

THESES OF THE DOCTORAL (PHD) DISSERTATION

EXAMINING THE DIGITAL TRANSFORMATION OF THE CORPORATE CONTROLLING FUNCTION, WITH A SPECIAL FOCUS ON THE SITUATION OF SMALL AND MEDIUM-SIZED ENTERPRISES IN HUNGARY

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1. RESEARCH BACKGROUND, GOALS AND HYPOTHESES OF THE DISSERTATION

The decision-supporting controlling function has been evolving dynamically since its birth, as a result of the evolution of the socio-economic system and the continuous changes in the external environment and internal operational processes of the organisations. This change is inevitable, as the new internal operating conditions resulting from the new market conditions or the development of the organisation in question mean that the methods, tools and rules previously used may no longer be able to effectively support management decision-making. For processes to work as they used to, adaptation and innovation are needed, otherwise controlling may lose its relevance.

Today, the transformation of the corporate controlling function is influenced by several trends, the most important of which are increasing globalisation, the expansion of worldwide business relationships, the constant change in consumer demand and the continuous, dramatic development of information technology (WOLF et al., 2020). The latter is often referred to as the fourth industrial revolution, which impacts almost all aspects of socio-economic life. The corporate sector is no exception, where digitalization is also increasingly affecting all areas, including the decision-supporting control function. The application of digital technologies and innovative methods is leading to the emergence of new business models that are disruptively transforming current corporate structures, thereby also triggering changes in the controlling processes (FÄHNDRICH, 2024). The need for transformation is primarily driven by the drastic increase in the amount, diversity and quality of processable data, and the emergence of increasingly sophisticated data analysis tools and methods (SZUKITS et al., 2024).

MÖLLER et al. (2020) noted at the beginning of the decade that, although digitalization has had a major impact on the field of controlling, there is a significant gap between practice and theory. The phenomenon is not discussed in academic publications with the intensity that its practical relevance would require. RASHID et al. (2020) also point out that controlling techniques and the changing roles of controllers are relatively unexplored areas in the context of digital revolution. Since then, the literature of the topic has been growing and empirical research has become more frequent (FÄHNDRICH, 2023), but, as described by

KNUDSEN et al. (2020) and LOMBARDI and SECUNDO (2021), the evolution of technology and its impact on controlling is continuous, thus it requires continuous research.

Although the international literature on the relationship between controlling and digitalization is now rather widespread, its focus is very diverse, and the exact theoretical background and used methodology differ. Research in the field of controlling is characterised by the development of frameworks based on literature, or on their own primary results, or by the adoption of frameworks already established by other authors, which then determines the direction of the research (BURNS – SCAPENS, 2000; ALSHARARI et al., 2015). This direction also appears in the study of digital transformation (KEIMER – EGGLE, 2023; FÄHNDRICH – PEDELL, 2024). The aim of the secondary literature review of my thesis was to establish a grounded theoretical framework that comprehensively describes the relationship between the controlling function and digitalization, which could serve as a basis for my primary research.

The relationship between controlling and digitalization can be examined from several angles. Primarily, it is essential to explore how controlling processes and the work of controllers are transforming, how the methods, technological tools and competences of controllers could change (KEIMER – EGGLE, 2023). In addition, the transformation of the organisational role of controlling is a key dimension: a process often discussed in the related literature is the evolution of the role, where controllers are shifting from traditional data recorders dealing with accounting information to proactive advisors to management. The emergence of the so-called business partner role is seen by many researchers closely connected to the digital transformation of the field. The development of IT systems is widely seen as a driver of the role change, but findings are often contradictory (WOLF et al., 2020). Several authors describe how advanced technological tools can liberate controllers from their traditional time-consuming tasks, allowing them to focus on more qualitative activities with higher added value (SUHAIMI et al., 2016; RIEG, 2018; MÖLLER et al., 2020). However, JACK and KHOLEIF (2008) and HEINZELMANN (2018) articulate the opposite effect, arguing that technological development may push controllers back into the traditional role of information gathering and supplying. Although the role of business partner is described in the Hungarian literature (DOSZPOLY, 2019; KOVÁCS, 2019; MUSINSZKI – NÁCSA, 2021),

empirical research on its emergence is particularly scarce: its study represents a research gap, especially in the case small and medium-sized enterprises.

In their thought-provoking paper, MÖLLER et al. (2020) raise the following potential research question: what factors enable or hinder the digitisation of the controlling function? Answering this question is not easy, as successful digitalization could have a number of benefits, but also a numerous different barrier that can hinder transformation (BAJNAI, 2022), especially for the vulnerable SME sector. Incentives often include working more efficiently and faster, reducing costs, or increasing competitiveness and sustainability (AZUDIN – MANSOR, 2018), while the most relevant possible constraints are the lack of resources, the organisational resistance, or even the managerial conservatism (RADICIC – PETKOVIC, 2023). The financing difficulties of SMEs are highlighted by several studies, including those related to the implementation of ERP systems and business intelligence tools (PALOMINO – FREZATTI, 2016; ROFFIA – DABIC, 2024).

The specific characteristics of a company's operations can influence the appearance of its controlling system and its digital transformation. Contingency theory has a long research history on the emergence and change of control systems (CHENHALL, 2003). The most commonly highlighted contingency is firm size, but there are several other internal and external factors, such as the industry or geographical location of the firm. With regard to size, several authors describe how research in the field of controlling has mostly focused on large firms, although it would be particularly important to explore smaller firms (WOLF et al., 2020; BROCCARDO et al., 2024). Although the contingency theory-based analysis of the controlling area is widespread in Western literature, little research has been conducted focusing specifically on digital transformation (FÄHNDRICH – PEDELL, 2024). This is particularly true for Central and Eastern Europe, and especially for Hungary, where not only the digital focus but also the contingency-based literature is fundamentally scarce. However, my preliminary research suggests that there may be differences between smaller and larger firms, or even between firms in the industrial and service sectors, in terms of the digital transformation (BAJNAI, 2023).

The main objective of my research was to investigate the digital transformation of the controlling function among Hungarian SMEs, covering the dimensions defined above. After

establishing the theoretical framework, I conducted a questionnaire survey targeting domestic SMEs that have a separate controlling function. Prior to analysing the database, I considered it important to aggregate the information obtained into indices which, taken alone, could reliably characterise the digital development of the controlling function of a given enterprise. The construction of digitalization indices is a widely used method (KORZHYK et al., 2023), but no such index has been previously constructed for the controlling function. Beyond the detailed analysis of the dimensions, I considered it important to be able to characterise the overall controlling-digitalization situation of the domestic SME sector by means of a comprehensive analysis of the representative sample. I carried out a cluster analysis and then further compared the separate groups. My preliminary hypothesis is that the use of digital technology tools is the factor along which firms are most likely to be separated, given that financial constraints and organisational resistance also strongly influence – especially among SMEs – whether a firm moves from traditional office softwares to automated and integrated systems or even to AI-based tools (DE MAN – STRANDHAGEN, 2018; BANJAI, 2022).

