Kirikova, M. Knowledge Management for M&A Performance. **In:** *Proceedings of the 13th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management.* SciTePress, Volume 3, 2021, pp. 83–89. Doi: 10.5220/0010640100003064 (***Scopus, Web of Science***).
3. Lace, K., Kirikova, M. Post-merger Integration Specific Requirements Engineering Model. **In:** *Perspectives in Business Informatics Research. BIR 2021. Lecture Notes in Business Information Processing*. Springer, Volume 430, 2021, pp. 115–129. Doi: 10.1007/978-3-030-87205-2_8 (***Scopus***).
4. Lace, K., Kirikova, M. The Models for Knowledge Acquisition in PMI Specific Requirements Engineering. **In:** *The Practice of Enterprise Modeling. PoEM 2021. Lecture Notes in Business Information Processing*. Springer, Volume 432, 2021, pp. 34–47. Doi: 10.1007/978-3-030-91279-6_3 (***Scopus***).
5. Lace, K. Enhanced Enterprise Architecture Framework for M&A PMI. **In:** *Joint Proceedings of Baltic DB&IS 2022 Doctoral Consortium and Forum co-located with 15th International Baltic Conference on Digital Business and Intelligent Systems (Baltic DB&IS 2022).* Ceur-ws.org, Volume 3158. 2022, pp. 8–19 (***Scopus***).
6. Lace, K. Post-Merger Information System Integration Decision Framework. *Baltic J. Modern Computing*. 2022, 10(4), 754–775. Doi: 10.22364/bjmc.2022.10.4.09 (***Scopus***).
7. Lace, K., Kirikova, M. Managing Decision Complexity of Post-Merger Information System Integration. **In:** *Joint Proceedings of the BIR 2022 Workshops and Doctoral Consortium co-located with 21st International Conference on Perspectives in Business Informatics Research (BIR 2022)*. Ceur-ws.org, Volume 3223. 2022, pp. 116–126 (***Scopus***).
8. Lace, K., Kirikova, M. Pre-evaluation of Post-Merger Information System Integration Strategies. **In:** *Proceedings of the Forum at Practice of Enterprise Modeling 2022 (PoEM-Forum 2022) co-located with PoEM 2022*. Ceur-ws.org, Volume 3327. 2022b, pp. 142–156 (***Scopus***).
9. Lace, K. Supporting Information System Integration Decisions in Post-Merger Context. *Complex Systems Informatics and Modeling Quarterly*. 2023, 34, pp. 30-61.

The results of the Doctoral Thesis have been reported in 7 international scientific conferences:

1. The 13th IFIP WG 8.1. Working Conference on the Practice of Enterprise Modelling” (PoEM 2020), Riga, Latvia, November 25–27, 2020.
2. The 20th International Conference on Perspectives in Business Informatics Research (BIR 2021), Vienna, Austria, September 22–24, 2021.
3. The 13th International Conference on Knowledge Management and Information Systems (KMIS 2020), Valetta, Malta, October 25–27, 2021.
4. The 14th IFIP WG 8.1. Working Conference on the Practice of Enterprise Modelling” (PoEM 2021), Riga, Latvia, November 24–26, 2021.

5. The 15th International Baltic Conference on Digital Business and Intelligent Systems, Doctoral Consortium (Baltic DB&IS 2022), Riga, Latvia, July 4–6, 2022.
6. The 21st International Conference on Perspectives in Business Informatics Research (BIR 2022), Rostock, Germany, September 20–23, 2022.
7. The 15th IFIP WG 8.1. Working Conference on the Practice of Enterprise Modelling, Forum (PoEM 2022), London, United Kingdom, November 23–25, 2022.

1.9. Structure of the Doctoral Thesis

The Doctoral Thesis consists of an introduction, 4 chapters, results and conclusions, a bibliography, and eight appendices. In Chapter 1, the Doctoral Thesis problem is defined, the Doctoral Thesis research question is formulated and research goal and tasks are set, the research object and subject are defined, and the research hypothesis is formulated. This chapter presents the research process, describes the results of the Doctoral Thesis and their significance, and describes the structure of the Doctoral Thesis. In Chapter 2, the scope of the research is defined, the problem of the Doctoral Thesis is detailed, and the basic concepts are presented. In this chapter, the concept of support for PMI IS integration is defined and the relevance of the Doctoral Thesis is verified. Chapters 4 and 5 describe methods developed for supporting decision identification and decision-making in PMI IS integration. For each method, the context requirements are defined, a literature review is provided, the design is presented, and a description of the supporting tool is provided. Chapter 5 describes the validation of methods. For each of the methods, its validation process and results are described: simulation for a specific case, experimental evaluation to test the research hypothesis, and usability evaluation through experiment participants' surveys. The results and conclusions of the Doctoral Thesis are summarised in the conclusions where the prospects of further research are defined. The main text of the Doctoral Thesis comprises 142 pages and is explained in 111 figures and 37 tables. The bibliography lists 202 titles.

2. THE CONCEPT OF METHODOLOGICAL SUPPORT FOR PMI IS INTEGRATION

The Doctoral Thesis focuses on PMI IS integration support and presents an approach that compensates for the lack of expertise in this field. According to Salas et al. (2009), expertise as such includes the following components: (i) the use of *standardised processes* to automate repetitive activities and reduce cognitive resources, (ii) pattern recognition and the application of *previous experience*, and (iii) *context investigation* to broaden the decision-making model (Salas et al., 2010). To improve specialists' awareness, the concept of support for PMI IS integration proposes corresponding replacement solutions for each of these expertise components, namely: (i) a process model for the standard process, (ii) an information model for context investigation, and (iii) both process and information models enhanced with knowledge management elements for the application of previous experience.

Furthermore, this expertise replacement solution is applied to the two phases of the extended decision-making process (Chapter 1.2), namely, decision identification and decision-making. The support concept for PMI IS integration was implemented through the corresponding support methods that focus on identifying groups of ISs to be integrated (method for supporting informed decision identification (AMILI)) and analysing available IS integration options (method for supporting informed decision-making (AMILP)). To facilitate practical application of the methods, a support tool was developed for each of them (Fig. 2.1).

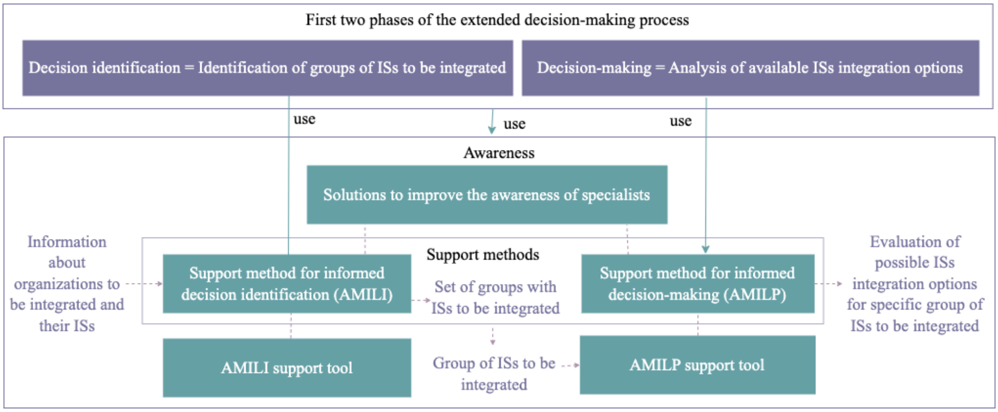

Fig. 2.1. Methods for supporting informed decision identification and decision-making.

According to the expertise replacement solution, each method consists of a process model and an information model, both containing knowledge management elements (Fig. 2.2). The development of methods is based on several solution root research areas. These research areas were selected and explored to identify existing solutions which can be applied to PMI initiatives. An overview of method components and selected solution root research areas is provided below.

The process model defines the necessary steps for identifying decisions (AMILI) or for decision-making (AMILP). This model aids in understanding and adhering to the process of identifying and making decisions regarding the PMI IS integration. This reduces the time required to learn the process and decreases the number of errors made (Henningsson, 2015). For the process model design, solution research areas that aim for similar outcomes were selected. In the case of the AMILI method, principles from requirements engineering were utilized. This research area aims to identify the changes required in current ISs to meet specific objectives. For AMILI, this transforms to identifying groups of ISs where decisions on their integration options are required (van Lamsweerde, 2000). For the AMILP method, techniques from multi-criteria decision-making were adopted. The objective of this research area is to quantitatively compare different potential solutions based on selected criteria. In terms of AMILP, this means comparing a range of potential integration options for ISs (Aruldoss, 2013; Velasquez and Hester, 2013; Bhole, 2018).

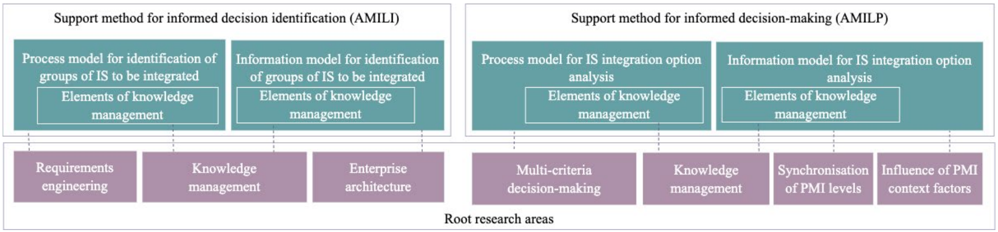

Fig. 2.2. AMILI and AMILP methods.

The information model brings together concepts related to the context of a PMI initiative into a unified structure. This model promotes awareness of the specific context of a PMI initiative, applying the knowledge gained to identify and make decisions about IS integration, adapting and tailoring them to the context (Henningsson, 2015). When developing the information model, research areas were chosen that focus on recognising and analysing the context of the PMI domain. For the AMILI method, enterprise architecture was selected due to its orientation towards recognising and coordinating changes in the organisation on a broad scale, from strategy to execution. In the case of AMILI, this would involve understanding business and IT changes when identifying necessary alterations in ISs (Törmer and Henningsson, 2017; Gampfer et al., 2018; Henningsson and Toppenberg, 2020). For the AMILP method, synchronisation of decisions made at the business, IT, and IS levels during a PMI was chosen. In the AMILP context, this would involve taking into account decisions made at the business and IT levels when analysing possible IS integration options (Baker and Niederman, 2014). Additionally, for the AMILP method, the impact of PMI context factors on the implementation of the IS integration strategy was considered. In the AMILP case, this would mean including PMI context factors in the analysis of potential integration options (Eckert et al., 2012).

