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Motivations and Barriers for Cross-Cultural Volunteering Among International Students: A Study at the University of Sopron, Hungary

***Nechirvan Othman*[1] *– István János Bartók*[2]**

Abstract: This study explores the motivations and barriers influencing international students' participation in cross-cultural volunteering at the University of Sopron, Hungary. A quantitative approach was employed, using an adapted questionnaire, to gather data on volunteering experiences, motivations, and barriers. A total of (53) International students responded to the questionnaire. The results show that while international students recognize the benefits of volunteering such as enhancing teamwork skills, community integration, and personal fulfilment, their engagement in voluntary activities significantly decreases after arriving in Sopron. Key motivations identified include career development, personal growth, and a desire to contribute to the host community. However, barriers such as language challenges, lack of accessible information, and academic pressures hinder participation. The findings underscore the importance of addressing these obstacles to improve volunteer engagement and integration within the host community. Recommendations for future volunteer programs and institutional support are provided, aimed at fostering greater participation among international students.

Keywords: *international students, cross-cultural volunteering, motivations and barriers, University of Sopron, community integration*

JEL Codes: *I23, J24, L31*

[1] OTHMAN, Nechirvan (PhD Student)
(https://orcid.org/0000-0002-9704-4151)
University of Sopron, Alexandre Lamfalussy Faculty of Economics, István Széchenyi Doctoral School
(Nechirvan.othman@phd.uni-sopron.hu | nechirvanothman@gmail.com)

[2] Dr. BARTÓK István János (Associate Professor)
(https://orcid.org/0000-0003-0412-576X)
University of Sopron, Alexandre Lamfalussy Faculty of Economics
(bartok.istvan@uni-sopron.hu)

Introduction

Students pursue international education for various reasons, typically related to career aspirations, personal development, and cultural exposure. While obtaining a degree from a foreign country is often the primary objective, studying abroad also offers additional opportunities. One such opportunity is engaging in volunteer work, which can be supported by educational institutions. In recent years, voluntary work has gained considerable attention due to its positive impact on both individuals and communities. For international students, volunteering provides a unique opportunity to integrate into their host communities, develop new skills, and contribute to meaningful social causes.

The University of Sopron, which attracts international students from various countries through its diverse programmes, has recorded a significant increase in enrolments for the 2024-2025 academic year (Linda, 2024). Understanding the motivations and barriers international students encounter when engaging in voluntary activities can help the university design more effective initiatives to enhance student integration and participation in community development projects.

This research aims to explore the factors influencing international students' participation in cross-cultural volunteer work. The findings will provide insights for the International Office to develop targeted activities that encourage international students to engage in voluntary work. To achieve this, the research seeks to answer the following main tow questions:

What are the motivations influencing international students' participation in voluntary activities at the University of Sopron?

What are the barriers that reduce international students' participation in voluntary activities at the University of Sopron?

Literature review

International students are an increasingly significant demographic group in higher education institutions worldwide, drawn by the pursuit of diverse educational opportunities, career goals, and personal development. This group promotes cultural exchange and makes economic contributions to host countries. However, international students often encounter challenges such as cultural adjustment, academic pressures, and difficulties with social integration (Smith & Khawaja, 2011). Participating in voluntary activities can help ease some of these challenges, offering international students' opportunities to

engage with their host communities, gain new skills, and contribute positively to society (Clary et al., 1998b; Stukas et al., 2016).

Scholars have provided varying definitions of volunteering and its related concepts. Hustinx et al. (2010) describe volunteering as an activity undertaken by individuals who willingly offer their time and skills to assist others without expecting financial compensation, often within the context of civic engagement aimed at promoting social cohesion and community resilience (Hustinx et al., 2010). Similarly, Wilson (2000) defines volunteering as any activity where time is freely given to benefit another person, group, or cause (Wilson, 2000). Volunteerism is also described as activities of general interest that promote intercultural understanding and solidarity, are social or humanitarian in nature, non-professional, and carried out within the framework of nonprofit, non-governmental organizations (Akintola, 2011). In our research, we adopted Wilson's (2000) definition of volunteering as any activity in which time is freely given to benefit another person, group, or cause (Wilson, 2000).

International students often engage in voluntary work for various reasons, Clary and Snyder (1999) suggest that motivations for volunteering typically include career development, personal growth, and a desire to contribute to the local community (Clary & Snyder, 1999). Which assists international students in coping with the challenges of living in a foreign country. It can alleviate stress by providing a constructive outlet for their energy and helping them build a support system within their host community (Clary et al., 1998a). According to Wilson (2012), a key motivation for international students is the opportunity to gain practical experience and improve their employability (Wilson, 2012). Additionally, a sense of moral duty is a common motivator, as explained by Haski-Leventhal et al. (2010). Some international students are motivated by a desire to give back to society and support causes they care about, viewing voluntary work as a means of making a positive impact in their host country, which in turn enhances their personal fulfilment (Haski-Leventhal et al., 2010).

Despite volunteering motivations, international students encounter several barriers when participating in voluntary activities. Volet and Ang (2012) identified language barriers as one of the most significant obstacles. Students who are not fluent in the host country's language may struggle to communicate effectively, hindering their full engagement in volunteering (Volet & Ang, 2012). Cultural differences have also been highlighted as a barrier. Handy and Greenspan (2009) explained that international students

may have varying perceptions of volunteering based on their cultural backgrounds, which can influence their participation (Handy & Greenspan, 2009). Additionally, time constraints and academic pressures present further challenges. International students often have demanding academic schedules, leaving little time for voluntary activities. Balancing academic commitments with part-time employment adds additional pressure, making it difficult for students to engage in volunteer work (Holdsworth & Brewis, 2014).

Research methodology

This study seeks to answer the following research questions:

What are the motivations influencing international students' participation in voluntary activities at the University of Sopron?

What are the barriers that reduce international students' participation in voluntary activities at the University of Sopron?

To address these questions, a quantitative approach was employed, rooted in a positivist research philosophy, thus allowing the investigation of motivations and barriers through measurable data. Data collection was facilitated through a questionnaire adopted from (Clary et al., 1998a; Wondimu & Admas, 2024). The questionnaire as shown in Appendix (1) included key sections addressing different aspects of volunteering, with an additional five items dedicated to demographic data. Furthermore, open-ended questions were included to allow respondents to provide comments or further details. The questionnaire was accompanied by an introduction that clearly outlined the study's objectives and stressed the voluntary nature of participation. A multi-stage sampling strategy was employed, using both volunteer and convenience sampling techniques. These methods were chosen to ensure broad reach and effective recruitment of potential participants. The survey was conducted online via Google Forms, and participants were recruited through the University of Sopron's International Office, email invitations, and WhatsApp groups dedicated to student communities. A total of (53) individuals participated in the survey. To ensure the reliability of the scale, Cronbach's alpha was calculated, providing a measure of internal consistency. Following this, a comprehensive descriptive analysis was performed to address the research question. This analysis aimed to calculate the (mean scores, standard deviations, relative weights, item rankings), for each dimension of volunteering motivations and barriers, providing a clear understanding of the factors influencing international students' engagement in cross-cultural volunteering.

Data analysis and discussion

Reliability test

In addition to the demographic and open-ended questions, the questionnaire used in this study includes 30 items -that must be answered by choosing one answer from the scale –, divided into two dimensions: 14 items for volunteering motivations and 16 items for volunteering barriers. As summarized in Table (1), a reliability test was conducted to assess the consistency and internal coherence of the research instrument. Cronbach's alpha was used as the measure of reliability for the two dimensions: Volunteering Motivations, Volunteering Barriers, and the overall set of items.