Main objectives and hypothesises of the research

1. Establishing the theoretical framework.

2. Design and analysis of digitalization indexes.

H1: There is a significant positive relationship between the level of digitalization of the controlling function and the efficiency and speed of the function.

3. Examining the relationship between controller roles and digital transformation.

H2: Of the controller roles studied, the positive relationship of the business partner role and the high degree of digitalization and high quality of the controlling function is the strongest.

H2a: Of the controller roles studied, the positive relationship of the business partner role and the high degree of digitalization of the controlling function is the strongest.

H2b: Of the controller roles studied, the positive relationship of the business partner role and the high quality and speed of the controlling function is the strongest.

4. Examining the role of drivers and barriers to the digital transformation of the controlling function.

H3: Financial factors are the main drivers and barriers to the digital transformation of the controlling function in SMEs.

H3a: For enterprises with a higher level of digitalization of the controlling function, the strongest driver of digitalization is the potential cost reduction.

H3b: For enterprises with a lower level of digitisation of the control function, the strongest constraint to digitisation is the high cost of development.

5. Contingency analysis of the digital transformation of controlling.

H4: The most important contingency factor distinguishing the elements of the sample in terms of the digital transformation of the controlling function is the size of the enterprise.

6. Separation of the elements of the theoretical framework and the enterprises of the sample into well interpretable groups.

H5: The enterprises of the sample can be classified into groups according to the dimensions of the digital transformation framework.

H5.1: The most important element for the separation of clusters is the use of digital technological tools.

2. DATABASE AND THE INTRODUCTION OF THE APPLIED METHODS

2.1. Basic description of secondary and primary research

My dissertation was based on a comprehensive secondary literature search, the main aim of which was to develop a theoretical framework, and to identify research gaps. During the literature review, I used Google Scholar and Scopus databases to access Hungarian and international academic books, journal articles and studies related to the topic. A questionnaire was developed based on the established framework. Besides case studies, questionnaire survey research is the most common data collection method in controlling research (HIEBL – RICHTER, 2018). To finalize my questionnaire and to refine and test its questions, I conducted professional interviews with controlling managers of three companies. The interviewees were professionals from a manufacturing company, a market research company and a passenger transport company. A synthesis of the findings from the literature and useful managerial insights resulted in the final questionnaire, which was structured in the following question blocks:

1. Questions on the basic characteristics of businesses.
2. General questions on the controlling function and digitalization of businesses.
3. Questions on the roles of controllers.
4. Questions on the dimensions of the digital transformation of controlling.
5. Questions on the drivers and constraints for the digital transformation of controlling.

Apart from the multiple-choice questions in the first block, each question is a closed-form Likert-type question. The Likert scale is a widely used measurement tool in social science research that allows respondents to express their level of agreement or disagreement with a statement. The original five-point scale has a neutral option at its centre, which further facilitates data collection by not necessarily requiring the respondent to choose between positions (LIKERT, 1932). Although several versions of the Likert scale have been used throughout its history, I chose the classic five-point symmetrical scale, which includes a neutral response option. For each of the scaled questions, the two extreme points are a relevant variation of 'not at all' and 'completely'. It is important to highlight that for Blocks 3 and 4, I used a dual questioning approach for each item: respondents indicated how prevalent a

particular digital element is in their enterprise at present, and then how important they think it will become in the near future in their control processes.

Due to the difficulty in reaching the target group and the length of the questionnaire, I decided to use data collection assistance to obtain a sufficiently large and representative sample. For the domestic SME sector, I used the services of a market research company with a large database of company contacts. The market researcher primarily used an online interviewing method (CAWI – “Computer Assisted Web Interview”) to reach professionals, but in some cases, it was also necessary to contact and interview them by telephone (CATI – “Computer Assisted Telephone Interview”).

The data collection took place between 8 December 2023 and 31 January 2024, during which time 244 professionals from different companies completed the questionnaire. The respondents are either controllers of the companies or managers or employees of the companies with controlling tasks. The sample is representative in terms of company size (distribution of small and medium-sized enterprises) and regional distribution. Items can be divided into two well-defined groups according to their size: 67.2% of the sample belong to the small enterprise category, while 32.8% can be considered medium-sized enterprises. In terms of their main activity, 8.6% of the sample belong to the agricultural sector, 20.1% to the manufacturing and energy sector, 10.7% to the construction sector, 23.4% to the traditional service sector, 13.5% to the knowledge-intensive service sector and 23.8% do other services.

2.2. Introduction of the methods used in the primary research

The process and methodology of my secondary and primary research is illustrated in Figure 1.