Elements of knowledge management are integrated into the process and information models to facilitate the application of previous experience. These knowledge management elements ensure the preservation, distribution, and use of available experience about identifying and making decisions on PMI IS integration, reducing the risks of incorrect causality interpretations and erroneous assumptions (Henningsson, 2015). For both methods, knowledge management was chosen to support the learning process as an effective practice of knowledge exchange in large organisations. For AMILI and AMILP, this would involve incorporating the not documented knowledge of experts in the fields related to PMI into the process of, respectively, identifying necessary decisions and decision-making for IS integration (Wiig, 1997; Henningsson and Yetton, 2013; Henningsson, 2015; Wynne and Henningsson, 2018).

Based on the solutions identified in the PMI level synchronisation research area, a unified classification of possible integration options at the business, IT, and IS levels was developed. Mutual dependencies between options at different levels were also determined. Furthermore, based on the solutions identified in the research area of PMI context factor impact, a set of influential context factors was identified, and their effect on the implementation of various integration options was defined. Detailed information is provided in Chapter 4.

In areas such as requirement engineering, multi-criteria decision-making, enterprise architecture, and knowledge management there are various solutions available for improving specialist awareness (detailed information is provided in Chapters 3 and 4). Several solutions were chosen from each of these areas that could be applied to PMI initiatives. The selected solutions were integrated into the AMILI and AMILP methods. To compare and choose among these solutions, criteria were used that measured how well each solution met the defined requirements of the PMI context.

Based on the principles set by the International Requirements Engineering Board (International Requirements Engineering Board, 2022), the requirements for the PMI context describe what properties or capabilities a supporting method should have to be applicable for PMI IS integration. The exact PMI context requirements that apply to support methods should also be used to solutions integrated within these methods. To balance uniformity across methods while respecting each method's individual characteristics, the requirements definition process was conducted in two iterative stages. The initial iteration established a set of general requirements applicable to both methods. The subsequent iteration delved deeper, tailoring the initially defined general requirements to align with the unique characteristics to each method. Below are four general conditions, with more specific requirements for each method further detailed in Chapters 3.1 and 4.1. In accordance with the principles mentioned above and those of defining context requirements from the International Requirements Engineering Board (International Requirements Engineering Board, 2022), the Doctoral Thesis establishes the following general PMI context requirements, whichapply to both the support methods and the solutions incorporated within them:

1. **Task support.** The method must facilitate activities that are critical for achieving its intended results. Furthermore, the method should be applicable within the context of the processes it supports, specifically in identifying and making decisions related to PMI integration.
2. **Specialist preparedness level support.** The method should be easy to learn for individuals involved in its execution. The method should draw from the specialist expertise in IS integration and compensate for these individuals' lack of expertise in the making identification of PMI integration decisions and decision-making processes.
3. **Alignment with determining factors.** The method must accommodate and align with the context's determining factors, thereby ensuring the process' outcomes, specifically the decisions identified and decisions made, are more coherent with these

factors. The AMILI and AMILP methods should support PMI objectives, synchronise with the PMI business and IT levels, and should respect the specifics of the individual PMI initiative.

4. **Minimizing the blocking factor's impact.** The method must account for the context's blocking factors, aiming to mitigate their impact on the outcomes of the process it supports, specifically regarding the decisions identified and decisions made. The AMILI and AMILP methods should be applicable even when there is a lack of knowledge, time, or other resources.

When setting the general requirements, the impact of cultural conflict and human factors, often identified as detrimental elements in PMI integration, has been acknowledged (Marks and Mirvis, 2001; 2011; Weber, 2015). Therefore, the first two requirements focus on the method's compatibility with existing processes during PMI IS integration and with the expertise of the professionals carrying out these processes. These requirements aim to ensure a smoother method implementation by minimising resistance to change and reducing the learning curve. The third and fourth requirements address the method's adaptability with the determining and blocking factors outlined in Chapter 1.1. These requirements have been established to guarantee that decision making stays aligned with the context even in initiatives with heightened uncertainty and resource shortages.

The methods have been developed in accordance with the design science research (Johannesson and Perjons, 2014; Wieringa, 2014) and by performing related work research. The Doctoral Thesis research process is elaborated upon in Chapter 1.5. The corresponding AMILI and AMILP research studies are represented in Chapters 3 and 4, respectively.

3. THE METHOD FOR SUPPORTING INFORMED DECISION IDENTIFICATION (AMILI)

Informed decision identification takes as input data the business architecture of the newly created organisation, as well as the business and information architectures of the organisations to be integrated, identifies IS whose functions overlap and combines them into groups of ISs to be integrated.

The method is developed based on the concept of methodological support for PMI IS integration (Chapter 2). The design of the AMILI method consists of a process model, which is based on existing solutions in requirements engineering and knowledge management, as well as an information model, which is based on existing solutions in enterprise architecture and knowledge management. Both models are adapted for use in the PMI context by selecting existing solutions according to PMI context requirements.

3.1. Literature review of AMILI solution root research areas

The AMILI method should support PMI IS decision identification in accordance with the defined requirements. Specific context requirements for the AMILI method (Table 3.1) are defined by detailing general requirements of the PMI context (Chapter 2) to represent the specifics of PMI IS integration decision identification.

Table 3.1

Specific Context Requirements for Decision Identification

Generic requirement	Task support	Specialist preparedness level support	Alignment with determining factors	Minimising blocking factor's impact
Specific requirement	○ Software development support	○ Support for IT professionals, specifically business analysts and requirements engineers	○ Support the business objectives of the PMI ○ Support the alignment between PMI levels	○ Applicability in case of limited documented knowledge ○ Applicability in case of time and other resource constraints

Existing solutions in the solution root research areas were identified through literature analysis. The existing solutions were evaluated based on their conformity with defined context requirements and selected solutions are provided in Table 3.2. Requirements engineering framework BABOK (A Guide to the Business Analysis Body of Knowledge) was selected as the main solution for the AMILI process model (International Institute of Business Analysis, 2015). TOGAF (The TOGAF® Standard) was selected as the main solution for the AMILI information model enterprise architecture framework (The Open Group Architecture Forum, 2022). Both frameworks, better than others, comply with requirements, especially with software development support and support for IT professionals, as well as support for business objectives and the alignment between PMI levels. However, these frameworks do not consider the aspect of knowledge availability and assume that the necessary documented knowledge is available and can be obtained. Also, frameworks include a comprehensive set of activities but do not include mechanisms for their adaptation for applicability in case of time and other resource constraints.

Table 3.2

Selected Solutions for Decision Identification

Process model		Knowledge management in process and data/knowledge models	Data/knowledge model	
Requirements engineering frameworks (4 frameworks were reviewed)	Requirements engineering research areas (7 areas were reviewed)	Knowledge management models (9 models were reviewed)	Enterprise architecture frameworks (4 frameworks were reviewed)	Enterprise architecture research areas (6 areas were reviewed)
o BABOK (A Guide to the Business Analysis Body of Knowledge) (International Institute of Business Analysis, 2015)	o Agile (Schön et al., 2017) o Business goal orientation (Mendonça et al., 2016) o Model-based approach (Inkermann et al., 2019)	o Nonaka & Takeuchi's (Nonaka and Konno, 1998) o Bukowitz & Wiliams (Bukowitz and Williams, 1999) o Choo sense-making (Choo, 2007)	o TOGAF (The TOGAF® Standard) (The Open Group Architecture Forum, 2022)	o Agile (Duijs et al., 2018) o Software development-oriented enterprise architecture (Jamróz et al., 2014)

Furthermore, in AMILI, the process and information models were integrated with additional solutions, which supported at least one of the requirements and did not conflict with any other requirement:

- For applicability in situations with time and other resource constraints, Agile principles (Schön et al., 2017) and Bukowitz & Williams principle of knowledge concept (Bukowitz and Williams 1999), were selected.
- For applicability in cases with limited documented knowledge, Nonaka & Takeuchi's not-documented (tacit) knowledge concept (Nonaka and Konno, 1998) was selected.
- For better support of alignment between PMI levels, Choo's concept of knowledge orientation on strategic decision-making (Choo, 2007) was selected.
- For better support of business objectives stated for PMI, the corresponding research directions in requirements engineering (Mendonça et al., 2016) were selected.
- For better software development support, the corresponding research directions in enterprise architecture (Jamróz et al., 2014) were selected.
- For both model design representations, the model-based approach (Inkermann et al., 2019) was selected.

3.2. AMILI design

3.2.1. AMILI design considerations

The process of the AMILI method is based on the requirements engineering framework BABOK (A Guide to the Business Analysis Body of Knowledge) where Agile principles and knowledge management activities are integrated. The method uses an adapted TOGAF (The

TOGAF® Standard) architecture. Organisation entities (*Organisation* in *Business Architecture*) are perceived as business units, behaviour entities (*Behaviour* in *Business Architecture*) are perceived as functions, and application entities (*Application* in *Information Systems Architecture*) are perceived as ISs. The available information about the business units and the integration of their functions is perceived as a context of PMI IS integration.

A set of groups of IS to be integrated (*ISG*) is identified using the information about a set of business units to be integrated, a set of their functions, and a set of their IS:

$$ISG = < BU, BF, IS >, \tag{3.1}$$

where

BU – a set of business units to be integrated;

BF – a set of business functions of business units to be integrated;

IS – a set of ISs of business units to be integrated.

The set of business units to be integrated (*BU*) is determined by identifying all existing business units in the organisations to be integrated (which are transformed to form the future business unit).

$$BU = \{BU_i \mid BU_i \; is \; transformed \; to \; form \; BUF_j\}, \tag{3.2}$$

where BU_i is business unit and UF_j is future business unit.

The set of business functions (*BF*) is determined by identifying the business functions of the business units to be integrated.

$$BF = \{BF_i \mid BF_i, which \; fulfills \; BU\}, \tag{3.3}$$

where BF_i is business function.

The set of ISs supporting business functions (*BIS*) is determined by identifying all ISs in both organisations that support at least one of identified business functions. A single business function may be supported by multiple ISs within an organisation.

$$BIS = \{IS_i \mid IS_i, which \; supports \; BF\}, \tag{3.4}$$

where IS_i is individual IS.