Table (1): Reliability test

Dimension	Number of Items	Cronbach's alpha
Volunteering Motivations	14	0.92
Volunteering barriers	16	0.83
All items	30	0.73

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

The Cronbach's alpha for the Volunteering Motivations dimension is 0.92, indicating excellent internal consistency. As the value above 0.90 is generally considered highly reliable, showing that the 14 items measuring motivations for volunteering are closely related and consistently reflect the same underlying concept. The Volunteering Barriers dimension has a Cronbach's alpha of 0.83, which also demonstrates strong internal consistency. For the overall scale, which includes all 30 items (both motivations and barriers), the Cronbach's alpha is 0.73. Although this value is slightly lower than the individual dimensions, it still falls within the acceptable range for social science research, where alpha values between 0.70 and 0.80 are considered satisfactory. The results of the reliability analysis show that the instrument is reliable, with well-correlated items that demonstrate internal consistency.

Sample analysis

A descriptive analysis of the sample was conducted, as summarized in Table (2). The sample consists of 53 respondents. The gender distribution is nearly equal, with (49.06%) male (26 individuals) and (49.06%) female (26 individuals). Only (1.89%) of respondents (1 individual) preferred not to disclose their gender. This balanced representation suggests that the survey includes insights from both male and female perspectives, which helps reduce gender bias in the results.

Table (2): Sample analysis results.

Category	Frequency	Percent	Category	Frequency	Percent
Gender			**Level of Study**		
Male	26	49.06%	Under-graduate	14	26.42%
Female	26	49.06%	Master's	20	37.74%
Prefer not to say	1	1.89%	PhD	19	35.85%
Category	**Frequency**	**Percent**	**Category**	**Frequency**	**Percent**
Age			**Duration of Stay in Sopron**		
18-24	20	37.74%	Less than 6 months	10	18.87%
25-30	16	30.19%	6 months to 1 year	6	11.32%
31-35	13	24.53%	1-2 years	16	30.19%
36 and above	4	7.5%	More than 2 years	21	39.62%

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

Regarding educational level, the majority of respondents are pursuing either Master's degrees (37.74%) or PhDs (35.85%), while (26.42%) are undergraduates. This indicates that most participants are engaged in advanced studies, which may influence their level of involvement in academic activities, including volunteering. Higher education students, particularly those at the post-graduate level, may have more opportunities and motivation for participating in cross-cultural volunteering activities.

In terms of age distribution, (37.74%) of respondents are in the (18-24) age group, followed by (30.19%) in the (25-30) range. The (31-35) age group

makes up (24.53%), while only (7.55%) are (36) years or older. The majority of respondents are younger. Younger individuals may be more open to new experiences and more actively involved in university life, which could influence their participation in cross-cultural activities and volunteering.

The analysis of the duration of stay in Sopron shows that (39.62%) of respondents have lived in Sopron for more than two years, while (30.19%) have stayed between (1-2) years. About (18.87%) have been in Sopron for less than six months, and (11.32%) have stayed between (6) months to (1) year. This shows that a significant portion of respondents (around 70%) have been in Sopron for over a year, likely making them more familiar with the local culture and community. This familiarity could lead to higher engagement in cross-cultural volunteering. On the other hand, newer arrivals (approximately 30%) may still be adapting to life in Sopron, which could impact their willingness or ability to participate in such activities.

Analysis of Volunteering Engagement Before and After Arriving in Sopron

The analysis of volunteering engagement among respondents before and after arriving in Sopron as shown in table (3) shows a notable decline in participation rates. Prior to their arrival, a significant majority 69.20% (36 respondents) reported having participated in voluntary activities, indicating that they were familiar with and likely committed to community engagement in their home countries. In contrast, after arriving in Sopron, this number decreased to only 19.20% (10 respondents) actively participating in voluntary activities,

Table (3) Volunteering Engagement Before and After Arriving in Sopron.

Category	Before Coming to Sopron		After Arriving in Sopron	
	Frequency	**Percent**	**Frequency**	**Percent**
Participated in voluntary activities	36	69.20%	10	19.20%
Did not participate in voluntary activities	16	30.80%	41	80.80%

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

while a staggering 80.80% (41 respondents) reported not engaging in any volunteering activity in Sopron. This sharp decline suggests that, despite their prior experience and predisposition to volunteer, substantial barriers may be hindering their participation in Sopron.

Volunteering motivations

Table (4) presents respondents' attitudes toward various statements related to their motivation for volunteering in Sopron. The analysis includes mean scores, standard deviations, relative weights, item rankings, and the overall attitudes of respondents toward 14 statements about volunteering motivations. This provides a comprehensive overview of the key factors influencing participants' willingness to volunteer.

Table (4) Volunteering motivations items.

Item	Item Ranking	Mean	Std. Deviation	Relative Weight	Respondents' Attitude
Volunteering allows me to practice teamwork skills.	1	4.37	0.73	87.54	strongly agree
I believe in giving back to the community and helping others.	2	4.35	0.83	87.16	strongly agree
Volunteering helps me to meet new people and make friends.	3	4.32	0.80	86.41	strongly agree
Volunteering gives me a sense of personal achievement and fulfillment	4	4.13	0.87	82.64	Agree
Volunteering helps me to integrate better into the local culture.	5	4.03	0.75	80.75	Agree
Volunteering helps me to improve my language skills	6	4.01	0.79	80.37	Agree
Volunteering would help me understand the local culture better.	7	3.98	0.79	79.62	Agree
Volunteering well help me in career development.	8	3.98	0.84	79.62	Agree
Volunteering well be added value to my CV.	9	3.96	0.91	79.24	Agree
My culture values community service, and I feel its important to uphold this value while abroad.	10	3.90	0.88	78.11	Agree
Volunteering allows me to practice leadership skills	11	3.88	1.01	77.73	Agree
volunteering helps to reduce stress and improve your mental health.	12	3.83	0.87	76.60	Agree
participating in voluntary activities to reduce feelings of loneliness	13	3.79	0.98	75.84	Agree
participating in voluntary activities helps to reduce feelings of homesickness	14	3.54	0.99	70.94	Agree

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

The top three statements (Volunteering allows me to practice teamwork skills with mean (4.38) and relative importance (87.55), I believe in giving back to the community and helping others with mean (4.36) and relative importance (87.17), and Volunteering helps me to meet new people and make friends with mean (4.32) and relative importance (86.42)) indicate a strong belief in

the social and collaborative aspects of volunteering, suggesting that respondents view volunteering as a significant means to enhance their teamwork abilities, contribute to their community, and build social connections.

On the other hand, the lower-ranked statements, such as "Participating in voluntary activities helps reduce feelings of homesickness" (mean = 3.54, relative weight = 70.94), indicate that while respondents recognize the emotional benefits of volunteering, such as mitigating homesickness and loneliness, these aspects are viewed as less significant compared to other motivations like skill development and social engagement. Items related to reducing stress and improving mental health (mean = 3.83, relative weight = 76.60) and practicing leadership skills (mean = 3.88, relative weight = 77.73) also reflect a moderate level of agreement, suggesting that although these are important factors, they are secondary to the more dominant social and community-oriented motivations.

The standard deviations for the motivation statements range from 0.740 to 1.013, indicating a moderate level of variability in responses. Overall, respondents tend to lean toward "strongly agree" and "agree" for most statements, reflecting a generally positive perception of volunteering. However, the variation in standard deviation values highlights differing opinions on specific aspects, such as the impact of volunteering on leadership skills and its role in reducing homesickness. The higher standard deviations for these items (1.01 and 0.99, respectively) suggest that while many respondents recognize the benefits of volunteering in these areas, their views on these particular aspects are more diverse.