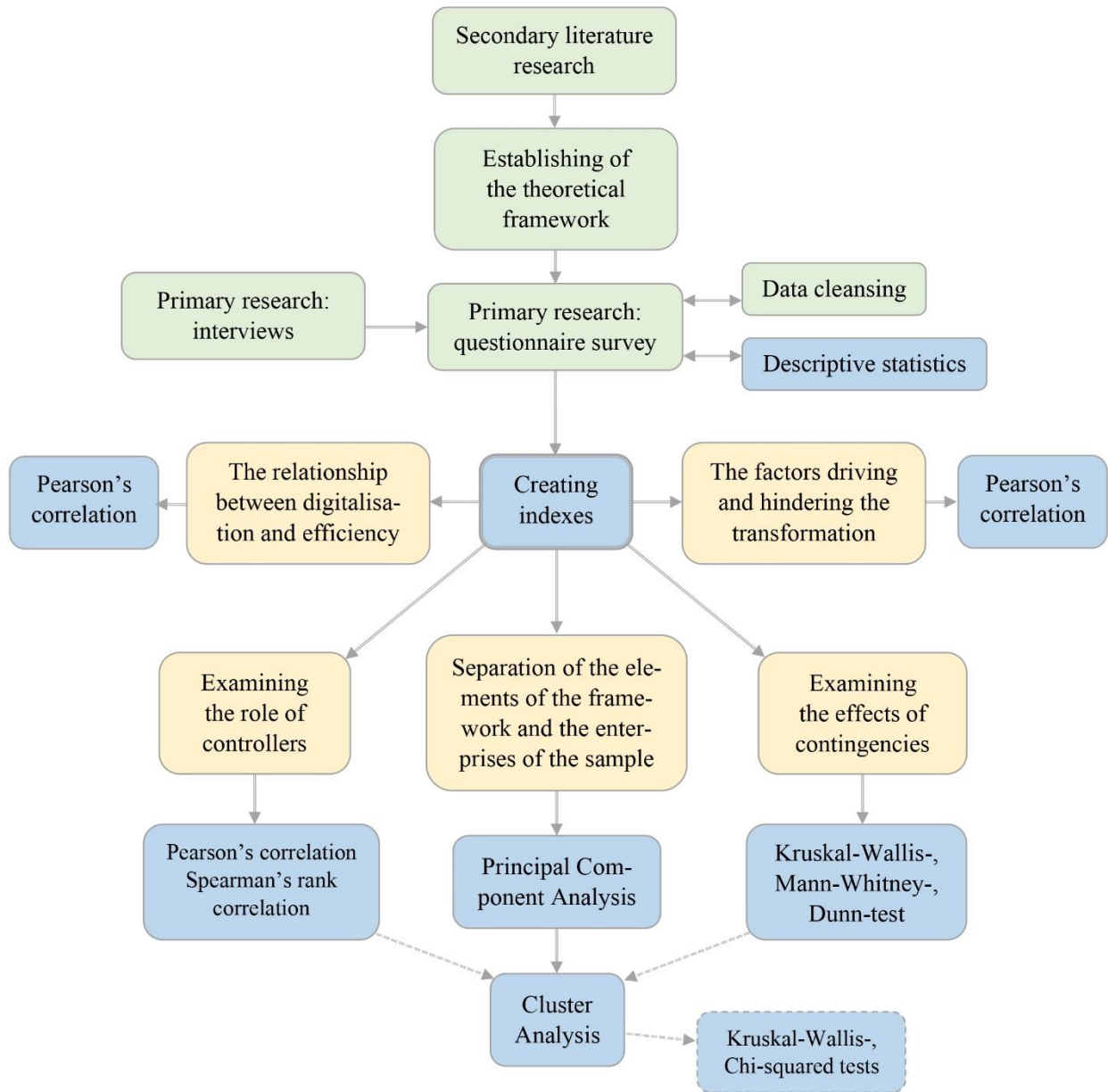


Figure 1. Methodological map of the research

Source: Own editing (2024)

After cleaning the database, the primary objective was to create digitalization indices, which would form the basis for following analyses.

The components of the primary digitalization index are the elements of the dimensions and their sub-areas (factors determining the controlling of digitalization and the digitalization of the data environment, digital technology tools, advanced types of methodologies and competences required in the digital age) presented in the theoretical framework and supported by literature. Each of the components was presented in the questionnaire as a 5-point Likert scale question item, and can therefore take a value between 1 and 5, depending on the extent to which they are currently present in the respondents' companies' controlling processes.

Using the codes explained in the thesis, the following formula for calculating the index can be formulated.

$$X_i = \frac{(D1 + D2) + (A1 + \dots + A5) + (E2 + \dots + E8) + (M2 + \dots + M4) + (K3 + \dots + K16)}{31}$$

After calculating the basis of the index, rescaling was also carried out to ensure that it always takes a value between 0 and 1, where 1 indicates perfect digital development of controlling. This is how the “ConDig”, or controlling digitalization index, was created.

$$ConDig_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

where $X_{min}=1$ and $X_{max}=5$

The index is a simple arithmetic average of its components. It should be stressed that no weighting has been used in the calculation of the average, as the authors in the related literature do not distinguish between the importance of each dimension and its constituent elements.

In addition to the central digitalization index, a second index was developed to deepen the analysis. This is calculated in the same way as the former, except that it is not based on the current level of use of the elements, but on the expected future importance associated with them. In this way, a controlling digitalization importance index (“ConDig_{FOR}”) is created, which shows, for each company in the sample, the overall level of future importance they associate with the digital transformation of the function.

I could get an index with higher information content by displaying the two sets of values used for the two indices above at the same time. To do this, a third index was created: a modified version of the formula shown above was used to calculate it. In this case, the value of a given component is the difference between its current level of appearance and the expected future importance. The value of the element is then ideally 0: the current level and the expected importance are equal. For the least ideal extreme value, all components have a value of -4 (current (1) minus assigned importance (5)), in which case X_i also has a value of -4. The opposite extreme value may occur if all components are 4 (current (5) minus assigned importance (1)), in which case X_i is also 4.

I have named the index that defines the relationship between the current level and the expected importance as the "relative controlling digitalization index" and I call it "ConDig_{REL}". In its construction, the scaling method is slightly different from the above, as the minimum and maximum values are different.

$$ConDig_{REL} = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

where $X_{min} = -4$ and $X_{max} = 4$

The ConDig_{REL} index can take a value between 0 and 1. The lower the value, the greater the company's controlling digitalization "backlog" relative to the future importance indicated by the respondent. A value of 0.5 represents the ideal situation, where current development level is equal to the expected level.

In addition to the above, I also developed a fourth index, which is identical in method to the ConDig_{REL} index, however, when calculating the values of its elements, not the own expected importance was subtracted from the current level of use, but the average expected importance of the given industry. The resulting industry relative controlling digitalization index ("ConDig_{IPAR-REL}") shows the level of development of the controlling area of a given enterprise compared to the expected importance in its own industry. The information content and practical applicability of this latter index are particularly high, but its use in further analyses would have been incorrect from a statistical point of view. When it was developed, the values of a given element were linked to the values of other elements of the sample, so the variable cannot be considered independent.

The relationship of the indices with the effectiveness of the controlling function, the controller roles, and the factors stimulating and hindering digitalization were examined using Pearson's correlation and Spearman's rank correlation (hypotheses H1, H2 and H3).

Pearson's correlation examines the strength of the relationship between two continuous variables. In the case of a significant relationship ($p < 0.1$), the correlation coefficient (r) should be examined, which can take values between 1 and -1: 1 means a perfectly positive correlation, while -1 indicates a negative, reverse relationship between the two variables (CLEOPHAS – ZWINDERMAN, 2018).

SCHOBER et al. (2018) describe the following guidelines for evaluating coefficients:

- $0,00 < r < 0,10$: negligible correlation
- $0,10 < r < 0,39$: weak correlation
- $0,40 < r < 0,69$: moderate correlation
- $0,70 < r < 0,89$: strong correlation
- $0,90 < r < 1,00$: very strong correlation

The authors also suggest that instead of using simplified rules and adhering to strict intervals, the strength of a given coefficient should be interpreted in the context of the given scientific question (SCHOBER et al., 2018). During the analysis, I evaluated the coefficients accordingly.

Spearman's rank correlation can also be used to examine the strength of the relationship between two variables; however, the procedure requires both variables to be at least ordinal level. In the case of a significant relationship ($p < 0.1$), the correlation coefficient (r) should also be examined, the characteristics of which are the same as those of the Pearson's correlation coefficient, so the interpretation of their results is the same (SCHOBER et al., 2018). During the analysis, I used this method when examining pairs of ordinal variables.

To examine the effect of contingency factors, I used Mann-Whitney and Kruskal-Wallis tests (hypothesis H4).