Additionally, for each of the identified IS from *BIS,* related ISs are identified – *SIS*, which are necessary for the functioning of this system (for example, access rights IS).

$$SIS = \{IS_i \mid IS_i, which \; supports \; BIS \; functioning\} \tag{3.5}$$

All from *BIS* identified ISs are grouped according to the relevant business functions, creating a set of IS groups supporting business functions – *BISG*.

$$BISG = \{BIS_i \mid BIS_i, which \; support \; the \; same \;\; BF_i\} \tag{3.6}$$

All identified ISs from *SIS* are grouped according to the type of support they provide to business functions supporting IS, creating a set of IS groups supporting other ISs – *SISG*.

$$SISG = \{SIS_i \mid SIS_i, which \; provide \; the \; same \; support \; for \; BIS\} \tag{3.7}$$

The full set *ISG* of ISs to be integrated is formed as a union of a set of IS groups supporting business functions and a set of IS groups supporting other ISs.

$$ISG = BISG \cup SISG. \tag{3.8}$$

3.2.2. AMILI process model

The AMILI process model is based on selected solutions described in Chapter 3.1 and design considerations described in Chapter 3.2.1. The AMILI process model represents the process for identifying groups of IS to be integrated. By the context requirements (Chapter 3.1), concepts familiar to the process executors are used in the process description. This helps reduce the learning curve and the number of errors and increases the specialists' commitment to this process (Marks and Mirvis, 2011; Weber, 2015). The PMI IS integration is often assigned to IT professionals, specifically business analysts and requirements engineers (Morrison and James, 2002; Sangar et al., 2020). They are used to working on software development projects and using requirements engineering standards. Therefore, the process is based on the phases of the requirements engineering framework BABOK (A Guide to the Business Analysis Body of Knowledge): requirements elicitation, current and future state description, recent state analysis, and gap definition between present and future states. Information about organisations to be integrated is used as input data for the process. Groups of IS to be integrated are produced as output data of the process. The AMILI process model is represented using a notation similar to the UML (The Unified Modeling Language) activity diagram (Fig. 3.1).

In the *requirements elicitation phase,* PMI goals and PMI context are explored. Compared to the broad spectrum of objectives in software development projects, PMI integration is mainly focused on reducing the redundancy of the IS architectures in organizations to be integrated (Land and Crnkovic, 2007; Jia et al., 2022).

Current business and IS architectures and future business architecture are defined during the *current and future state description phase*. In the subsequent process phases, these architectures are analysed. To reduce the redundancy of IS architectures, it is necessary to describe the existing IS architectures in both organisations and identify their overlap. IS architecture overlap is referred to as ISs in both organisations, which support similar business functions. Given that the primary function of ISs is to support business needs and goals (Wijnhoven et al., 2006; Mehta and Hirschheim, 2007; Baker and Niederman, 2014), addressing the overlap of IS architectures is critical for successful PMI integration. This overlap is related to the overlap of corresponding business architectures, which also needs to be addressed as part of PMI integration. Business architecture overlap is referred to as business units in both organisations that will be transformed to create the future business architecture. Business overlap can be identified by analysing the business architectures of both organisations. To continue the process, the future business architecture is defined as future business unit(s), which requires the elimination of overlaps in existing business and IS architectures.

In the *current state analysis phase,* the relevant business units (*BU*) for each of the future business units are sequentially identified in each organisation (Chapter 3.2.1, Expression (3.2)), along with their corresponding business functions *BF* (Chapter 3.2.1, Expression (3.3)), supporting IS (*BIS*) (Chapter 3.2.1, Expression (3.4)), and additional related IS (*SIS*) (Chapter 3.2.1, Expression (3.5)). It is important to note that, as a result of the identification of business functions, one standard list of business functions in both organisations is created, which is further used to identify ISs supporting these functions in both organisations. If necessary, several process iterations are executed if some additional business units and IS to be integrated are identified.

In the phase of *gap definition between current and future state,* the identified ISs are grouped as *ISG* (Chapter 3.2.1, Expression (3.8)). Business support systems are grouped according to supported business functions as *BISG* (Chapter 3.2.1, Expression (3.6)), and additional related ISs are grouped according to their type of support for other BIS as *SISG* (Chapter 3.2.1, Expression (3.7)).

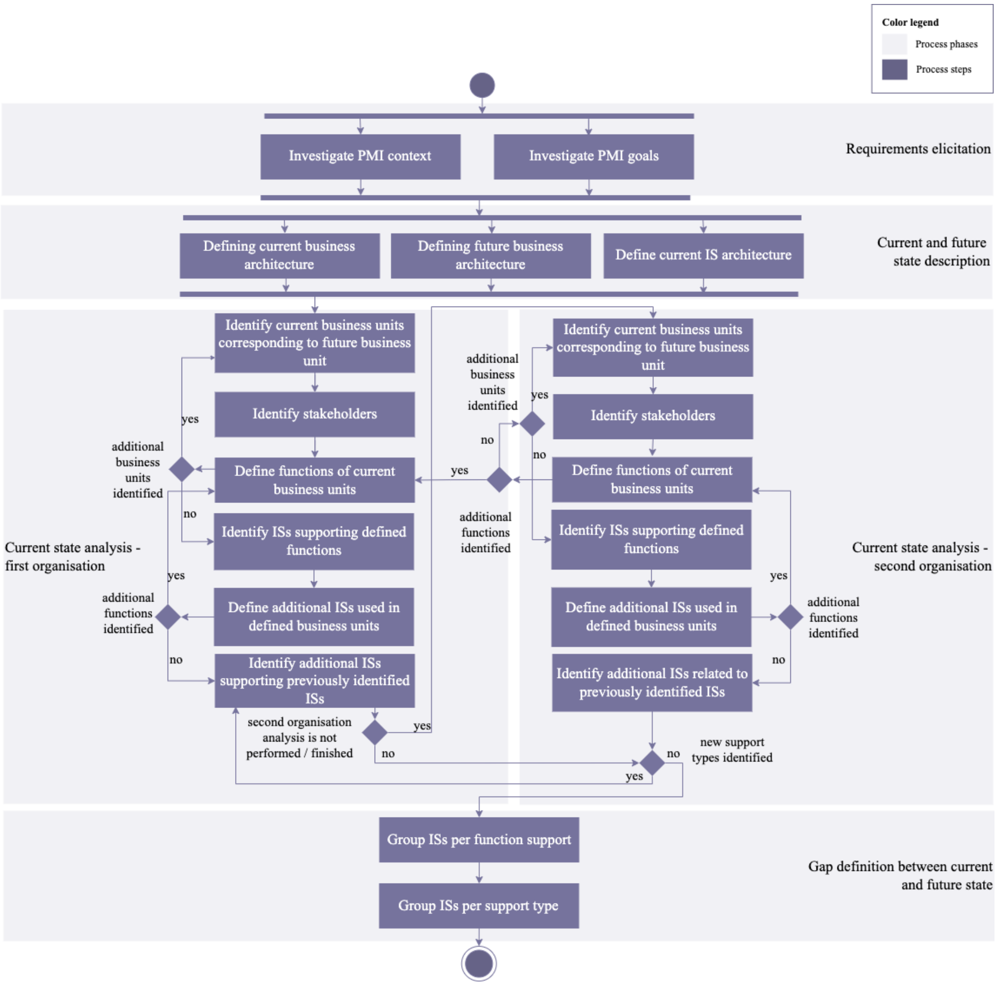

Fig. 3.1. AMILI process model.

Requirements engineering standards use documented knowledge that is created as output in one activity and expected as input in subsequent activities (International Institute of Business Analysis, 2015). Due to time and other resource constraints in PMI IS integration, it is necessary to remove any additional activities, including those related to the creation of documented knowledge. Reducing the amount of documented knowledge requires additional mechanisms for managing undocumented knowledge (Sutcliffe and Sawyer, 2013; Al-Alshaikh et al., 2020). The

AMILI method implies stakeholder identification and active engagement in the process (Fig. 3.2). Business representatives are identified for each business unit and help identify the business functions of the business unit and their supporting ISs. IT specialists also provide additional information about the ISs used in the organisation.

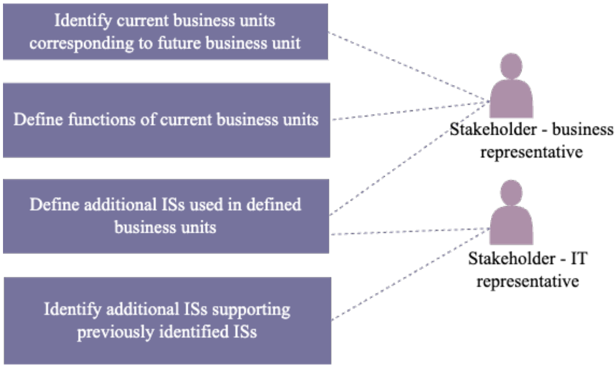

Fig. 3.2. Stakeholder involvement in the AMILI process.

3.2.3. AMILI information model

The AMILI information model represents the knowledge acquired during the process of identifying ISs that need to be integrated. The AMILI information model is represented using a notation similar to the UML (unified modeling language) class diagram (Fig. 3.3). Documented and non-documented knowledge in the model is highlighted with different colours.

Given the AMILI context requirements related to the time and other resources constraints, knowledge gathered in the requirements elicitation phase about *PMI goals* and *PMI context* is not documented. However, it is replaced with documented knowledge about relevant *stakeholder*s who have relevant knowledge and can be involved as required. *Stakeholders* are related to the *organisation* and can be related to one or several *business units*.

To save time and other resources, the following input data about merging organisations is used: for the existing business architecture, the *organisational structure* is used (Niemi and Pekkola, 2017), and for the existing IS architecture, the *IS set* in both organisations is used in any available format. *PMI decisions on the business architecture level* are used for future business architecture as they are often applied to existing organisational units (Toppenberg et al., 2015; Henningsson and Toppenberg, 2020). Using information about these decisions, *future business units* are identified.

For each identified future *business unit,* the corresponding business units in the current business architecture (*BU*) are related (Chapter 3.2.1, Expression (3.2)). With the help of the corresponding *stakeholders*, for each of the current business units, its *business functions* (*BF*) are related (Chapter 3.2.1, Expression (3.3)). For each business function, *supporting ISs* are related (*BIS*) (Chapter 3.2.1, Expression (3.4)). One IS can be related to several business functions in different business units. Each IS supporting business functions can be related to one or several ISs required for its functioning (*SIS*) (Chapter 3.2.1, Expression (3.5)).