In contrast, the lower standard deviations for the top-ranked items, such as teamwork skills and community service, indicate stronger agreement, reinforcing the idea that these social and collaborative aspects of volunteering are more valued among the respondents. Overall, the data indicates that respondents are primarily motivated by the social, cultural, and skill-building opportunities volunteering provides, with less emphasis on emotional benefits such as stress relief and combating homesickness. These findings emphasize the need to tailor volunteer programs to enhance these key areas of motivation, while also addressing the emotional benefits for those who may find them important.

Volunteering barriers

The analysis of barriers to volunteering, as presented in the table (5), shows significant insights into the challenges faced by respondents in Sopron. The

top-ranked item, "I have difficulty finding information about volunteering opportunities in Sopron", has a mean score of 4.07 and a relative weight of 81.50, indicating strong agreement among respondents regarding the lack of accessible information. This suggests that a significant barrier to engagement in volunteering is the difficulty in obtaining relevant information about available opportunities.

Table (5) Volunteering barriers items analysis.

Item	Item Rank	Mean	Std. Dev.	Relative Weight	Respondents' Attitude
I have difficulty finding information about volunteering opportunities in Sopron.	1	4.07	0.99	81.50	strongly agree
I am not familiar with how volunteering works in this Sopron.	2	3.79	1.18	75.84	Agree
I feel uncomfortable volunteering due to language barriers	3	3.50	1.33	70.18	Agree
I am hesitant to volunteer because I do not feel fully integrated into the local community.	4	3.32	1.23	66.41	Neutral
Volunteering can lead to frustration when expectations are not met.	5	3.28	0.98	65.66	Neutral
I have trouble finding transportation to volunteering locations.	6	3.16	0.99	63.39	Neutral
The cost of volunteering (e.g., transportation, meals) is a barrier for me.	7	3.11	0.97	62.26	Neutral
I do not have enough time to volunteer due to part-time work commitments	8	2.90	1.24	58.11	Neutral
I lack the necessary skills or training for some volunteer roles.	9	2.86	1.09	57.35	Neutral
My academic schedule is too demanding and doesn't allow time for volunteering.	10	2.86	1.00	57.35	Neutral
I feel voluntary work is not highly valued in Sopron.	11	2.77	0.97	55.47	Neutral
Volunteering sometimes causes me emotional exhaustion or burnout.	12	2.6	0.99	53.96	Neutral
I have concerns about the legality of voluntary activities in Sopron.	13	2.60	0.86	52.07	disagree
I have concerns about the safety of voluntary activities in a Sopron.	14	2.56	0.93	51.32	disagree
I am concerned that volunteering might affect my studies negatively	15	2.47	1.03	49.43	disagree
I feel voluntary work is not highly valued in my home culture.	16	2.45	1.20	49.05	disagree

Source: *Data analysis from (Own survey, 2024) using SPSS Version 27.*

Following this, the second-ranked item, "I am not familiar with how volunteering works in Sopron," with a mean of 3.79 and relative weight of 75.84,

reflects a moderate agreement, suggesting that many respondents feel uncertain about the volunteering process in the area. This lack of familiarity may hinder their willingness to participate in volunteer activities. The third item, "I feel uncomfortable volunteering due to language barriers", has a mean of 3.50 and a relative weight of 70.18, indicating that language challenges are a significant concern for some individuals, which may affect their confidence and comfort in volunteering environments.

The remaining barriers show varying levels of agreement, with items such as "I am hesitant to volunteer because I do not feel fully integrated into the local community" (mean = 3.32, relative weight = 66.41) and "Volunteering can lead to frustration when expectations are not met" (mean = 3.28, relative weight = 65.66) receiving neutral attitudes from respondents. This suggests that while these concerns are present, they may not be as pressing as the higher-ranked barriers. Additionally, logistical challenges, such as transportation difficulties and costs associated with volunteering, are indicated by lower-ranking items like "I have trouble finding transportation to volunteering locations" (mean = 3.16, relative weight = 63.39) and "The cost of volunteering (e.g., transportation, meals) is a barrier for me" (mean = 3.11, relative weight = 62.26), which contribute to the overall hesitation to engage in volunteer activities.

Most items in the barriers section exhibit mean scores that reflect neutral attitudes, with several items falling below 3.00. For instance, concerns about the legality of volunteering activities (2.60), safety (2.56), and the potential negative impact on studies (2.47) received lower mean scores, suggesting that these are not significant barriers for most respondents. This indicates that while there are perceived obstacles, many respondents may not prioritize these concerns as strongly as issues related to information accessibility and integration into the local community.

The standard deviations for the barrier items range from 0.86 to 1.33, showing a moderate level of variability in responses. The higher standard deviation for the item related to language barriers (1.33) suggests greater diversity in opinions about this particular barrier, indicating that individuals experience these challenges differently. In contrast, lower standard deviations for items concerning transportation and costs reflect more consensus on these logistical barriers.

Overall, the findings suggest that while respondents recognize several barriers to volunteering, the most significant challenges relate to the accessibility of information and a lack of familiarity with the volunteering landscape

in Sopron. Addressing these barriers through targeted outreach and support could enhance participation in volunteering, ultimately fostering greater community engagement and integration among respondents.

Volunteering Activities

Previous Volunteering Engagement

The survey aimed to gather insights from respondents regarding their prior engagement in voluntary activities before coming to Sopron. The questions were designed to elicit detailed responses, allowing participants to specify their experiences in various categories of voluntary work. The findings are summarized in table (6):

Table (6): Previous Volunteering Engagement of International Students

Category	Type of Voluntary Work
Community Engagement	Community Services
	Maintaining Elderly Homes and Supporting Street Boys
	Working with Kids (Foundation and Church)
	Feeding the Hungry and Visiting Elderly Homes
	Social Work
	Youth Parliament
	Elected Member of the General Students' Committee
Environmental Initiatives	Planting Trees and Cleaning Beaches
	Afforestation and Reforestation
	Environmental Clean-ups
	Ecological Volunteering
Educational Support	New Students Orientation
	Teaching and Helping with Organizations
	Teaching Arabic to Non-Arabic Speakers
	Education and Community Engagement
	Tutoring Kids from Disadvantaged Backgrounds
	Graduate Training in Entrepreneurship
Other Activities	Charity Run and Charity Flea Market
	Helping Special Needs Individuals at Sporting Events
	Assisting Small and Medium Entrepreneurs with Financial Statements

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

These results indicate a rich variety of previous volunteering experiences, with significant participation in community services, environmental initiatives, and educational support. This variety suggests that the respondents are

well-acquainted with diverse types of voluntary work that foster both community development and individual growth.

Volunteering Activities in Sopron

Upon arriving in Sopron, respondents were asked to specify their volunteering activities, revealing a somewhat narrower scope of engagement. The summarized activities in table (7) shows the volunteering activities that international students engaged in since their arrival at Sopron.

Table (7): Volunteering Activities of International Students in Sopron

Category	Activity
Educational Activities	Mentorship for New Students
	Project Week in Faculty of Economics
	Youth Exchange
	International Student Mentorship
Mental Health	Mental Health Programme
Environmental Activities	Replanting Burned Forests

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

These findings indicate that the majority of volunteering activities in Sopron are by university-led initiatives. This reliance confirms the lack of accessible opportunities for students outside the university context as explained in the barriers analyses.

Preferred Areas of Volunteering in Sopron

The analysis of preferred volunteering areas highlights the specific interests of students regarding their future engagements in Sopron as shown in table (8).