A Mann-Whitney-próba két egymástól független minta mediánjainak egyezésének igazolására alkalmazható nem paraméteres eljárás.

The Mann-Whitney test is a non-parametric method that can be used to verify the parity of the medians of two independent samples. According to the null hypothesis, the two populations belong to the same distribution. The condition for its application is that the variables involved are at least of ordinal measurement level and are independent of each other. The significance value obtained as a result of the test must be examined: if $p > 0.1$, then there is no difference, however, if $p < 0.1$, then there is a difference, i.e. the two examined groups are significantly different from each other (MANN – WHITNEY, 1947).

The Kruskal-Wallis test is also a non-parametric statistical test, but it can be used to assess the differences between three or more independent groups on a non-normally distributed,

continuous or ordinal variable (KRUSKAL – WALLIS, 1952). An important feature of the test is that it does not show in itself which groups exactly have a significant difference. To reveal this, the Dunn test can be used, which performs a pairwise comparison between the individual independent groups and shows which categories differ statistically significantly from each other by means of the adjusted p value ($p < 0.1$) (DUNN, 1964).

In all the above procedures, I have set a significance level of 0.1. The most commonly used values are 0.05 and 0.01, but in the dissertation, I define the probability of committing a type I error more broadly. THIESE et al. (2016), BENJAMIN et al. (2018) and FROST (2020) also argue that the strictness of the significance level is context-dependent. The use of a level of 0.1 is acceptable in exploratory research, where the data may be noisier, and the researcher is willing to accept a possible false positive result with a higher probability in order not to miss any potentially important discovery. Based on the above, in my dissertation, I determine a significance level of 0.1 during hypothesis testing, however, the p-values are visible in all cases, so beyond the 10% level, the results accepted at 5% and 1% levels can also be distinguished.

In order to classify the elements of the theoretical framework and the enterprises of the sample into distinct groups, I conducted principal component analysis and cluster analysis (hypotheses H5 and H5.1).

Principal Component Analysis (PCA) is a method of factor analysis. Factor analysis procedures can be used to examine the relationships between variables based on their mutual correlation, with the primary goal of data reduction and summarization (FIELD, 2013). After the factor analysis problem is formulated and the variables to be included are determined, the correlation matrix of the variables is established, then the method of factor analysis and rotation is selected – finally, the rotated factors are evaluated (MALHOTRA – SIMON, 2009).

Factor analysis can be performed if preliminary tests support the applicability of the model. Bartlett's test of sphericity assesses the null hypothesis that the variables in the population are uncorrelated with each other – a high value of the test questions the applicability of factor analysis. A low value of the Kaiser–Meyer–Olkin goodness-of-fit index (KMO) indicates that the correlation between pairs of variables cannot be explained by other variables,

and thus factor analysis is not an appropriate method. The method can be performed if the value of the index is above 0.5 (MALHOTRA – SIMON, 2009).

Among the methods of the procedure, I used principal component analysis, which considers the entire variance of the data and is recommended if our goal is to determine the smallest number of factors and create principal components that can later be used in multivariate analysis; I used varimax rotation as a rotation method. When interpreting the principal components and determining the variables that most characterize them, I evaluated the resulting correlation coefficients according to the intervals described above and considered the relationship to be significant above a value of 0.4.

Principal component analysis served as the basis for effective cluster analysis, the aim of which is to "reveal and form relatively homogeneous groups based on the characteristics of relatively heterogeneous objects" (SIMON, 2006, p. 629). An important feature of the analysis is that there is no limit to the number of variables involved, and their weight does not need to be determined. What needs to be paid attention to is that variables relevant to the study are included, and there should not be too strong a correlation between the variables – for the latter reason, preliminary factor analysis is recommended. The groups created as a result of successful cluster analysis can be interpreted professionally and can be logically separated from each other (SIMON, 2006).

In my dissertation, I used the two-step clustering method, which, according to TKACZYNSKI (2017), is more reliable and accurate than the traditional methods. As the name suggests, the method consists of two steps. In the first stage, the data is grouped into so-called pre-clusters, the aim of which is to reduce the size of the distance matrix. During the second step, the pre-clusters are re-grouped using a hierarchical clustering method. This step results in more solution options, the number of which is then reduced based on Schwarz's Bayesian information criterion, thereby creating the best number of clusters.

According to TKACZYNSKI (2017), the procedure is often supplemented with a third step, during which the clusters are compared to each other with the grouping variables left out of the model using Chi-square tests. The Chi-square test is a non-parametric statistical technique that examines the existence of a significant difference between an empirical and a conditional frequency table. In the case of the independence test, the null hypothesis is that

the variables under examination are independent, i.e. they do not influence each other, and the alternative hypothesis is that there is a relationship between them, so they influence each other. The strength of the relationship can also be examined using Cramer's association coefficient: the indicator takes a value between 0 and 1 and shows a stronger relationship the closer the value is to 1 (HUNYADI – VITA, 2008).

Statistical analysis and data visualization were performed using SPSS, R, and Microsoft Excel softwares.

3. MAIN FINDINGS OF THE DISSERTATION

In the theoretical framework, I explored the following dimensions of the digital transformation of controlling and the components that define them. The revised version of the framework based on my results is shown at the end of the chapter, in Figure 3.

- *Control of digitalization*: supporting, or even proactively initiate the digital transformation of the whole enterprise
- *Data digitalization*: data management, data governance, data-driven decision-making, use of large, complex, external and unstructured data
- *Digitalization of technological tools*: ERP-systems, analysing and reporting business intelligence tools, cloud computing, mobile devices, dashboards, RPA tools, generative AI
- *Digitalization of methods*: diagnostic, predictive and prescriptive analytics
- *Digitalization of competencies*: management, digital, personal and interpersonal competencies
- *Evolution of controller roles*: technical expert, navigator, business partner, hybrid controller
- *Contingencies influencing the transformation*: firm size, industry affiliation, geographical location, ownership structure, perceived environmental uncertainty
- *Factors driving or hindering the transformation*

First, I described the average current digitalization status and future expectations of the entire sample of 244 enterprises in relation to the above elements, and then related the digitalization indices presented above. I presented the development status of the elements of the sample in a two-dimensional coordinate system by connecting the ConDig index describing the current digital development level and the ConDig_{FON} index showing the perceived importance of digital development. Figure 2 shows the relative location of the enterprises according to how digitally developed their controlling function is currently and how important they consider such development for the near future. In the further analyses, I used the ConDig index and the ConDig_{REL} index, the latter connecting the two indices above.