Each *IS group ISG* (Chapter 3.2.1, Expression (3.8)) is related to several ISs which support the same business function (*BISG*) (Chapter 3.2.1, Expression (3.6)), or several ISs that provide the same type of support for other IS (*SISG*) (Chapter 3.2.1, Expression (3.7)).

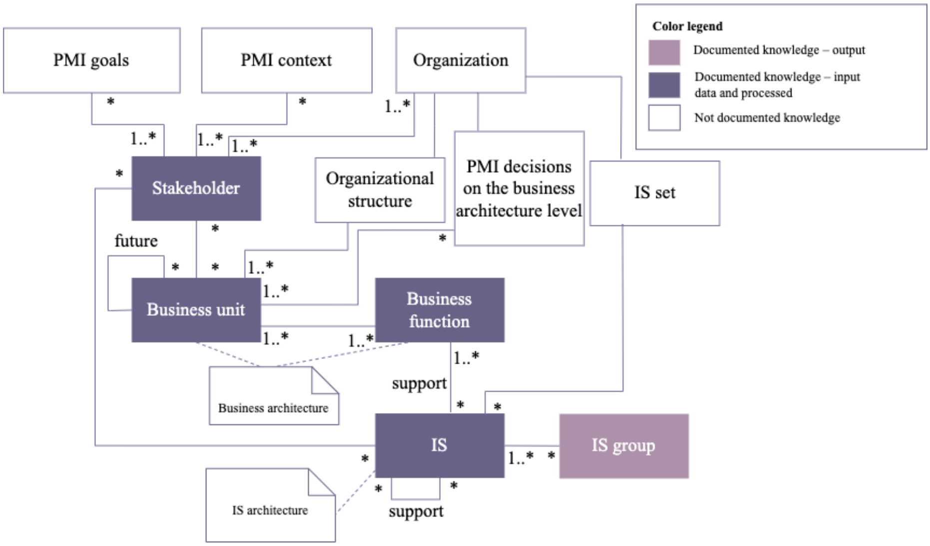

Fig. 3.3. AMILI information model.

3.3. AMILI support tool

A tool has been developed to support the practical use of the method. The materials of the tool are freely available online (Lace, 2023a). The tool helps to apply the method and identify groups of IS to be integrated.

The main component of the tool is a file with table templates in the format of a spreadsheet editor. Table templates contain a data structure corresponding to the method's information model and are filled in during the execution of the process described in the method's process model. Each tool sheet corresponds to a specific step in the method's process model.

As a tool format, the spreadsheet editor supports the execution of the process and the structuring and availability of all the knowledge accumulated during the analysis of the business architecture and IS architecture. In addition, this format helps to simplify the introduction of the tool. The tool template can be converted to any other spreadsheet editor format. Usage of the tool is based on the familiar principles of the spreadsheet editor, making it easier to learn the tool. The tool also contains instructions for use, and additional in-line instructions are integrated into each spreadsheet.

The structure and format of the tool help involved specialists act in a scientifically proven way and the training materials of the tool help in learning how to use the tool. The training materials contain an example of tool usage with already filled tables and video recordings explaining how these tables were filled in. The in-line instructions help understand the essence of the method and facilitate the execution of the informed identification of IS groups to be integrated.

4. THE METHOD FOR SUPPORTING INFORMED DECISION-MAKING (AMILP)

Informed decision-making takes as input data groups of IS to be integrated and evaluates different possible integration options for ranking them in the order of recommendation.

The method is developed based on the concept of methodological support for PMI IS integration (Chapter 2). The design of the AMILP method consists of a process model, which is based on existing solutions in multi-criteria decision-making and knowledge management, as well as an information model, which is based on existing solutions in PMI level synchronisation, and PMI context's impact on different integration options, as well as knowledge management. Both models are adapted for use in the PMI context by selecting existing solutions according to PMI context requirements.

4.1. Literature review in AMILP solution root research areas

The AMILP method should support PMI IS decision-making in accordance with the defined requirements. Specific context requirements for the AMILP method (Table 4.1) are defined by detailing general requirements of the PMI context (Chapter 2) to represent the specifics of PMI IS integration decision-making.

Table 4.1

Specific Context Requirements for Decision-making

Generic requirement	Task support	Specialist preparedness level support	Alignment with determining factors	Minimising blocking factor's impact
Specific requirement	o IS integration option comparison	o Support decision-making for non-experienced professionals	o Support the business objectives of the PMI o Support the alignment between PMI levels o Support specific PMI contextual factors	o Applicability in case of limited documented knowledge o Applicability in case of time and other resource constraints

Existing solutions in the solution root research areas were identified through literature analysis. Existing solutions were evaluated based on their conformity with defined context requirements, and selected solutions are provided in Table 4.2. Eleven multi-criteria decision-making methods were examined as potential solutions to be used in the AMILP process model. The methods were grouped into four groups according to their principle of operation. All reviewed methods support IS integration option comparison and decision-making for non-experienced professionals. But their applicability is complicated in cases of limited documented knowledge, as well as in cases of time and other resource constraints. The AMILP method was based on the principles of reviewed methods, adapted for usage in cases when time and other resources are constrained. The AMILP process model applies the quantitative normalised evaluation of integration options according to selected criteria to compare different options with each other. The method process also includes the involvement of experts to obtain their recommendations for IS integration options.

For the AMILP information model, a unified classification of integration options on different PMI levels was created. It was used to identify possible IS integration options and assess their alignment with other PMI levels. Also, groups of PMI context factors were defined and used as evaluation criteria for IS integration options. The AMILP information model incorporated the same knowledge management solutions as the AMILI information model.

Table 4.2

Selected Research Solutions for Decision making

Process model	Knowledge management in process and data/knowledge models	Data/knowledge model	
Multi-criteria decision-making frameworks	Knowledge management models (9 models were reviewed)	PMI integration levels (Table 4.3)	Specific PMI contextual factors (Table 4.4)
o AHP (analytical hierarchy process) Pairwise comparison (Saaty, 2008) o TOPSIS (technique for order of preference by similarity to ideal solution) Distance-based (Hwang et al., 1993) o ELECTRE (elimination and choice translating reality) Outranking (Figueira et al., 2005) o MAUT (multi-attribute utility theory) Value/utility function (Dillon and Perry, 1977)	o Nonaka & Takeuchi's (Nonaka and Konno, 1998) o Bukowitz & Wiliams (Bukowitz and Williams, 1999) o Choo Sense-making (Choo, 2007)	o Business unit integration o Information technology integration o IS integration	o Contribution to PMI goals o Stakeholder support o User satisfaction o Integration cost o Integration time o Integration risks

4.2. AMILP design

4.2.1. AMILP design considerations

The AMILP method is based on multi-criteria decision-making and the involvement of experts, enhanced with knowledge management solutions. For decision-making, the assessment of IS integration options is used. The assessment is based on aligning with other PMI levels and relevance to PMI context factors.

As a result of the method application, a decision is made as a selection of a specific IS integration option IOS. The decision is made using the information about the group of ISs to be integrated, a set of integration options, a set of option evaluations, and a set of expert recommendations for option selection.

$$IOS = < ISG, IO, IOE, ER >, \tag{4.1}$$

where

ISG – a group of ISs to be integrated;

IO – a set of IS integration options;

IOE – a set of IS integration option evaluations;

ER – a set of expert recommendations for IS integration options.

The group of ISs to be integrated (ISG) contains ISs which require a decision about their integration. This group of ISs can be provided as output data in the AMILI method: the group of ISs (ISG_i). But the AMILP method can also be used without the AMILI method. In this case, it can be a group of ISs obtained in any other way.

$$ISG = \{ISG_i \mid ISG_i \ which \ requires \ a \ decision \ about \ integration\}, \quad (4.2)$$

where ISG_i is ISs to be integrated.

The set of IS integration options IO contains all possible integration implementation options. For each group of ISs to be integrated it is possible to define its specific set of IS integration options. However, to simplify PMI decision-making, a set of default integration options can be used (Land and Crnkovic, 2007; Eckert et al., 2012).

$$IO = \{IO_i \mid IO_i \ as \ possible \ IS \ integration \ option\}, \quad (4.3)$$

where IO_i is the IS integration option.

The set of expert recommendations ER contains IS integration option recommendations from involved experts as ordered lists of possible options, where the most preferable option is at the beginning of the list and the least preferable option is at the end of the list. A group of experts is involved for each group of ISs to be integrated. The experts represent the following expertise areas: business, IT and PMI IS integration.

$$ER = \{ER_i \mid ER_i \ as \ expert \ recommendation, which \ is \ ordered \ IO \ list\}, \quad (4.4)$$

where ER_i is expert recommendation for IS integration option as an ordered IS integration option;

The IO list, where the first option is the most recommended, and the last one is least recommended.

The set of evaluations of IS integration options IOE contains evaluation for each IS integration option.

$$IOE = \{IOE_i \mid IOE_i \ as \ IO_i \ evaluation\}, \quad (4.5)$$

where IOE_i – IS integration option evaluation.

The evaluation of IS integration option IOE is based on the alignment model of IS integration options between different PMI levels (Fig. 4.1) and the value of the IS integration option in the specific PMI initiative.

$$IOE = < IOA, IOV >, \quad (4.6)$$

where

IOA – evaluation of the IS integration option alignment with other PMI levels;

IOV – evaluation of the IS integration option value in the specific PMI initiative.

The following approach is proposed for evaluating the IS integration option.

The alignment of integration options is evaluated for the following PMI levels: business unit integration, information technology integration and IS integration (Mehta and Hirschheim, 2007; Baker and Niederman, 2014). Possible integration options were defined for each PMI level, and the alignment between options on different levels was evaluated (Fig. 4.3). The alignment evaluation was based on the number of existing functions to be reused in the future organisation in case the corresponding integration option is selected (Wijnhoven et al., 2006; Henningsson and Yetton, 2013; Baker and Niederman, 2014; Henningsson and Kettinger, 2016a).

Based on the house of quality approach (Behzadian et al., 2010), three different levels of alignment can be distinguished: minimum alignment (no line between integration options), medium alignment (a dashed line between integration options), and maximum alignment (a bold line between integration options). To evaluate the alignment level quantitively, values of {1, 3, 9} are used, where 1 represents weak alignment, 3 represents medium alignment, and 9 represents strong alignment.