The results show a preference for environmental matters (32 occurrences) underscores a significant inclination toward ecological sustainability. Following this, education and academic matters (25 occurrences) reveal a strong desire to support educational initiatives. Other noteworthy areas include social and disability matters (20 occurrences) and humanitarian services (18 occurrences), reflecting a commitment to social justice and community welfare.

Table (8): Preferred Areas of Volunteering for International Students in Sopron

#	section	Occurrence
1	Environmental matters	32
2	Education and Academic Matters	25
3	Social and disability Matters	20
4	Humanitarian Services	18

Source: Data analysis from (Own survey, 2024) using SPSS Version 27.

The comparison of volunteering activities that international students engaged in their homelands or in Sopron and the preferred activities illustrates a dichotomy between the students' rich history of volunteering across diverse sectors and their current concentrated interests in environmental sustainability and educational support. While their previous experiences reflect a broad engagement in community and individual development, the present opportunities in Sopron appear limited to university-organized activities. This alignment between past experiences and preferred volunteering areas suggests that local organizations could benefit from creating targeted volunteer opportunities that resonate with students' skills and interests, thereby enhancing their engagement and integration within the Sopron community.

Conclusion and suggestions

The research highlights the critical factors influencing international students' participation in cross-cultural volunteering at the University of Sopron. The findings reveal that although international students recognize the benefits of volunteering – such as improving teamwork skills, social integration, and contributing to the community – their actual engagement in voluntary activities significantly decreases after arriving in Sopron. This decline, from 69.20% participation before arriving to only 19.20% after, suggests that despite students' initial interest in volunteering, substantial barriers limit their involvement.

The primary motivations for volunteering are rooted in social and cultural integration, personal achievement, and skill development. Respondents strongly agree that volunteering helps them practice teamwork, give back to the community, and build social connections. However, emotional benefits like reducing homesickness and stress, although acknowledged, are not as

highly prioritized. These insights reflect a general orientation toward the interpersonal and collaborative aspects of volunteering, rather than individual emotional gains.

Conversely, barriers to volunteering include challenges such as difficulty finding information, unfamiliarity with the volunteering process, and language barriers. These factors contribute significantly to the sharp decline in participation rates. Although logistical barriers such as transportation and time constraints are present, they are not as influential as informational and cultural obstacles.

The research confirms that international students possess a wealth of experience in diverse volunteering sectors, particularly in community services and environmental initiatives. However, their participation in Sopron is largely limited to university-led initiatives, and for reducing the gap the study suggests below Suggestions:

- Improving Access to Volunteering Information: The University of Sopron should prioritize making volunteering opportunities more accessible to international students. For instance, integrating volunteer fairs into student orientation programs would allow new students to explore opportunities early in their academic journey.
- Targeted Volunteering Programs: to better align with students' interests and previous experiences, the university and local organizations should create targeted volunteer programs in areas such as environmental sustainability and education, which were the most preferred fields among respondents.
- Language Support Initiatives: since language barriers pose a significant challenge, offering language support in volunteer activities – either through bilingual coordinators or language training workshops – would enable students to participate more confidently. This could also enhance their integration into the local community.
- Cultural Orientation on Volunteering: organizing workshops that familiarize international students with local volunteering norms and expectations could reduce uncertainty and hesitation. Such initiatives would help students better understand how volunteering works in Sopron and how they can contribute effectively.
- Collaboration with Community Organizations: encouraging collaboration between the university and local organizations could help diversify volunteering opportunities beyond university-led initiatives.

This partnership would not only provide students with more avenues to engage with the local community but also foster stronger ties between the university and the broader Sopron community.

Recommendations for Future Research

- Conduct qualitative interviews to explore deeper insights into the varying opinions, particularly for statements with higher standard deviations.
- Investigate potential barriers to volunteer participation, especially for those who may not strongly agree with the benefits outlined in the lower-ranked statements.

By addressing these barriers and enhancing support structures, the University of Sopron can significantly boost international students' engagement in cross-cultural volunteering, fostering stronger social integration and personal development for the students, while contributing positively to the local community.

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Appendix (1): Research instrument

Survey questionnaire.

Dear Student,
My name is **(will be added after review)**, a PhD student at **(will be added after review)** , Iam conducting research titled:

"Motivations and Barriers for Cross-Cultural Volunteering Among International Students: A Study at the University of Sopron, Hungary."

As part of the research process, I invite you to participate in a survey designed to gather valuable data that will contribute to a better understanding of the cross-cultural Volunteering in our University.

Confidentiality: Rest assured that all information provided in this survey will be treated with strict confidentiality and will be used exclusively for scientific purposes.

Contact Information: if you have any questions or require further clarification, please feel free to contact me: **(will be added after review)**
Your cooperation and generous response are highly appreciated.
Best regards,

Volunteerism Definition: Any activity in which time is given freely to benefit another person, group or Society.

Section 1

Volunteering experience	Elements
Before coming to Sopron	• Have you participated in voluntary activities before coming to Sopron? If the responder answered Yes She/he will be asked: • If yes, please describe the type of voluntary work you have been involved in
After arriving in Sopron	• Have you participated in voluntary activities since arriving in Sopron? If the responder answered Yes she/he will be asked: • If yes, please describe the type of voluntary work you have been involved in

Section 2: Volunteering motivation statements

Motivations	Elements
Motivations statements with Likert scale optional answers	• Volunteering well help me in career development • Volunteering well be added value to my CV. • Volunteering allows me to practice leadership skills • Volunteering allows me to practice leadership skills • Volunteering helps me to meet new people and make friends. • Volunteering helps me to integrate better into the local culture. • I believe in giving back to the community and helping others • Volunteering gives me a sense of personal achievement and fulfillment • My culture values community service, and I feel it's important to uphold this value while abroad. • Volunteering would help me understand the local culture better. • Participating in voluntary activities helps to reduce feelings of homesickness • Participating in voluntary activities to reduce feelings of loneliness • Volunteering helps to reduce stress and improve your mental health.
Open ended question:	• What would motivate you to Engage more in voluntary activities while studying in Sopron?

Section 3: Volunteering barriers statements

Barriers	Elements
Motivations statements with Likert scale optional answers	• I am concerned that volunteering might affect my studies negatively • My academic schedule is too demanding and doesn't allow time for volunteering. • I do not have enough time to volunteer due to part-time work commitments • I am not familiar with how volunteering works in this Sopron. • I am hesitant to volunteer because I do not feel fully integrated into the local community. • I feel voluntary work is not highly valued in my home culture. • I feel voluntary work is not highly valued in Sopron. • Volunteering sometimes causes me emotional exhaustion or burnout. • Volunteering can lead to frustration when expectations are not met. • I have concerns about the safety of voluntary activities in a Sopron. • I have concerns about the legality of voluntary activities in Sopron. • I feel uncomfortable volunteering due to language barriers • I have difficulty finding information about volunteering opportunities in Sopron. • I have trouble finding transportation to volunteering locations. • The cost of volunteering (e.g., transportation, meals) is a barrier for me. • I lack the necessary skills or training for some volunteer roles.
Open ended question:	-Are there any reasons not mentioned above that discourage you from engaging in volunteering activities?