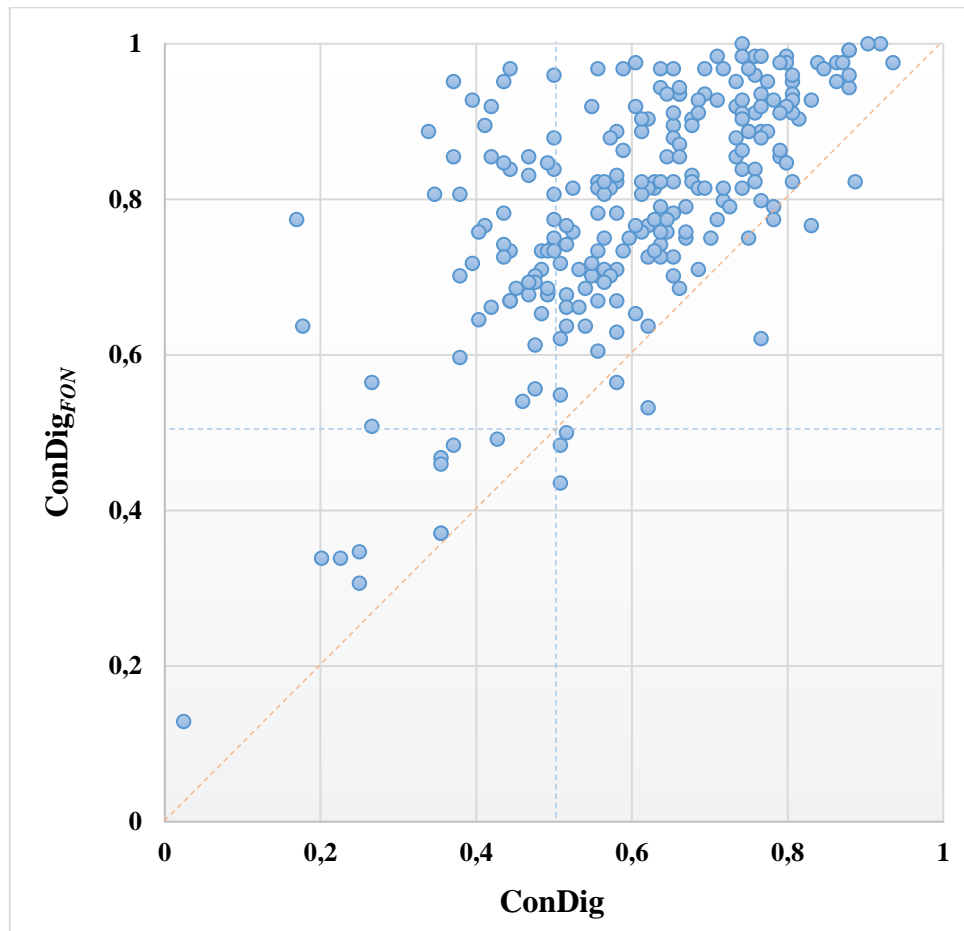


Figure 2. The controlling digitalization of the enterprises (ConDig) and the importance they associate with it (ConDig_{FON}) (n=244)

Source: Own editing (2024)

After creating and calculating the controlling digitalization indices based on the theoretical framework, it became possible to fulfill the further objectives of the dissertation and to examine the hypotheses related to them. To test the first hypothesis, I determined the relationship between the digitalization indices (as continuous variables) and the efficiency and speed of controlling (“ConHat”, as an ordinal variable) using Pearson correlation. In the case of the ConDig index, the correlation coefficient ($r=0.524$) indicated a medium-strength relationship, while in the case of the ConDig_{REL} index ($r=0.262$) there is a weaker correlation. Based on the result, I accepted the H1 hypothesis: in the case of the sample, it can be stated that the higher the digitalization of their controlling area, the more efficient and faster their management decision support is. In addition, I found that the more the digitalization of an enterprise’s controlling corresponds to the level expected in the near future, the more efficient and faster the management decision support is. However, the former, ConDig index, has a stronger relationship with efficiency, which is why I have treated it as a central

index. It is important to emphasize that the relationship is not necessarily causal, and my findings only describe the correlation between them.

My third objective was to examine the relationship between controller roles and digital transformation, in which the relationship between the three defined roles (technical expert, navigator, business partner) and the digitalization indices and the variable expressing the efficiency of controlling was analyzed. During the study, I found that instead of role change, the vast majority of the sample enterprises are characterized by role extension, i.e. the hybrid controller role. A role hybridization index (“ConHib”) was also developed using a specific method, which is also included in the analysis. During the study, I used Pearson correlation and Spearman’s rank correlation to explore the relationship between ordinal and continuous variables – the results of this can be seen in Table 1.

Table 1. The relationship between controller roles and the digitalization indices and the efficiency of controlling (n=244)

		ConDig	ConDig_{REL}	ConHat
Technical expert _{currently}	r	,361	,211	,272
	p	,000	,001	,000
Navigator _{currently}	r	,455	,170	,379
	p	,000	,008	,000
Business partner _{currently}	r	,368	,191	,249
	p	,000	,003	,000
Technical expert _{importance}	r	,164	-,007	,205
	p	,013	,913	,001
Navigator _{importance}	r	,247	-,019	,229
	p	,000	,773	,000
Business partner _{importance}	r	,266	,040	,050
	p	,000	,538	,441
ConHib (hybridization of the roles)	r	,505	,228	,370
	p	,000	,001	,000

Source: Own editing (2024)

Based on the coefficient values (r) shown in the table, I rejected hypothesis H2a: although a positive correlation can be seen between the business partner role and digitalization, the relationship between the transitional, navigator role and digitalization is stronger. In addition, I also rejected H2b: although a positive correlation can be detected between the current

presence of the business partner role and the efficiency of controlling, the relationship between the technical expert and the transitional, navigator role with efficiency is also stronger. In terms of the assigned importance, there is no correlation between the business partner role and the efficiency variable. Based on the rejection of the sub-hypotheses, I rejected hypothesis H2: in the case of the sample companies, the relationship between the business partner role and the high degree of digitalization and high quality of the controlling function is not the strongest among the examined controller roles. With a few exceptions, international literature agrees that the digital development of the field goes hand in hand with the changing role of controllers, specifically with the emergence of the business partner role. Based on my analysis of a sample of Hungarian small and medium-sized enterprises, this can be confirmed, but it is also clear that the more traditional navigator role has a stronger connection with digitalization and the efficiency of the function.

By examining the ConHib index, I also found that it is not the individual roles, but the level of role hybridization that has the strongest relationship with the digital development of controlling, and a particularly strong relationship with its efficiency. Based on this, I considered it important to include the ConHib index in further statistical tests of the dissertation.

My fourth objective was to examine the factors that stimulate and hinder the digital transformation of the controlling area – I used Pearson correlation to explore the relationship between the digitalization indices and ten ordinal variables belonging to the factors. The potential stimulating benefits examined were all positively correlated with the ConDig index: companies with a higher current level of controlling digitalization attach higher importance to the driving factors and recognize the positive effects of digital transformation better than less digitalized companies.