Table 4.3

Integration Options on PMI Levels

Scope of functions to reuse	Business unit integration options (Malekzadeh and Nahavandi, 1988; Haspeslagh and Jemison, 1991; Marks and Mirvis, 2001)	Information technology integration options (Yetton and Dameri, 1996; Wijnhoven et al., 2006; Henningsson and Kettinger, 2016a)	IS integration options (Yetton and Dameri, 1996; Wijnhoven et al., 2006; Henningsson and Yetton, 2011)
All functions from merging organisations will continue to be used in the future organisation	No changes in separation No changes to holding	Coexistence Synchronisation	No changes in IS IS integration
Functions from one merging organisation will take over in the future organisation, functions from another organisation will be discontinued	One company absorbed	Replacement Replacement with bolt-on Replacement with sculpting	IS expansion IS extension IS enhancement
Part of selected functions from both merging organisations will be used to build the solution for future organisation	Both companies mixed	Combination	-
No functions from merging organisations will be used in the future organisation – new solutions will replace them	Both companies start a new way	Transformation	New IS

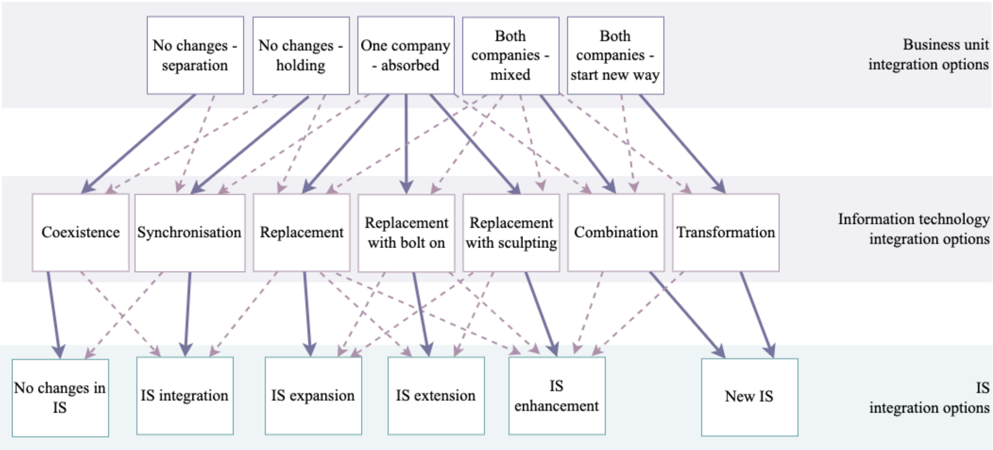

Fig. 4.1. Alignment of the integration options between different PMI levels.

An alignment IOA of IS integration options with integration options on other PMI levels is defined through the alignment with business unit integration and information technology integration:

$$IOA = IOT + IOB, \tag{4.7}$$

where

IOT – an alignment between the IS integration option and the information technology integration option;

IOB – an alignment between the IS integration option and the business units integration option, which is defined according to the following formula:

$$IOB = IOT + ITB, \tag{4.8}$$

where ITB is an alignment between the information technology integration option and the business units integration option.

By replacing in Expression (4.7) the alignment between IS integration option and the business unit integration option as per Expression (4.8), an alignment IOA between the IS integration option and the integration option on other PMI levels can be determined according to the following formula:

$$IOA = 2 \times IOT + ITB. \tag{4.9}$$

IS integration option evaluation is based on the principles for option assessment in multi-criteria decision-making. In the AMILP method, IS integration options are compared according to their value. The IS integration option value depends on factors in the PMI context (Eckert et al., 2012). The literature review results identified the PMI context factors that can impact the outcome or costs of IS integration options (Table 4.4).

Table 4.4

PMI IS Integration Option Evaluation Criteria

IS integration option selection criteria		References
Outcome	Contribution to PMI goals	(Alaranta, 2005; Carlsson and Henningsson, 2006; Mehta and Hirschheim, 2007; Henningsson and Carlsson, 2011; Eckert et al., 2012; Henningsson et al., 2018; Bauer and Friesl, 2022)
	Stakeholder support	(Alaranta, 2005; Carlsson and Henningsson, 2006; Mehta and Hirschheim, 2007; Henningsson and Carlsson, 2011; Eckert et al., 2012; Alaranta and Mathiassen, 2014; Henningsson and Kettinger, 2016b; Henningsson et al., 2018)
	User satisfaction	(Alaranta, 2005; Henningsson and Kettinger, 2016b; Henningsson et al., 2018)
Costs	Integration cost	(Carlsson and Henningsson, 2006; Land and Crnkovic, 2007; Mehta and Hirschheim, 2007; Jain et al., 2008; Breivold et al., 2012; Eckert et al., 2012; Alaranta and Mathiassen, 2014; Benitez and Ray, 2018; Henningsson et al., 2018)
	Integration time	(Alaranta, 2005; Henningsson and Yetton, 2013; Alaranta and Mathiassen, 2014; Henningsson and Kettinger, 2016a, b; Benitez and Ray, 2018; Henningsson et al., 2018)
	Integration risks	(Bannert and Tschirky, 2004; Eckert et al., 2012; Alaranta and Mathiassen, 2014; Henningsson and Kettinger, 2016a)

The value of IS integration options IOV is calculated as the ratio of the outcome value to the cost value. Outcome and costs are represented as corresponding criteria. For each criterion, it is possible to define its degree of importance.

$$IOV = \frac{IG \times G + IS \times S + IU \times U}{IC \times C + IT \times T + IR \times R}, \quad (4.10)$$

where

G – IS integration option contribution in PMI goals;

S – stakeholder support for IS integration option;

U – user satisfaction in case of IS integration option;

C – costs required for IS integration option development and maintenance;

T – time required for IS integration option development and maintenance;

R – risks related to IS integration implementation;

IG, IS, IU, IC, IT, IR – the degree of importance of the relevant criteria.

Criteria evaluation is based on the house of quality approach (Behzadian et al., 2010) and uses the following value set for quantitative evaluation – {1, 3, 9}. Each criterion has specific evaluation scales (table 4.5).

Table 4.5

Criteria Evaluation Scales

Scale value	Outcome			Costs		
	Contribution to PMI goals (*CG*)	Stakeholder support (*SS*)	User satisfaction o Motivation (*UM*) o Preparedness (*UP*) o Experience stability (*UE*)	Integration cost o Baseline costs (*CD, CM*) o Costs increase (*CDI, CMI*)	Integration time o Baseline time (*TD, TM*) o Time increase (*TDI, TMI*)	Integration risks o Probability (*RP*) o Impact (*RI*)
1	o Not sufficient contribution	o Not sufficient support	o Not sufficient motivation o Not sufficient preparedness o Significant instability	o Small cost o Small increase	o Short time period o Small increase	o Minimum probability o Minimum impact
3	o Sufficient contribution	o Sufficient support	o Sufficient motivation o Partial preparedness o Partial stability	o Average cost o Average increase	o Average time period o Average increase	o Average probability o Average impact
9	o Significant contribution	o Significant support	o Significant motivation o Full preparedness o Sufficient stability	o Significant cost o Significant increase	o Significant time period o Significant increase	o Significant probability o Significant increase

IS integration option contribution G to PMI goals is calculated as a sum of the contributions to each goal selected for the specific PMI initiative, multiplied by the degree of importance of the respective goal.

$$G = \sum_{i=1}^{n} G_i \times CG_i, \tag{4.11}$$

Where

n – the number of goals selected for the evaluation;

G_i – the degree of importance of the specific goal, a number from 1 to 5 (5 is the highest degree);

CG_i – IS integration option contribution to a particular goal.

Stakeholder support S for the IS integration option is calculated as a sum of the stakeholders' degree of support multiplied by the corresponding stakeholder's impact level.

$$S = \sum_{i=1}^{n} SI_i \times SS_i, \tag{4.12}$$

where

n – the number of stakeholders selected for the evaluation;

SI_i – the impact level of the specific stakeholder, a number from 1 to 5 (5 is the highest level);

SS_i – support of the particular stakeholder for the IS integration option.

User satisfaction U in the case of IS integration option is calculated as a sum of the degree of motivation, the degree of preparedness and the degree of experience stability for the user group, multiplied by the user group's impact level of the relevant user group.

$$U = \sum_{i=1}^{n} UI_i \times (UM_i + UP_i + UE_i), \tag{4.13}$$

where

n – the number of user groups selected for the evaluation;

UI_i – the impact level of the specific user group, a number from 1 to 5 (5 is the highest level);

UM_i – the degree of motivation of the specific user group for the IS integration option;

UP_i – the degree of preparedness of the specific user group for the changes related to the IS integration option;

UE_i – the degree of user experience stability for the specific user group during and after the implementation of the IS integration option.

Costs C of the development and maintenance of the IS integration option are calculated as a sum of the baseline development and maintenance costs for the IS integration option, adjusted for the specific PMI context.

$$C = CD + CM + \sum_{i=1}^{n}(CDI_i + CMI_i), \quad (4.14)$$

where

CD – baseline cost level for the implementation of the IS integration option;

CM – baseline cost level for the maintenance of the IS integration option;

n – the number of considered PMI context factors selected for the evaluation;

CDI_i – adjusted baseline implementation cost level due to considered PMI context factors;

CMI_i – adjusted baseline maintenance cost level due to considered PMI context factors.

After considering all factors in the PMI context, the lowest possible cost C cannot be less than zero.

Time T for the development and maintenance of the IS integration option is calculated as a sum of the baseline development and maintenance time for the IS integration option, adjusted for the specific PMI context.

$$T = TD + TM + \sum_{i=1}^{n}(TDI_i + TMI_i), \quad (4.15)$$

where

TD – baseline timeline for the implementation of the IS integration option;

TM – baseline timeline for the maintenance of the IS integration option;

n – the number of considered PMI context factors selected for the evaluation;

TDI_i – adjusted baseline implementation timeline due to considered PMI context factors;

TMI_i – adjusted baseline maintenance timeline due to considered PMI context factors.

After considering all factors in the PMI context, the shortest possible time T cannot be less than zero.

The risks R related to the IS integration option are calculated as a sum of the probability of risk in the case of IS integration option and the negative impact if the specific risk appears. The study does not use risk probability and impact multiplication, as it may disproportionately affect the value of the integration option.

$$R = \sum_{i=1}^{n}(RP_i + RI_i), \quad (4.16.)$$

where

n – the number of risks selected for the evaluation;

RP_i – probability of the specific risk for the IS integration option;

RI_i – the impact of the particular risk for the IS integration option.