Section 4: open ended question for general feedback:

- Please add any notes or information that you fill that's its important for the study

Section 5: General Information:

Age: • 18-24 • 25-30 • 31-35 • 36 and above	**Country of Origin:** (Open-ended)
Level of Study: • Undergraduate • Master's • PhD • Other (please specify)	**Duration of Stay in Sopron:** • Less than 6 months • 6 months to 1 year • 1-2 years • More than 2 years
Gender: • Male • Female	**Language Proficiency in Hungarian:** • Beginner • Intermediate • Advanced • Fluent • Do not speak Hungarian
Preferred Areas of voluntary engagement: • Environmental matters. • Education and Academic Matters • Social and disability Matters • Humanitarian Services • Other (Please specify)	

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Implementation of SAP S4HANA in the manufacturing industry: Challenges and Opportunities for the business model

Mohammad Reza Robatian[1]

Abstract: As small and medium-sized enterprises (SMEs) navigate the complexities of the digital economy, adopting advanced technologies such as SAP S/4HANA has become crucial for maintaining competitiveness. This paper examines the role of SAP S/4HANA in transforming business processes for small and medium-sized enterprises (SMEs) within the manufacturing industry. SAP S/4HANA, an ERP system leveraging the HANA in-memory database, offers real-time data processing and advanced analytics capabilities, streamlining operations and improving decision-making. The research investigates the benefits of using SAP S4HANA, such as enhanced process efficiency, data integration, and competitive advantage, alongside challenges including signifi-cant implementation costs and technical complexities. Through a review of existing studies and expert interviews, the paper explores how SAP S/4HANA supports digital transformation by integrating advanced technologies like AI and IoT. It emphasizes the need for strategic alignment, readiness for digitalization, and strong change manage-ment for successful ERP implementation. Ultimately, this research provides valuable insights into how ERP systems can foster innovation and long-term growth for SMEs, contributing to the broader discourse on digital transformation in the manufacturing sector.

Keywords: *ERP, Smart Manufacturing, Digital Transformation, Industry 4.0, ERP systems, SAP S/4HANA, manufacturing, digital transformation, process optimization*

JEL Codes: *C80, D2, L10, L23, L60, M11, M15, O33, Q55*

[1] ROBATIAN, Mohammad Reza
University of Sopron Istvan Széchenyi Economics and Management Doctoral School, Hungary
FOM University of Applied Science for Economics and Management, Essen, Germany
(RobatianMohammadReza@phd.uni-sopron.hu; https://orcid.org/0009-0007-2999-1046)

Introduction

In today's rapidly evolving digital economy the manufacturing industry faces significant pressure to optimize its operational processes while adopting advanced technologies. This challenge is particularly relevant for small and medium-sized enterprises (SMEs) that seek to maintain competitiveness while integrating innovative solutions like SAP S/4HANA into their business models. SAP S/4HANA, an enterprise resource planning (ERP) system built on the HANA in-memory database, promises to revolutionize business processes through real-time data processing and advanced analytics capabilities (Baumgartl et al., 2021). The significance of SAP S/4HANA lies in its potential to streamline and enhance traditional ERP functionalities by providing integrated, real-time insights across an enterprise. For SMEs, the introduction of such systems represents both an opportunity and a challenge: while the benefits of improved efficiency, enhanced decision-making, and simplified processes are clear, the implementation costs, organizational changes, and technical complexities can be substantial (Becker et al., 2019).

This publication aims to examine the necessity of ERP systems in the context of modern manufacturing and the digital economy, with particular focus on SAP S/4HANA. The goals of the analysis are threefold: first, to investigate how SAP S/4HANA impacts business models and operational strategies within SMEs; second, to explore the benefits and challenges associated with its implementation; and third, to provide a framework for understanding the strategic role of ERP systems in enhancing efficiency in digitally interconnected manufacturing environments (Kulkarni, 2019).

The hypothesis of this study is that the introduction of SAP S/4HANA in SMEs leads to significant improvements in process efficiency, data integration, and competitive advantage. However, these benefits are contingent upon several factors, including the company's readiness for digital transformation, the alignment of its strategic goals with technological advancements, and the effectiveness of its implementation strategy. Through a detailed analysis of these factors, the research will contribute to a deeper understanding of the value and challenges of ERP systems in the digital age (Ternès & Schieke, 2018).

Theory and state of research

The IDC study from May 2020 reveals that companies globally are prepared to invest 1.5 trillion USD in digital transformation, but only 26% of them are realizing the expected return on investment (ROI) from these expenditures (IDC Corporate, 2020). The study emphasizes that years of billion-dollar investments are now being critically analyzed in terms of their generated returns. Moreover, 92% of CEOs worldwide face significant pressure to ensure successful digital transformations. Many companies understand the necessity of digitalization, but they may not directly link these efforts with an SAP S/4HANA migration (Fenn & Raskino, 2008).

A digital business platform significantly enhances the maturity of a company's technological architecture. Companies with such a platform have a **40% higher probability** of achieving ROI from their digital investments (IDC Corporate, 2020). This digital platform extends beyond traditional IT infrastructure and fosters a collaborative ecosystem involving customers, partners, and suppliers (BMWi, 2016). Future technology architectures are envisioned as **digital platforms**, allowing data to flow seamlessly between applications and systems, ultimately contributing to a company's digital maturity and aligning with **Industry 4.0** objectives (Kollmann, 2019). Cyber-physical systems (CPS), which merge the physical and digital worlds, are seen as part of this digital evolution. CPS, especially in industries like automotive and manufacturing, support competitive advantages by leveraging embedded systems that consist of integrated software and electronics. 98% of microprocessors in today's systems are embedded, allowing devices to interact with their environments through sensors and actuators. This interconnection supports a new digital-technological foundation for processing and utilizing data, contributing to the emergence of Internet of Things (IoT). In a broader perspective, the digital business platform, when integrated into **Enterprise Resource Planning (ERP) -**systems like SAP S/4HANA, facilitates enhanced collaboration, data integration, and process automation. The transformation towards intelligent ERP (iERP) is driven by interdisciplinary teams across IT, finance, and operations, increasing internal productivity through innovation and transparent roadmaps for implementation (Niemann & Flug, 2018).

ERP systems integrate various business processes, including finance, human resources, and supply chain management into one centralized system,

thus providing a holistic view of operations and enabling more informed decision-making (Becker et al., 2017). In recent years, the digitalization wave has made ERP systems even more critical for businesses, particularly with the introduction of SAP S/4HANA, a next-generation ERP suite that operates on the SAP HANA database. This system has revolutionized business processes by offering real-time data processing capabilities and advanced analytics. SAP S/4HANA also integrates cloud computing technologies, offering businesses flexibility and scalability, which are essential in today's dynamic business environment (Kulkarni, 2019). The literature indicates that the introduction of SAP S/4HANA has the potential to significantly impact business models, especially for small- and medium-sized enterprises (SMEs). Studies show that digitalization via ERP systems is crucial for improving efficiency, transparency, and collaboration across departments (Scheer, 2020). However, the transition to SAP S/4HANA is not feasible without its challenges. It requires substantial investment in IT infrastructure, training for employees, and careful planning to ensure that the system is properly integrated with existing business processes (Hertfelder & Futterknecht, 2019).

In the broader academic discourse, ERP systems are recognized for their role in supporting digital transformation and business agility (Gong & Ribiere, 2023). The integration of ERP with advanced technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), allows for the automation of processes, predictive maintenance, and improved decision-making through big data analytics (Muduli & Choudhury, 2024). These innovations are reshaping industries, particularly in manufacturing, where real-time data and predictive capabilities can lead to significant efficiency gains (Wamba et al., 2017).