In addition to the above findings, it was more important to find out whether the examined benefits differed in terms of their importance. The resulting correlation coefficients indicated a low or medium-strength relationship in all cases. The four elements with the highest coefficients, in order:

- Faster, even real-time decision support. ($r=0,438$)
- Reducing the frequency of previously occurring errors. ($r=0,417$)
- More efficient risk and change management. ($r=0,414$)

- Better quality analysis and forecasting. ($r=0,405$)

In contrast, “Cost Reduction” factor had the second lowest correlation coefficient ($r=0.242$). According to the results, in companies with a more digitalized controlling function, the strongest driver is not the direct financial benefits (nor the strategic benefits related to product quality, sustainability or competitiveness), but the improvement of the quality of the operational controlling processes. Based on this, I rejected my hypothesis H3a.

The $ConDig_{REL}$ index helped in examining the impact of hindering factors. In the case of the index, I demonstrated a significant relationship with four factors, which are the following:

- Inflexibility of the regulatory and policy environment. ($r=0,166$)
- Little knowledge about digital opportunities. ($r= -0,161$)
- Lack of digitally skilled workforce. ($r= -0,131$)
- Insistence on traditional, familiar methods and tools. ($r= -0,109$)

In the case of the latter constraining elements, the negative correlation coefficients (their strength is low, but not negligible) indicate that their relationship is opposite to the development of the $ConDig_{REL}$ index. In the case of a given enterprise, the stronger the hindering factors little digital knowledge or the lack of people with specialist knowledge are assessed, the less the current level of digitalization corresponds to the expected importance. Regarding the financial hindering factors (“Investment would be expensive, the company does not have the opportunity to do so.” and “Investment would be possible, but it would not pay off.”), no significant negative relationship can be detected when examining either index. Based on this, I rejected hypothesis H3b: in the case of enterprises with a lower level of digitalized controlling function, the strongest limiting factor of digitalization is not the high cost of development, but the lack of qualified labor and related knowledge. Based on the above, I rejected hypothesis H3. A related result is that the positive correlation of element “Inflexibility of the regulatory and policy environment.” in both indices indicates that this can be considered the most important barrier in the case of companies with a more digitally advanced controlling function.

Examining the effect of contingency factors, I obtained the results shown in Table 2. In order to find differences between the categories of each variable, the Mann-Whitney test and the Kruskal-Wallis test were applied. The former was applied when examining size and

ownership structure, since in these cases two sample elements were compared. Significance values in the table shows that when examining the ConDig index, the sample elements differ significantly in terms of their size ($p < 0.05$) and regional location ($p = 0.1$). None of the contingency factors significantly affect the development of the ConDig_{REL} index.

Table 2. The relationship between the digitalization indices and the examined contingencies (n=244)

p	Size	Sector	Ownership	Region	Environm. uncertainty
ConDig	,088	,568	,874	,100	,163
ConDig_{REL}	,257	,292	,477	,152	,481

Source: Own editing (2024)

Based on the average index values in Table 3, I conclude that the controlling function of larger enterprises is more developed digitally. The result is in line with numerous findings in the literature and my preliminary assumptions. However, I also revealed an additional effect: regional differences are also significant, and according to the average index values, the North Great Plain (Észak-Alföld) region stands out, which is a particularly surprising result.

Table 3. The differences between average ConDig index values according to firm size and geographical location (n=244)

	Size						
	Small enterprises	Medium enterprises					
Average ConDig	0,5879	0,6317					
n	164	80					
	Region						
	Dél-Alföld	Dél-Dunántúl	Észak-Alföld	Észak-Magyaró.	Közép-Dunántúl	Közép-Magyaró.	Nyugat-Dunántúl
Average ConDig	0,5920	0,5949	0,6569	0,6023	0,5557	0,5838	0,5706
n	29	26	62	19	21	63	24

Source: Own editing (2024)

In order to determine which contingency has a stronger effect, I examined the indices separately, as well as their components and the other units of the theoretical framework. In addition to examining my hypothesis, I also considered it important to examine the impact of the contingencies in relation to each element of the framework, because this would allow for a deeper understanding of the sample, thus the digitalization of controlling in the Hungarian SME sector. In addition to the components of the digitalization indices, the analysis also covered the general questions, the three examined controller roles, role hybridization, and the factors encouraging and limiting the digital transformation of the function.

In addition to the fact that I established the significant importance of company size based on the detailed analysis – thereby accepting my related hypothesis – I also shed light on several interesting phenomena regarding the five examined contingencies. I identified further research directions regarding the effects of regional location, industry affiliation, ownership structure and environmental uncertainty.

My sixth and final objective was to provide a comprehensive picture of my research by condensing all possible analysis dimensions – my goal was to divide the elements of the theoretical framework and the sample enterprises into well-interpretable groups. To this end, I first performed a principal component analysis, the purpose of which was to reduce and summarize the data of the dimensions and areas of the theoretical framework, each containing a relatively large number of variables. The creation of principal components served a dual purpose. On one hand, it provided the basis for the cluster analysis to form well-differentiable and interpretable groups: by reducing the dimensions of the database, a lower number of variables can be included in the analysis, which can create clusters of better quality from a statistical and interpretable point of view. On the other hand, statistically sound elements and categories could be developed, which became part of a revised theoretical framework.

As a result, I managed to compress the originally available 55 variables into only 12 professionally interpretable principal components of statistically adequate quality, which are the following:

- Control of digitalization
- Data digitalization
- Use of traditional tools

- Use of digital technological tools
- Methodological digitalization
- Basic professional knowledge
- Management and digital skills
- Social skills
- Strategic level benefits
- Operational level benefits
- Human resource related limitations
- Organizational and external limitations

With the help of the components, I was able to revise and simplify some elements of the theoretical framework. The sub-area of the 2nd dimension, which denotes the development of competencies, originally consists of four competency categories, which can be combined into two groups: management and digital knowledge, and social skills. The groups of stimulating and limiting factors, which originally contained ten elements each, can be reduced to two categories each. The revised framework is shown at the end of the chapter, in Figure 3, and also includes the results of my previous analyses.

In the final analysis of my dissertation, I examined the sample in a comprehensive manner, condensing all possible analytical dimensions and using the results of the previous subchapters. My goal was to divide the examined enterprises into clearly distinct and interpretable groups – for this purpose I used cluster analysis.

I was able to reduce the range of variables included in the model, thus obtaining three high-quality clusters. In addition to the principal components listed above that determine digital controlling, the highlighted contingency factor was company size, and in relation to the controller role, role hybridization (ConHib index), which is most closely related to digitalization, was included. The results of the two-step cluster analysis conducted in this way are shown in Table 4. The importance of size can be observed, the three clusters were separated primarily along this factor. Among the principal components that capture the digital transformation of the controlling function, methodological development and the use of digital tools stand out. Among the competencies, management and digital knowledge is the most “divisive”, while among the benefits that drive development, the strategic-level group is the

one that differs more significantly between the clusters. Neither group of constraints can be considered an important separation factor.