4.2.2. AMILP process model

The AMILP process model is based on selected solutions described in Chapter 4.1 and design considerations described in Chapter 4.2.1. The AMILP process model represents the process for analysing possible IS integration options for a group of ISs to be integrated. The process follows the principles of multi-criteria decision-making and includes the following phases: context investigation; expert, option and criteria selection; integration option evaluation; and integration option recommendation. A group *ISG* of ISs to be integrated, which requires a decision on its integration, is used as input data of the process (Chapter 4.2.1, Expression (4.2)). As output data of the process, a decision is made to select one of the possible IS integration options, *IOS* (Chapter 4.2.1, Expression (4.1)). The AMILP process model is represented using a notation similar to the UML unified modeling language) activity diagram (Fig. 4.1).

In accordance with the context requirements (Chapter 4.1), the process should be easy to understand and execute in the context of time and other resource constraints. Therefore, only activities necessary for evaluating integration options and obtaining expert recommendations have been included in the process.

In the *context investigation phase,* PMI context factors that may affect the value of the integration options are identified. Information about impacting factors is later used in the integration option evaluation phase. In the context investigation phase, PMI objectives and decisions made on the other PMI levels are identified. This information is necessary for evaluating the degree of alignment of the integration option with other PMI levels.

In the *phase of defining experts, integration options, and criteria*, preparation for analysing integration options takes place. In the phase, the possible integration options *IO* are selected (Chapter 4.2.1, Expression (4.3)). In the following phases, the selected options are evaluated, and one is selected for IS integration. The method can be used for choosing from the default integration variants (Table 4.3), but the set of options can be customised. Some default options can be removed from the start if their selection is not possible in the particular case. The method also allows the inclusion of new integration options, but in this case, it is necessary to define the alignment of these options with other PMI levels. Also, in this phase, the criteria that will be used for integration option comparison are defined. The method can be used with the default criteria (Chapter 4.2.1). However, the method also can be adapted to the specific PMI initiative, and additional criteria representing an outcome or costs can be added. When adding additional criteria, it is necessary to define the expression for calculating the value of the criteria. All criteria are initially considered equally important by default, but it is possible to assign a greater level of importance to specific criteria if needed. In this phase, experts are also selected from business, IT, and PMI IS areas, who will evaluate integration options and provide their recommendations.

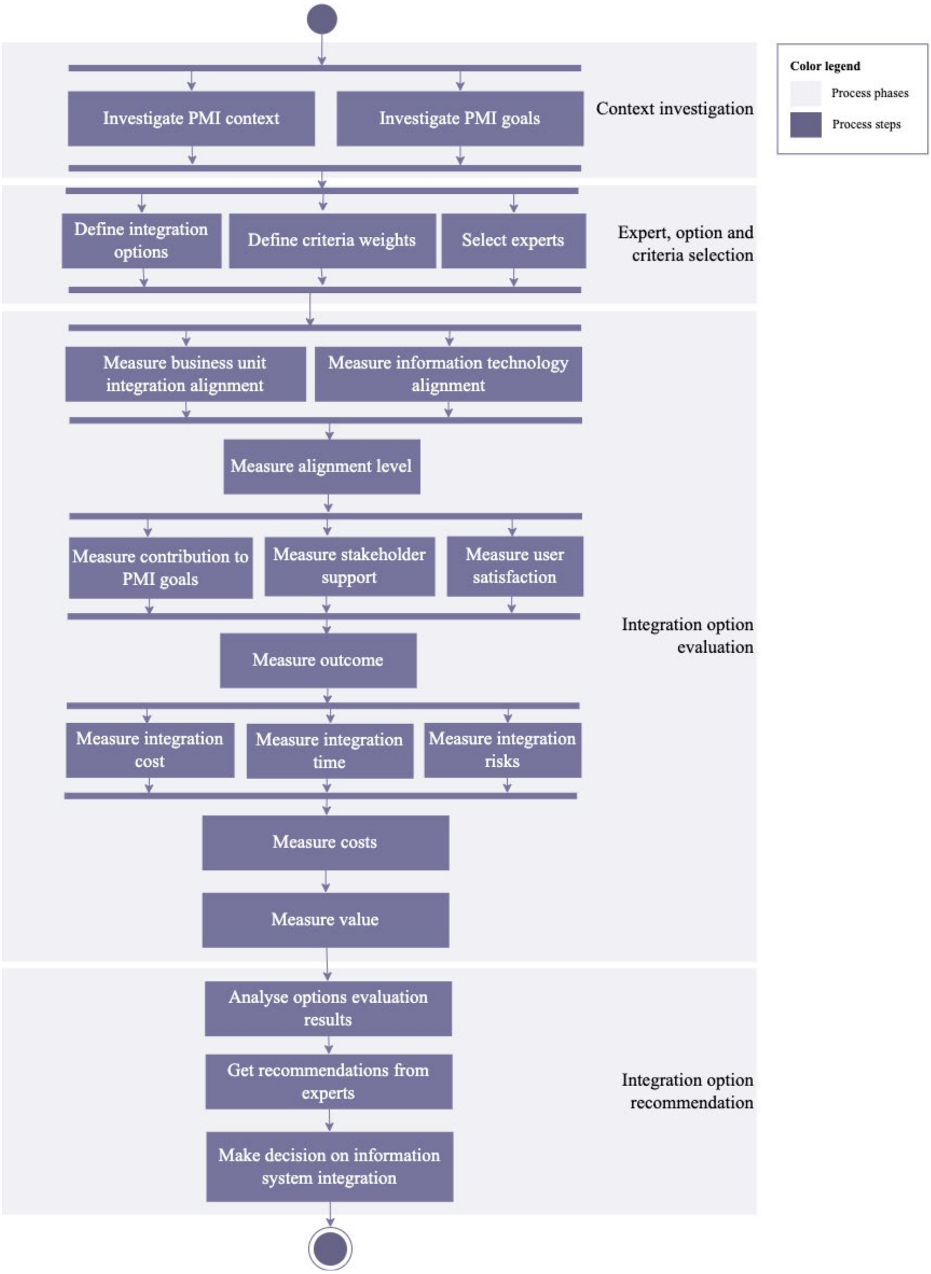

Fig. 4.2. AMILP process model.

During the *evaluation of the integration options phase*, each of the integration options gets the evaluation, *IOE* (Chapter 4.2.1, Expression (4.5)). To obtain the evaluation, the degree of alignment with other PMI levels, *IOA,* and the value of the integration option *IOV* are calculated (Chapter 4.2.1, Expression (4.6)). The previously defined expressions are used for calculations (Chapter 4.2.1, Expressions (4.7)–(4.16)). For easier comparison of options, the calculated values are normalised. Upon completing this phase, it becomes possible to assess the relative alignment and value of each integration option compared to the other options. To mitigate PMI challenges related to missing documented knowledge, stakeholders' business representatives, user representatives, and IT representatives are involved in evaluating options (Fig. 4.3, the right side of the image).

In the *integration option recommendation phase*, selected experts from the business, IT, and PMI areas are involved in recommending their integration option (Henningsson and Kettinger, 2016b; Henningsson et al., 2018) (Fig. 4.3, the left side of the image). Based on the available evaluation results and expertise, each of them offers a set of recommended options, *ER,* as a list of options ordered from the most preferable to the least preferable (Chapter 4.2.1, Expression (4.4)). Based on the evaluation of the options and the experts' recommendations, the responsible specialist can make an informed decision on the choice of the integration option.

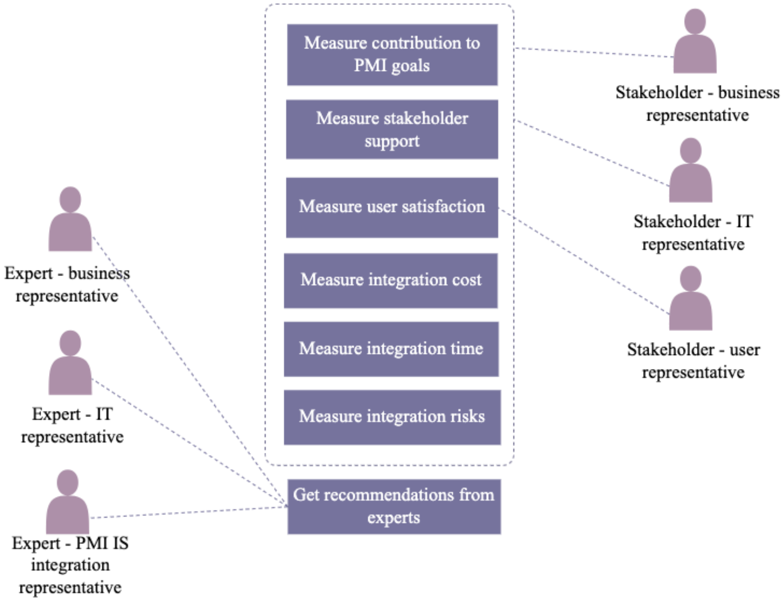

Figure 4.3. Stakeholder involvement in the AMILP process

4.2.3. AMILP information model

The AMILP information model represents the knowledge obtained from analysing possible IS integration options. The AMILP information model is represented using a notation similar to the UML (unified modeling language) class diagram (Fig. 4.4). Documented and non-documented knowledge in the model is highlighted with different colours.

The method requires input data in the form of *IS group* (*ISG*), which contain several *ISs* requiring a decision about their integration. *PMI goals* and *PMI context* are explored for the provided *IS group*. However, due to time and resource constraints, gathered knowledge is not documented but is replaced with documented knowledge about *stakeholder*s who have relevant knowledge and can be involved as required.

Possible *IS integration options* (*IO*) are selected based on the specifics of the *IS group* and *PMI context* (Chapter 4.2.1, Expression (4.3)), along with their *evaluation criteria*, which represent the *outcome* or *cost* of the integration option. Experts are also selected to provide their recommendations for the integration option.

With the help of involved stakeholders, for each *IS integration option,* the evaluation (*IOE)* of the integration option is performed (Chapter 4.2.1, Expression (4.5)). Using the individual *criteria values*, for each integration option, the *cost* and the *outcome* values are defined. The integration option *value (IOV)* is defined as a ratio between the *outcome* and the *cost* (Chapter 4.2.1, Expression (4.10)). For each integration option, the *alignment level* with other PMI levels (*IOA*) (Chapter 4.2.1, Expression (4.9)) is defined based on the alignment with *business unit integration* and *information technology integration*.