Despite the clear benefits, there are also risks and challenges associated with ERP implementation. Many businesses, particularly SMEs, struggle with the cost and complexity of deploying and maintaining such systems. The financial burden associated with ERP systems is a critical concern for SMEs. Subscription fees for cloud-based ERP systems can accumulate to 20-30% of the cost of on-premise systems, which can be a significant factor for smaller organizations (Becker et al., 2017). Additionally, a system's integration can account for up to 40% of the total ERP deployment costs, emphasizing the need for SMEs to be aware of these hidden expenses (Péči & Važan, 2014). This financial strain can deter SMEs from pursuing comprehensive ERP solutions, making it essential to consider phased implementations that allow for gradual financial commitment.

The five theoretical frameworks:

Research suggests that the above mentioned challenges can be mitigated by adopting a phased implementation approach, focusing on key functionalities in each business areas first and gradually expanding the system's scope. Additionally, ensuring adequate training and support for employees during and after the implementation phase is critical for the system's success (Kulkarni, 2019). Therefore, five theoretical frameworks were investigated to find the best approach:

Business Model Canvas by Osterwalder & Pigneur, the St. Gallen Management Model (SGMM), Wirtz's Business Model Framework, Stähler's Business Model Canvas, and Gary Hamel's Business Model Concepts provide valuable insights for understanding how digital transformation technologies, like SAP S/4HANA, can impact each business areas of small and medium-sized enterprises (SMEs) in the manufacturing industry. Osterwalder & Pigneur's Business Model Canvas emphasizes the nine key components of a business model, including value propositions, customer segments, and revenue streams. This structured approach is useful for SMEs implementing SAP S/4HANA as it allows them to assess how the ERP system will impact each aspect of their business from streamlining internal processes to enhancing customer relationships (Osterwalder & Pigneur, 2010).

The St. Gallen Management Model (SGMM), with its focus on integrating various subsystems (resources, processes, stakeholders), provides a holistic view of how SAP S/4HANA can align internal operations with external market conditions. This model is particularly useful for understanding how real-time **data** from SAP can improve coordination between departments and across the supply chain (Rüegg-Stürm, 2005).

Wirtz's Business Model Framework highlights the importance of **innovation** and **customer-centricity**. In the context of **SAP S/4HANA**, this framework is essential for SMEs looking to maintain agility and adapt to changing market demands through **data-driven insights**. The system's integration of advanced technologies like **AI and IoT** supports Wirtz's emphasis on continuous innovation (Wirtz, 2011). **Stähler's Business Model Canvas** focuses on the **interaction between value propositions and customer expectations**. For SMEs, **SAP S/4HANA** helps enhance **customer satisfaction** by delivering faster, more accurate responses to customer needs through **automated processes** and **real-time analytics** (Stähler, 2002). Finally, **Gary**

Hamel's Business Model Concepts encourage businesses to embrace **disruption and strategic innovation**. This is directly relevant to the **radical changes** introduced by **SAP S/4HANA** in terms of integrating cutting-edge technologies and transforming traditional operations. Hamel's framework supports the idea that SMEs can use **S/4HANA** to stay competitive by rethinking their core business processes (Hamel, 2000).

In summary, the literature demonstrates that ERP systems like SAP S/4HANA are pivotal in enabling digital transformation in the manufacturing industry. They provide a unified platform for managing operations, improving efficiency, and facilitating real-time decision-making in each business area. However, the successful implementation of such systems requires careful planning, adequate investment, and continuous support to overcome the associated challenges (Hertfelder & Futterknecht, 2019).

Methodology

The chosen research methodology is primarily qualitative. While both qualitative and quantitative methods were initially compared to assess their suitability for the study, only the qualitative method was ultimately used. The research focuses on conducting **expert interviews** to gather in-depth insights into the impact of SAP S/4HANA on small and medium-sized enterprises (SMEs) (Baur & Blasius, 2014).

Since the research question requires project support as well as specialist knowledge and experience in the field of "SAP S/4HANA project migration" as selection criteria, the selection of possible interview participants was limited. Through an internal network, 15 qualified potential participants from various companies (energy, manufacturing, automotive, production) could be categorized. These 15 target persons met the selection criteria and were contacted by e-mail to inquire about their availability and willingness to participate. Nine of these people expressed their interest, five of whom were ultimately able to make the time. These interviews were aimed at gathering insights into the challenges, experiences and the strategic motivations behind the migration. The stakeholders included IT managers, consultants, and business decision-makers who were involved in the project phases of planning, implementation, and post-implementation.

The interview guideline is structured to align with the research question and theoretical hypotheses, which can be validated using the expertise of interview participants. This structure is based on three essential requirements.

First, the number and sequence of questions were established, though the literature does not prescribe a specific number of questions, as this varies depending on the subject of research (Baur & Blasius, 2019).The Business Model Canvas served as the thematic foundation for creating the interview questions, ultimately leading to the development of 25 key questions. There are no fixed standards for the length of an interview; however, given the time constraints of the experts, a duration of 60 minutes was chosen. The questions followed a natural flow of conversation rather than adhering to a strict sequence (Kaiser, 2014).

The second requirement involves informing the interviewees about the objectives and conditions of the interview, including the research intent (known as "informed consent") and measures to safeguard their personal data (Gläser & Laudel, 2009). The final requirement focuses on the role of the interviewer, who is viewed as a "co-expert." The interviewer's role is to engage with the interviewee by adapting questions and demonstrating deep knowledge of the subject, while remaining neutral to avoid influencing responses. The guideline follows a principle of "collect, check, sort, summarize". Initially, questions were generated without restriction, then organized into a meaningful sequence. The questions were divided into nine thematic areas, supported by an introduction and conclusion, ensuring the interview's structure was clear to the participants. To analyze the qualitative data collected from these interviews, the software **MAXQDA (VERBI – Software. Consult. Sozialforschung. GmbH, MAXQDA2020 – RS5ffcb6ec1fac4)** was employed. MAXQDA enabled the coding and structuring of the interview responses, facilitating a thorough analysis of recurring themes and insights related to the implementation process. The use of this tool ensured that the qualitative data was systematically organized and that the findings were presented in a structured and meaningful way (Rädiker & Kuckartz, 2019).

This qualitative approach, supported by expert interviews and analyzed through MAXQDA, provided a comprehensive understanding of the strategic and operational impact of SAP S/4HANA on SMEs. The analysis focused on identifying the key benefits and challenges faced during the implementation phase, as well as the broader implications for digital transformation within the industry (Rädiker & Kuckartz, 2019). The framework used for this research was based on a combination of established models for digital transformation and ERP implementation. In particular, the St. Gallen Management Model (SGMM) and Business Model Canvas (BMC) provided the

foundation for analyzing how S/4HANA impacts different business areas (Osterwalder & Pigneur, 2010).

Process Evaluation and Limitation

The use of computer-assisted qualitative data analysis software (CAQDAS) like MAXQDA in this study facilitated the processing and analysis of the interview transcripts. The software applied the coding guidelines from the search grid and ensured that the step-by-step analysis was consistently linked back to the original transcripts. This helped improve the quality of the results by making it easier to manage recurring code segments, which played a crucial role in answering the research questions.

Despite the added convenience of using CAQDAS, the software did not replace the need for meaningful coding and analysis by the researcher. MAXQDA was selected specifically because it integrates methodological features based on Mayring, 2015 and (Rädiker & Kuckartz, 2019), supporting the scientific quality of the analysis. In total, 11 main code systems were developed: nine focused on the theoretical structure of the business model canvas (BMC) and two addressed organizational and summary points of view. These systems provided independent and consistent perspectives for evaluating the expert interviews.

The study was limited to a specific region and industry sector, which could affect the generalizability of the findings. Future research could expand on this by including more diverse industries and geographical regions (Becker et al., 2019).