I accepted hypothesis H5: although the variables of the dimensions had to be reduced and compressed, I was able to do it effectively with the help of my previous results, thus I was able to divide the sample into well-differentiable groups. However, based on the results, I rejected hypothesis H5.1, since, contrary to my preliminary assumptions, the use of technological tools is not what distinguishes the clusters the most. Although their importance is clear, the separation effect of the applied methodology, albeit by a small margin, is more significant.

Table 4. Values of the variables that separate the clusters

Variables	Importance of variable	Cluster 1 (n=77)	Cluster 2 (n=87)	Cluster 3 (n=80)
		Average value of variable		
Size	1,00	1 (100%)	1 (100%)	2 (100%)
Methodological digitalization	0,33	-0,77	0,46	0,24
Use of digital technological tool	0,32	-0,77	0,40	0,30
Control of digitalization	0,24	-0,68	0,39	0,23
Data digitalization	0,20	-0,60	0,44	0,10
Strategic level benefits	0,17	-0,56	0,38	0,12
Management and digital skills	0,14	-0,45	0,44	-0,04
Role hybridization (ConHib)	0,11	0,41	0,63	0,53
Operational level benefits	0,08	-0,41	0,27	0,09
Social skills	0,05	-0,14	0,30	-0,19
Human resource related limitations	0,02	-0,20	0,07	0,12
Organizational and external limitations	0,01	0,10	-0,00	-0,10

Source: Own editing (2024)

Clusters 1 and 2 contain only small enterprises, while cluster 3 fully covers the medium-sized enterprises. The really interesting differences can be observed in the relation between clusters 1 and 2, and between clusters 2 and 3. In the case of cluster 1, almost all principal components appear with negative values; the lower the average value, the less developed the enterprises of the given cluster are in a given dimension. In contrast, the average values of cluster 2 are always positive – although this group also includes small enterprises, the digitalization of their controlling function is at a significantly higher level. Although the values of cluster 3 are also positive in most cases, the averages of cluster 2 exceed them.

- Cluster 1 is the group of digitally lagging small businesses. Their controlling processes are least characterized by digitalization related to their methodological and technological tools, but controlling of digitalization, data digitalization and the appearance of management and digital skills are also particularly low among them. In terms of the appearance of social skills, they are somewhat similar to medium-sized enterprises. Controller role hybridization does appear among them, but at a lower level. They do not really recognize possible benefits of development, and strategic ones even less than operational advantages. Organizational and external barriers hinder their digitalization the most.
- Digitally innovative small businesses form cluster 2: they are advanced in all dimensions, especially their methodological and data digitalization is at a high level. They recognize the benefits of transformation and are primarily motivated by strategic benefits. Human resource-level barriers, such as organizational resistance and lack of knowledge, are the ones that somewhat hinder the development of their controlling function. In the case of the controllers of the cluster, role hybridization is high, and they are also best characterized by the business partner role. Their controlling organization is significantly larger in terms of staff size than in the companies of cluster 1. It is important to note that there are no significant differences between the two small business clusters in terms of revenue, average headcount, or company age. Their differences can be explained more by their attitude to digitalization, since the companies of cluster 1 generally feel that it is less important for the company's success, and they do not even feel that the budget allocated to it is significantly lower.
- Cluster 3 consists of the digitally developing medium-sized enterprises of the sample. Its level of innovation is clearly lower than that of cluster 2. The digital development of their controlling processes is rather high, this is mainly characterized by the use of digital tools, while their data digitalization is less strong. They are more likely to recognize the benefits, and their developments are somewhat more motivated by strategic promises. The hybridization-level of their controllers is medium, and they are less characterized by advanced competencies. Their limitations are more related to human resources.

Based on the evaluation of the variables of the cluster model, and the results of the Kruskal-Wallis tests and chi-square tests analyzing the variables left out from the model, I confirmed the acceptance of hypothesis H5: the three clusters can be well differentiated and interpreted, and the professional information content of their separation is high.

I summarize my formed hypotheses, the applied methodology and results obtained in Table 5.

Table 5. Summary table of hypotheses, applied methodologies and results obtained

Hypothesis	Applied methodology	Result
H1	Pearson's correlation	Accepted
H2(a,b)	Pearson's correlation, Spearman's rank corr.	Rejected
H3(a,b)	Pearson's correlation	Rejected
H4	Kruskal-Wallis, Mann-Whitney and Dunn-test	Accepted
H5	Two-step cluster analysis,	Accepted
H5.1	Kruskal-Wallis and Chi-squared test	Rejected

Source: Own editing (2024)

4. NEW AND NOVEL RESULTS OF THE DISSERTATION

Below, I highlight the most important results of the dissertation in line with my objectives.

Thesis 1.: Based on the Hungarian and international literature, I developed and then revised a comprehensive theoretical framework based on my primary results, which describes the dimensions of the relationship between the corporate controlling function and digital transformation, and can be used in the future when presenting the topic in various forums.

Thesis 2.: Based on the framework and my questionnaire survey, I created four different, interconnected digitalization indices. The indices are unique in the field and can also be applied in practice. Analyzing the available sample of small and medium-sized enterprises with the help of two prominent indices, ConDig and ConDig_{REL}, I determined that there is a significant positive relationship between the efficiency and speed of management decision support and the digital development of the controlling function.

Thesis 3.: I filled a research gap by examining the relationship between the change and expansion of the controller roles and the digitalization of the field on a Hungarian sample. I found that none of the three defined roles can be considered dominant among domestic SMEs, and controllers are mostly characterized by role hybridization. The digital development of controlling is not most strongly correlated with the business partner role, but rather with hybridization and the transitional, navigator role.

Thesis 4.: It has been proven that the digitalization of the controlling area of the Hungarian SME sector is primarily driven and constrained by non-financial factors. In companies with a more digitally advanced controlling function, the strongest incentive is not the cost reduction represented by automation and integration, nor the longer-term, strategic benefits, but the improvement of the quality and efficiency of operational controlling activities. I also found that the strongest barrier is not the high costs related to development, but the lack of sufficient digital knowledge and the lack of a workforce with the necessary skills. In more digitalized companies, the inflexibility of the regulatory and policy environment appears as a relatively important barrier.

Thesis 5.: By examining the controlling digitalization of SMEs according to the contingency theory, I filled a research gap. It was proven that the most important contingency distinguishing the elements of the sample in terms of the digital development of controlling is the

company size: the controlling area of medium-sized enterprises is overall more digitally developed, but in several aspects, for example, in the case of advanced methodological application and certain competencies, there is no difference. Based on my detailed examination, I uncovered several additional, particularly interesting phenomena. Regional differences significantly influence the level of digitalization, but I found only minor differences in terms of ownership background, industry, and uncertainty of the operating environment. The latter – especially regional and industry differences – indicate further research directions.