Each selected expert creates an *expert recommendation* (*ER*), ranking each integration option within the set of ordered integration options (Chapter 4.2.1, Expression (4.4)). Finally, the *decision on IS group integration* (IOS) is made by taking into account the value and alignment degree of each integration option, along with the recommendations of all experts involved. As a result, one specific integration option is selected (Chapter 4.2.1, Expression (4.1)).

To save time and other resources, the method only documents knowledge about stakeholders, IS integration options evaluation, and selected integration option. The responsible specialist can decide to transform other information into documented knowledge based on the available resources and expected benefits.

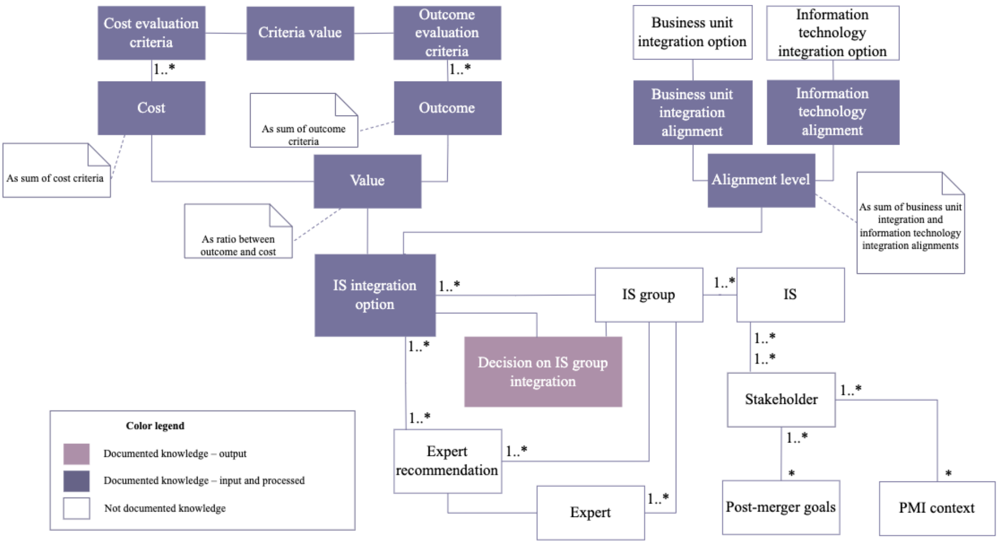

Fig. 4.4. AMILP information model.

4.3. AMILP support tool

A tool has been developed to support the practical use of the method, The materials for this tool are freely available online (Lace, 2023b). The tool assists in applying the method, i.e., analysing and evaluating IS integration options.

The main component of the tool is a file with table templates in the format of a spreadsheet editor. These table templates contain a data structure that corresponds to the method's information model and are filled in during the execution of the process described in the method's process model. Each sheet within the tool corresponds to a specific step in the method's process model.

This format was chosen due to the abovementioned considerations of easier implementation and learning of the tool. The tool also includes instructions for use, and additional in-line instructions are integrated into each spreadsheet. Automated evaluation calculations, as well as automated result compilation, are integrated into the tool.

As a tool format, the spreadsheet editor supports the execution of the process and the structuring and availability of all the knowledge accumulated during the analysis and evaluation of IS integration options.

The structure and format of the tool assist specialists in acting in a scientifically proven way, and the training materials of the tool aid in learning how to use it. The training materials include an example of tool usage with already filled tables and video recordings explaining how these tables were filled in. The in-line instructions help to understand the essence of the method and facilitate the execution of informed decision regarding the integration option.

5. VALIDATION OF METHODS

Both methods were validated through simulation, experimental evaluation and usability evaluation. The first validation stage simulated the application of the methods to decision identification and decision-making cases to ensure that the methods and tools are usable and achieve the intended results. In the second validation stage, the research assumption and hypothesis were tested for both methods using experiments. In the third validation stage , the usability of the methods and tools was assessed by surveying the experiment participants.

5.1. Simulation of methods

During the AMILI simulation process, the groups of ISs to be integrated were identified in the scope of future business unit creation, which will be accomplished by merging two organizations (Lace, 2023c). As a result of the AMILI method simulation, all the expected ISs to be integrated were identified. The AMILI method allowed for identifying several ISs that were initially missed in the actual PMI initiative, including access rights management systems and internal communication systems. By grouping systems based on business functions, the scope of IS integration could be controlled and divided into smaller projects focused on integrating specific business units. This approach also enabled the identification of additional systems. The method was designed to use close and understandable concepts to the stakeholders involved, making it easy for them to provide the required input. By involving business and IT representatives, it was possible to identify information systems that are not directly used by the business but are still important for integration. The iterative nature of the method allowed for the return to previous steps to add information, which made it possible to identify additional business units, their functions, and supporting information systems.

The identified groups of ISs to be integrated can be used as input data for decision-making on IS integration option selection. However, the manual process and data copying between the tool's spreadsheets can lead to errors and be time-consuming. Analysing large tables can also be cumbersome. To make the results easier to understand, the visual display of the results obtained during the execution of the method was found to be helpful in understanding the relationships between business units, functions, and ISs. The next step would be to replace the images with analysable models that could also be used in automated input validation. Considering the aspect of time and other resource limitations in PMI, future versions of the method could have a more elaborate ratio between the required effort and gained results. One option to increase the value of the documented knowledge created in the tool is to consider its reusability across multiple PMI initiatives.

During the AMILP simulation process, with the help of the method support tool, the integration options of two information systems were analysed and evaluated in three different PMI cases, where a different recommended integration option was expected for each case (Lace, 2023c). As a result of the AMILP simulation, the alignment degree and value of the integration options matched the expected results. The AMILP method allows for evaluating integration options from different perspectives and considers the specifics of the concrete PMI initiative.

Using the method, it is possible to identify integration options that are better suited to various PMI contexts. However, evaluating the risk criterion may not be adaptable to the specific context, as it gave identical results in all cases despite the different probabilities and impact levels of the individual risks. The risk level assessment expression could be reviewed and adjusted for better adaptation to the probability and impact of the risk. Additionally, the results of all criteria evaluations could be verified with more research cases. In the simulation of the method, the degree of importance of the criteria was not used, and their effects were not investigated. In addition, the limitation of the simulation was related to the executor of the method, the author of the method. The author of the method could unintentionally impact the results, as she knew the expected results. Therefore, the method validation was expanded to include other validation approaches, such as experimental and usability evaluation. By selecting only three main aspects for the evaluation of each criterion and choosing aspects for goals, risks, and context factors from predefined lists, the usability of the method improves. In the next versions of the method and tool, it could be helpful to consider additional usability improvements.

5.2. Experimental evaluation of methods

The results of the methods were tested experimentally by comparing the results of the methods' execution for two groups of experiment participants: experts and specialists without expertise in PMI IS integration. Each group consisted of 10 participants. Two selection criteria were applied to the sample of participants. The expert group included participants with experience in performing similar tasks in at least three PMI initiatives. In contrast, the group of specialists without expertise in PMI IS integration included participants without such experience. Participants were asked to rate their knowledge of PMI IS integration theory on a scale of 0 to 10, with 10 being the highest level of knowledge. The expert group included participants whose self-assessment was higher than 7, but the group of specialists without expertise in PMI IS integration included participants with a self-assessment lower than 5.

To minimise the impact of external factors, three additional decisions were made. The first decision was to limit the impact of knowledge limitations. As input data for the experiment, all participants were given only documented knowledge about the task and the case context. The second decision was to minimize the involvement of external stakeholders in the execution of the experimental task to reduce the possible impact of these persons on the results. The third decision was made to minimise the effect of time constraints. All experiment participants were given the same time to complete the task. Based on the known information about the time the experts needed to complete the task in the actual PMI case, a corresponding time limit was set for each case. The results of the AMILI experiment were evaluated using two error values: identified IS error and grouped IS error. Identified IS error represents the difference between the expected and actual number of identified IS, including incorrectly identified and unidentified expected systems. Grouped IS error represents the difference between the total number of IS groups and the number of correctly grouped ISs, which were predefined. The experiment results (Figs. 5.1 and 5.2) showed that for specialists without expertise in PMI IS integration and without method support, both error values were more significant than for experts. However, with the support method, all error values decreased. By comparing the results of the group members using a T-test and Mann–Whitney U test, it was observed that the difference between experts and specialists without expertise in PMI IS integration and support method was significant only for the identified IS error, but not for the grouped IS error. With the support method, no significant difference was observed between the experts and the specialists without expertise in the PMI IS integration for both identified and grouped IS errors.

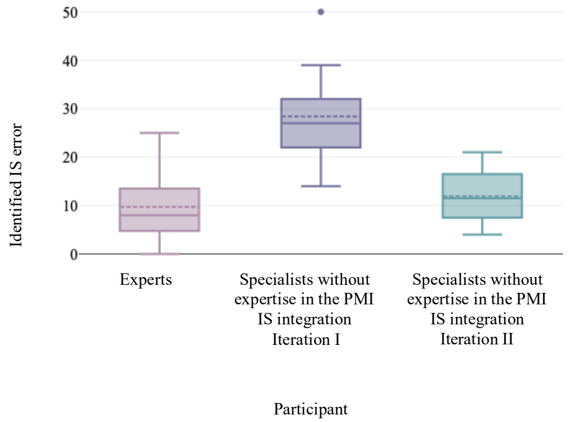

Fig. 5.1. AMILI experiment results – identified IS error (relative).

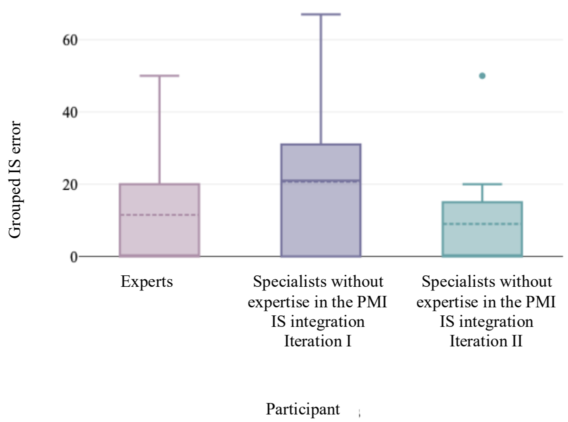

Fig. 5.2. AMILI experiment results – grouped IS error (relative).