Results

The implementation of SAP S/4HANA within the context of medium-sized enterprises has yielded significant results, particularly in terms of efficiency and process optimization. One of the key findings highlighted in the study was the ability of SAP S/4HANA to reduce operational costs by consolidating and automating processes (Kulkarni, 2019). This reduction of process complexity allowed businesses to improve overall responsiveness and agility, especially in reaction to customer demands. The system's integration capabilities have played a crucial role in fostering better coordination between various departments and locations, enabling quicker decision-making and re-

ducing error rates across the board (Hertfelder & Futterknecht, 2019). Another important result is related to the improvement in financial processes. The adoption of SAP S/4HANA, supported by its in-memory HANA database, has allowed faster financial reporting and real-time analytics, leading to a more transparent view of the organization's financial health. The system's ability to generate financial reports "on-the-fly" has also contributed to a more streamlined closing process for financial periods, reducing the time previously required for this task (Baumgartl et al., 2021).

The study also discusses the impact of SAP S/4HANA on digital transformation initiatives. The system's advanced functionalities have made it easier for companies to embark on broader digitalization strategies, which include integrating technologies like AI and IoT. This has facilitated the deployment of predictive analytics and improved real-time insights, empowering businesses to optimize their supply chain and production processes effectively (Born, 2018). Furthermore, the standardization of business processes through SAP S/4HANA has led to a significant reduction in IT maintenance and development costs. Companies no longer need to rely heavily on custom development as the system's configuration options provide robust solutions that can be applied across different operational areas. This has allowed organizations to focus their resources on strategic activities rather than maintenance (Osterhage, 2014).

Additionally, MAXQDA's frequency tables were used to examine the frequency of coded segments in the interviews, allowing for structured evaluation. The following figure shows the frequency overview in relation to the top three main code systems with the corresponding subcodes:

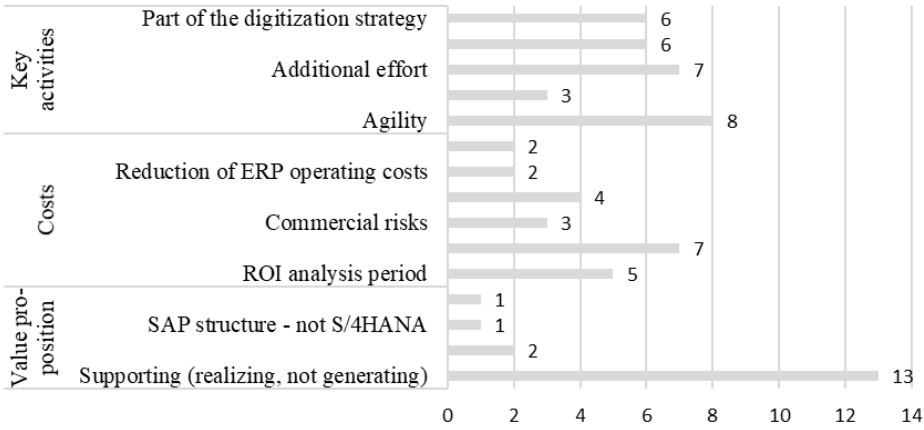

Figure 1: Frequency of the top three coded segments

For example, "key activities" was the most frequently mentioned code with 30 coded segments, while system stability was the least mentioned with seven codes. These insights contributed to the in-depth evaluation of the expert interviews, ultimately enhancing the overall analysis.

Furthermore, the clear statement can be made from the "value proposition" area that the S/4HANA system only supports the implementation of the project. Another figure shows the most frequently mentioned "expectations" of the S/4HANA project:

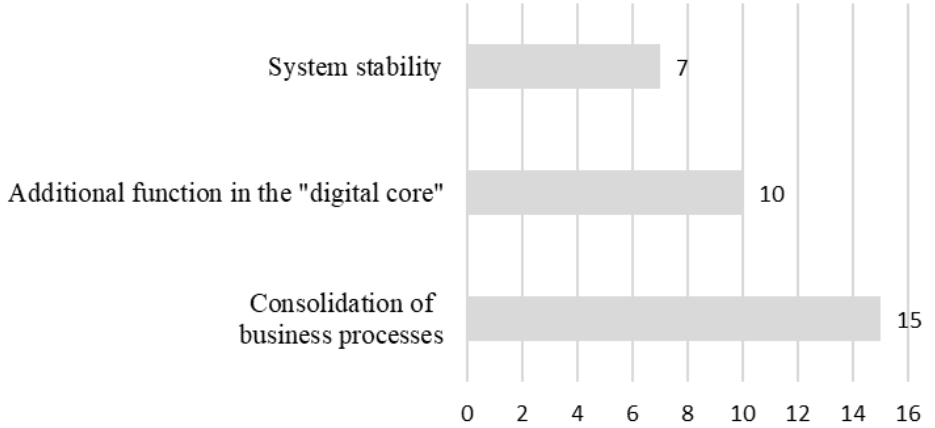

Figure 2: Frequency of the top three expectations & added value coded segments

It can be noted that the consolidation of business processes was mentioned most frequently with 15 codes and the system stability was mentioned least frequently with seven codes.

Summary of Expert Interviews on SAP S/4HANA Implementation

Value Proposition and CRM Integration:

Expert 1 highlighted that a substantial transformation in customer value necessitates the integration of SAP S/4HANA with C/4HANA, thereby facilitating the provision of novel services through digital data interchange. Conversely, other experts (2–5) contended that external CRM solutions, when integrated with S/4HANA, adequately suffice. They acknowledged SAP's endorsement of third-party interfaces but criticized its preference for native solutions. Overall, there existed a consensus that combining S/4HANA with a customer management system enhances value.

Innovation and Business Development:

The respondents underscored innovation as a pivotal factor driving the adoption of S/4HANA, citing the inability of legacy systems to fulfill impending demands. While Expert 2 reported the emergence of new business opportunities subsequent to migration, others (3–5) principally attributed advantages to efficiency enhancements and process optimization rather than to new revenue pathways. There was a limited expectation regarding immediate return on investment; however, experts underscored the potential for long-term benefits such as inventory reduction and cash flow improvements.

Downtime and Project Execution:

All experts agreed that downtime during migration had minimal financial impact, although some slower processes (e.g., returns handling) were acknowledged retrospectively. Expert 3 elaborated on the meticulous planning undertaken to circumvent disruptions, while other experts noted residual inefficiencies attributed to incomplete system utilization following migration.

Process Optimization and Change Management:

Process optimizations were widely realized, with heightened employee accountability identified as a significant determinant of success. Experts 1, 3, and 5 reported enhanced employee engagement and ownership of SAP processes in the post-implementation phase. Conversely, Expert 2 pointed out inadequate change management, which culminated in persistent errors. The necessity of workshops and leadership commitment was emphasized as critical for forthcoming projects.

Agile Work and IT Structures:

Experts recognized a hybrid approach encompassing both traditional (waterfall) and agile methodologies during implementation. Nonetheless, they did not regard S/4HANA as a prerequisite for agile practices, instead stressing the importance of process workshops to equip teams with requisite competencies. Enhanced IT frameworks and newly established roles, such as process architects, were instituted to address business requirements and sustain SAP operations.

Cloud Strategy and Supplier Dependency:

Only Expert 1 reported the establishment of a comprehensive S/4HANA cloud strategy, utilizing short release cycles to foster innovation. The remaining experts (2–5) described hybrid configurations, which integrate cloud flexibility while retaining critical systems on-premises. Experts expressed concern about increased reliance on cloud providers, terming it "supplier-bounded."