Thesis 6.: I classified the enterprises in the representative sample into three distinct clusters. It was proven that the differences between the groups are primarily determined by size, then by the level of development of methodological application, and only then by the use of digital technological tools as a separating factor. A remarkable cluster is the group of digitally innovative small enterprises, whose controlling area can be said to be developed in all aspects, with a particularly high level of methodological and data digitalization, as well as the hybrid role, and within that the occurrence of business partner characteristics. Their controlling area is more developed than the medium-sized enterprise cluster, whose digitalization also differs in nature: the cluster is mainly characterized by the use of digital tools, with lower data and methodological development. The other cluster of small businesses is digitally lagging behind in all respects.



Figure 3. The revised framework for digitalization of controlling

Source: Own editing (2024)

5. PRACTICAL USE OF THE RESEARCH FINDINGS

The theoretical framework developed and revised based on the results of the research can be used by professional organisations and consultants working in this field, as well as by higher education institutions teaching controlling. The dynamic evolution of the field may require continuous revision and complementation of the framework, but even in its present form it can serve as a basis for explaining the relationship between controlling and digital transformation to both corporate actors and university students.

I recommend the use of the digitalization indices created for companies that have a separate controlling system and aim to improve their decision support processes by digitalizing it. The indices can be a useful measure of one of the central dimensions identified in my research, the control of digitalization: as KPIs, they can serve as indicators that are periodically assessed and evaluated, allowing the controlling area to monitor and motivate its own development. The average index values displayed in the results of the survey can serve as a benchmark for enterprises.

I recommend the decision-makers of small and medium-sized enterprises in Hungary to strengthen the organisational role of those working in their controlling area and to expand their scope of tasks and responsibilities. The aim should not necessarily be to 'train' pure business partners as members of management, but rather to expand the scope of responsibilities and increase the hybridisation of roles.

Related to the above, I would suggest that universities and professional organisations should expand their education and training portfolios. In addition to the digital data environment, predictive and prescriptive methodologies, and knowledge of advanced technological tools, it is also important to develop management competences and further strengthen social skills. Developing the workforce and ensuring a digitally literate workforce is of particular importance, as the primary barrier to transformation is the lack of competent professionals and knowledge of development opportunities.

The inflexibility of the regulatory and policy environment has been repeatedly raised as an important constraint, especially for more digitally advanced companies operating in a difficultly predictable environment. In my view, this may be due to legal barriers to data management and use, perhaps some constraints in the Act on Accounting, or a lack of incentives

and support from public bodies – my thesis does not provide a precise answer to this question and I recommend further, more detailed analysis.

I also suggest further investigation into contingencies. In terms of industries, I have found indications of a 'lagging behind' in agricultural enterprises and, in some respects, in the knowledge-intensive services sector. It is important to investigate the reasons for this in more detail, the specificities of controlling in these sectors and possible directions for improvement. Additionally, I propose to further examine my findings in the regional context. The higher digital development of the controlling area of enterprises in the Northern Great Plain is a surprising result, and I believe that further research is needed. If their advantage is confirmed, exploring the reasons for this could be quite beneficial.

The situation of the digitally underdeveloped cluster of small enterprises requires special attention – in my opinion, without a digital transformation of their controlling processes, these companies could easily lose their business positions, which could reduce the performance and competitiveness of the Hungarian economy as a whole. Innovative small enterprises are setting a good example. Professional organisations and the state can also play a role in stimulating and supporting their development: it is particularly important for them to recognise the strategic benefits of digitalization and overcome the barriers, the most significant of which are the external and organisational ones.

The development of larger firms is also important. Innovative small businesses also set a good example for medium-sized enterprises: my results show that methodological and data digitalization are of vital significance, and that they are the only basis for effective use of digital tools. Moreover, in the controlling area of larger firms, it is also essential to strengthen management skills and social competences.

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7. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

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6. BAJNAI, P. (2023): A vállalati controlling funkció digitális átalakulásának sajátosságai a hazai szolgáltató szektorban. *Jelenkori Társadalmi és Gazdasági Folyamatok*, 18(Különszám), pp. 37-52. <https://doi.org/10.14232/jtgf.2023.kulonszam.37-52>

Hungarian language conference paper

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Subject: PhD Publication List

Candidate: Péter Bajnai
Doctoral School: Doctoral School of Management and Business
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List of publications related to the dissertation

Articles, studies (7)

- Bajnai, P.:** A kereskedelmi vállalkozások controlling területének digitalizációs sajátosságai.
Economica. 14 (1-2), 49-59, 2023. ISSN: 1585-6216.
DOI: <http://dx.doi.org/10.47282/economica/2023/14/1-2/13217>
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- Bajnai, P.:** A vállalati controlling funkció digitális átalakulásának sajátosságai a hazai szolgáltató szektorban.
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Conference presentations (1)

8. **Bajnai, P.**, Fenyves, V.: A controllerek szervezetben betöltött szerepének hatása a controlling funkció és a teljes vállalat digitalizációjára.

In: 3. Farkas Ferenc Nemzetközi Tudományos Konferencia: "Menedzsment forradalmak":

Konferenciakötet. Szerk.: Benke Mariann, Schmuck Roland, Riedelmayer Bernadett,

Schmuck Roland, Riedelmayer Bernadett, Pécsi Tudományegyetem Közgazdaságtudományi

Kar Vezetés- és Szervezéstudományi Intézet, Pécs, 208-224, 2022, (VSZI kötetek, ISSN

2786-3891 ; 3) ISBN: 9789634299950

List of other publications

Articles, studies (4)

9. Sütő, D., **Bajnai, P.**, Fenyves, V.: Forecasting the financial performance of small and medium-sized enterprises: evidence from the Hungarian food retail sector.

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10. Fenyves, V., Tarnóczy, T., Bács, Z., Kerezsi, D., **Bajnai, P.**, Szoboszlai, M.: Financial efficiency analysis of Hungarian agriculture, fisheries and forestry sector.

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IF: 2.2

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13. Fenyves, V., Tarnóczy, T., Bács, Z., Kerezsi, D., **Bajnai, P.**, Szoboszlai, M.: Egy kiválasztott nemzetgazdasági ág vállalatainak hatékonysági elemzése.

In: Magyar Nemzeti Bank - Debreceni Egyetem kutatási konferencia Fenntartható gazdaság

Versenyképesség és digitalizáció / Fenyves Veronika, Debreceni Egyetem

Gazdaságtudományi Kar, Debrecen, 46-69, 2022. ISBN: 9789634904014

Total IF of journals (all publications): 3,8

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The Candidate's publication data submitted to the Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

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