The results for AMILP were compared based on the IS integration recommendation error, which was defined by the rank of the expected IS integration option in the recommendation. The results of the AMILP experiment (Figs. 5.3–5.5) indicate that specialists without expertise in PMI IS integration and without method support had a higher IS integration recommendation error than experts in all three cases. Furthermore, it was observed that the error value decreased with the support method. Comparing the results of group members using T-tests and the Mann–

Whitney U test, a difference was observed between experts and specialists without expertise in the PMI IS integration and without method support in two out of three cases. However, with the support method, no difference was observed between an expert and a specialist without expertise in the PMI IS integration in all three cases.

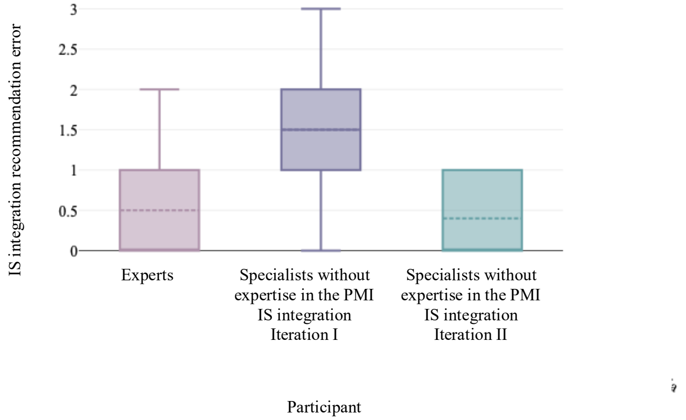

Fig. 5.3. AMILP experiment results: IS integration recommendation error (case I).

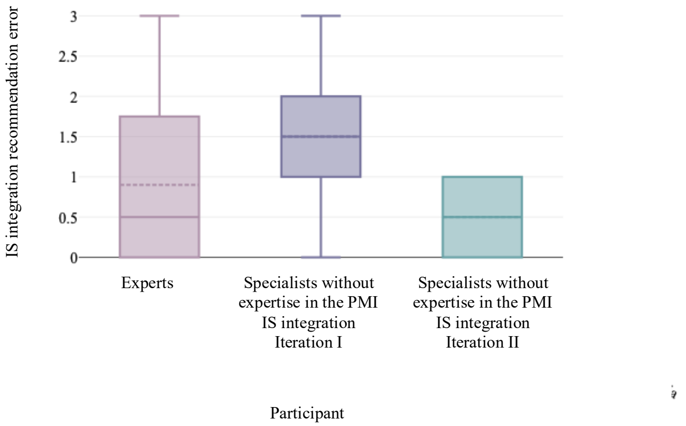

Fig. 5.4. AMILP experiment results: IS integration recommendation error (case II).

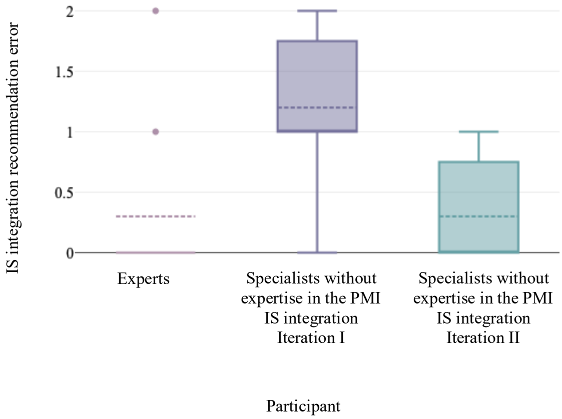

Fig. 5.5. AMILP experiment results: IS integration recommendation error (case III).

5.3. Usability evaluation of methods

The usability of the methods was evaluated based on three aspects: ease of learning, ease of use, and the benefits of using the methods. Participants of the experiments were invited to evaluate the usability of the methods immediately after using them and their tools as part of the experiment. The benefit of using the AMILI method was rated 4.5 out of 5, confirming that specialists appreciate the method's support for task performance. Ease of use was rated 3.6 out of 5, and ease of learning was rated 3 out of 5. Overall, the rating was above average, but there is room for improvement. Most of the recommendations for improving the method were related to the ease of learning: long instructions and processes with several steps described in text format were difficult to understand. Before applying the method, simulating it for test cases would be helpful.

The benefit of using the AMILP method was also rated 4.5 out of 5, indicating that specialists appreciated this method's support. However, ease of use was rated 3.1 out of 5, and ease of learning was only 2 out of 5. Many of the recommendations for improving the method were related to minimizing the reading of long and complex instruction texts and the desire for more illustrative examples. As stakeholders were not involved in the experiment, some comments were related to the context of the experiment: the difficulties of getting required information without the involvement of stakeholders. Several comments were related to the terminology used in the method and the need for more explanation, including reminding the importance of different integration options during the execution of the method. Future versions of the method could improve the ease of learning by considering these recommendations.

RESULTS AND CONCLUSIONS

In the Doctoral Thesis, a solution to one of the PMI IS integration problems is provided, specifically that organisations new to PMI lack expertise in PMI IS integration, which is why, in the IS integration decision identification and decision-making they are unable to achieve as good alignment with the determining context factors and low impact from the blocking context factors as organisations with PMI experience. The Doctoral Thesis aimed to answer the question: *What methods can help specialists without expertise in the PMI IS integration to achieve results comparable to the results of experts?*" Accordingly, to reach the goal of the Doctoral Thesis – *to develop methods for supporting the identification of groups of IS to be integrated (decision identification) and analysis of integration options (decision- making) in PMI initiatives*.

To reach the goal, all tasks stated in Section 1.2 were accomplished, and the following scientific results have been obtained:

1. A concept of support for decision identification and decision-making in the scope of PMI IS integration has been developed, based on compensation for the lack of expertise. For each identified component of the concept of expertise, the concept of support proposes the corresponding replacement solution to improve the awareness of specialists, namely: 1) a process model developed for the standard process, 2) an information model developed for context investigation, and 3) for application of the previous experience – both process and information models are enhanced with knowledge management elements.
2. A support method has been developed to identify IS groups to be integrated into the PMI. The method combines knowledge from the following fields: requirements engineering, enterprise architecture, and knowledge management.
3. A support method for analysing possible IS integration options in the PMI has been developed. The method combines knowledge from the following areas – multi-criteria decision making, knowledge management, synchronisation of PMI levels, and the impact of PMI context factors.

The scientific results achieved in the Doctoral Thesis have made it possible to make the following practical contributions:

1. a tool has been developed for each method to support its practical application.
2. Both methods and supporting tools are applicable in practice to compensate for the lack of expertise of the involved specialists in PMI IS integration.

The results allow us to state that the goal of the Doctoral Thesis has been achieved and the research question raised in the Doctoral Thesis has been answered. This is confirmed by the conclusions provided for each of the developed methods.

Conclusions on the AMILI method and opportunities for further research:

1. Based on the results of the simulation and experiments of the method, it can be concluded that the method supports the informed decision identification in the PMI IS integration, and its use ensures for specialists without experience in the PMI IS integration the results (identified groups of IS to be integrated) comparable to the results of experts.

2. Based on the results of the experiments, it was proved that the method can be used in cases of limited documented knowledge. It was also proven that the method could be used in cases of time constraints, as in the experiments the time required for specialists without experience in the PMI IS integration did not exceed the time required for experts in a real PMI initiative.
3. Based on the results of method simulation, experiment results and usability evaluation results, the following desired improvements of the method and support tool were identified: supplementing the tool with analytical models of the business unit, function and information system relationships; automating data entry and data validation; incorporating the usage of the documented knowledge created during the method among several PMI initiatives.

Conclusions on the AMILP method and opportunities for further research:

1. Based on the results of the simulation and experiments, it can be concluded that the method supports informed decision-making in the PMI IS integration, and its use ensures for specialists without experience in the PMI IS integration the results (the chosen option of IS integration) comparable to the results of experts.
2. Based on the results of the experiments, it was proved that the method can be used in cases of limited documented knowledge. It was also proven that the method could be used in cases of time constraints, as in experiments the time required for specialists without experience in the PMI IS integration did not exceed the time required for experts in a real PMI initiative.
3. Based on the method simulation, experiment, and usability evaluation results, the following desired improvements of the method and support tool were identified: transform the method instruction manual into an easier-to-understand format; provide easily accessible explanations for the concepts used in the method; test the risk level and other value criteria evaluation expressions on a more significant number of cases and through the use of criteria importance; implement repositories of criteria facet values and their default evaluations or implications for integration options.

Based on the obtained results and conclusions, it can be stated that the hypothesis "s*pecialists without expertise in the PMI IS integration with the support method can achieve results comparable to the results of experts in the identification of groups of IS to be integrated (identification of decisions) and analysis of integration options (decision-making)*" is confirmed.

The assumption defined for the Doctoral Thesis that "s*pecialists without expertise in the PMI IS integration without additional support achieve different results than experts*" is partially confirmed. Different experimental results, in the case of the AMILI method, were observed for the identified IS error, and in the case of the AMILP method, for the IS integration options recommendation error were observed in two of three cases. Therefore, considering the decrease of all error values when using the support methods, it can be concluded that even in cases where the results of experts and specialists without expertise in the PMI IS integration and without the method support are comparable, when using the method support, the results are closer to the expected ones. This, in turn, means that methods can potentially have a positive effect on expert results and can be a promising topic for future research. Future research could focus on further automation of methods, methods integration with business modeling tools, and development of method adaptation mechanisms for application in several sequential PMI initiatives. Considering the impact of innovation, digital transformation, and other factors on the development of large enterprise ISs, potentially the methods developed in the Doctoral Thesis could also be used in IS integration initiatives outside the PMI context, where the goal of integration is to reduce redundancy and overlap in the IS architecture. However, additional research is required to verify the applicability of these methods in other contexts.

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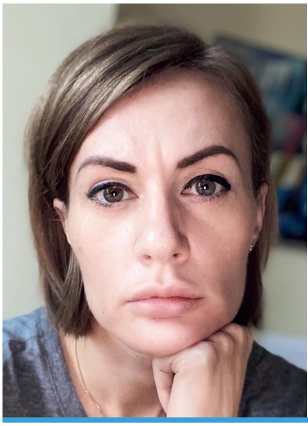

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