Key Partnerships and Costs:

Experts accentuated the significance of partnerships with SAP, with closer collaborations surfacing during implementation. While SAP's role was perceived as essential, some experts regarded the dependency as a negative aspect. Cost considerations remained a paramount concern, with external consulting fees identified as the predominant expenditure. Return on investment evaluations varied, with Experts 1 and 3 reporting favorable returns, whereas others cited inadequate preparation for the assessment of benefits.

Expectations and Outcomes:

Despite the diversity of experiences, all interviewees affirmed that fundamental expectations – such as system stability, cost savings, and consolidation of business processes – were predominantly fulfilled. Experts underscored advantages such as global inventory activation and personnel cost reduction but noted that success frequently hinged on the organization's readiness.

In summary, the introduction of SAP S/4HANA has driven considerable improvements in cost efficiency, process optimization, and digital transformation, thereby positioning medium-sized enterprises to compete more effectively in a rapidly evolving business landscape (Becker & Ulrich, 2019).

Discussion

The introduction of SAP S/4HANA has highlighted several key outcomes for mid-sized companies. One prominent theme emerging from the research is the need for balancing innovation and operational efficiency. SAP S/4HANA is often positioned as a powerful tool to drive digital transformation, yet its implementation has not always been straightforward for mid-

sized firms, especially given the substantial financial and structural commitments required for such a migration. Key interviews revealed a general hesitation among businesses, particularly regarding the perceived complexity of the migration process. Companies recognized the potential long-term benefits of adopting SAP S/4HANA, including improved business agility and more efficient resource management, however they were concerned about the immediate costs and disruptions. Specifically, companies in the early stages of transitioning to SAP S/4HANA were found to be more cautious about business process disruptions during the system changeover, which points to a gap in readiness for comprehensive digital transformation. In particular, businesses showed concern over the ROI (Return on Investment) associated with the transition, often struggling to quantify the long-term gains versus the immediate costs. Moreover, certain internal challenges were identified, such as the resistance from employees unfamiliar with the new ERP functionalities and the need for extensive training programs. IT departments were observed to face an uphill battle in aligning the new SAP S/4HANA environment with existing processes, which contributed to some operational delays.

Ultimately, SAP S/4HANA presents considerable opportunities for mid-sized businesses by providing a robust framework for integrated digital processes. However, the study underscores that the success of such implementations is heavily contingent on effective change management, stakeholder alignment, and ensuring that staff are adequately trained to manage the new systems. Additionally, there is a pressing need for more tailored solutions to address the specific needs and constraints of mid-sized enterprises, particularly regarding cost and complexity management.

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Sustainability Transitions – Innovation Eco-Systems – Digital Solutions 2024

Conference paper on: Discourse on the influence of digitalization from an ecological perspective on ESG Transformation and sustainable development in industry

Sándor Rostás[1]

Abstract: The main focus of this study is to research the effects of the use of digital technologies in the ESG transformation (Environmental, Social, Governance) with the goal to achieve growth and climate protection goals from an economic perspective. The use of digital solutions in automated processes offers opportunities to obtain information about impending disruptions when carrying out periodic tasks, and to avoid them in the sense of ecological sustainability to protect the natural resources (primary raw materials) that still exists. The purpose of this study is to examine the general understanding of ESG transformation and the connections within industry between digitalization and sustainable development through comparative analysis and comprehensive literature research. Despite the efforts in many scientific works that are increasingly concerned with sustainable development, the public often debates the increasing destruction of natural resources due to population and economic growth only, but makes no efforts in implementing relevant changes. Laws and guidelines such as the European Union's CSRD directive as a regulatory requirement (Corporate Sus-tainability Reporting Directive) have a direct impact on economic factors such as trade intensity, economic growth and unemployment. In summary, this work will show that the use of innovative digital solutions can both conserve existing resources and generate new growth opportunities.

Keywords: *digitalization, ESG-transformation, CSRD, sustainable development*

JEL Codes: *Q01, Q56, R11, O13, O35*

[1] ROSTÁS Sándor, Ph.D. Student
University of Sopron Alexandre Lamfalussy Faculty of Economics
(Rostas.Sandor@phd.uni-sopron.hu)

Introduction

Digitalization is currently considered to be of great importance in social and economic policies, both on the level of governmental regulations and also in the sustainability policies of the companies (Brockhaus et al., 2020). There are optimistic expectations that operational digitalization will optimize processes, preserve resources and thus increase sustainability in both production planning and upstream and downstream processes (D. Koch et al., 2022). Digitalization, digital transformation, IoT (Internet of Things) and AI (artificial intelligence) are often used synonymously, as the computerization of processes or as a digitalization term for the assumption of decisions by software-supported systems (Negi et al., 2024), not taking into consideration that the scope and the necessary investments for the transformation are very different (Brockhaus et al., 2020).

Such generalized statements make the transformation process more difficult because the terms of digitalization and artificial intelligence blur fiction and reality due to their frequent use in social media and feature films (Gethmann et al., 2022). Depending on the industry sector which the companies belong to, the ESG transformation (Environmental, Social, Governance) affects almost all areas: such as the business model, corporate financing, corporate value, CO2 compensation, marketing, production and strategic planning (Neumann & Forthmann, 2024). Digitalization offers the possibility of converting analogue issues into digital ones, which then creates *digitality* in which the information can be changed and communicated (Pausits et al., 2024). The three properties mentioned above − the transfer, the change and the communication − between different Internet-enabled devices are decisive for so-called IoT-products, which can better adapt products and services to customer needs and thus optimize certain processes (Jacob, 2023).

In order to do justice to the ESG transformation and ecological sustainability, the right conditions must first be created (werk21, 2022a) because they are still largely discussed separately, the so-called green economy is coming to the fore, which is the guiding principle of an ecologically sustainable economy that combines ecology and economy and increases social prosperity (werk21, 2022b). The prerequisites for the ESG transformation are sustainability regulations such as the GCD (Green Claims Directive), CSRD (Corporate Sustainability Reporting Directive) and the CSDDD (Corporate Sustainability Due Diligence Directive), which pose major challenges for companies when implementing the requirements (Falker, 2024). A study

conducted by KPMG shows that the ESG transformation of 47% of the participating companies is a clear competitive advantage, speaks of cost savings and reputational, financial and legal risks in the event of non-compliance, if one follows the interview conducted internally by two KPMG employees (Mazar, 2023). The challenges associated with implementation, such as the necessary investments in consulting, provision of resources, higher wage costs, the additional time required and the redesign of processes, which increases complexity, were not taken into account (Michen, 2023). Even with the support of digitalization and AI, implementation remains a major challenge if companies limit themselves exclusively to purpose-oriented action (predefined by goals and means) without understanding the complexity and meaningfulness (understanding-oriented action), because AI fails here in most cases – for the time being (Maio, 2024). Consequently, the discourse that arises in the initial situation of an ESG transformation will influence the final result according to the perception of the problem and the subsequent action and will determine the success (Heinemann, 2011). In this study, we took the opportunity to use the theoretical approach for the use of digitalization to increase the efficiency of electric drives along the product life cycle.

Relevance and problem

This topic becomes very important for every company or organization because all of them develop their own corporate culture over time, which is shaped by the prevailing behaviours, norms, values and attitudes (Lippold, 2024). As a result, the dominant corporate or organizational culture (hereinafter referred to as corporate culture) must be transformed into a sustainable corporate culture by which ecological and social sustainability goals and visions are communicated (Bruhn & Hadwich, 2024a). The transformation of corporate culture within the strategic objective is carried out on the one hand via company analysis (strengths/weaknesses) and on the other hand via stakeholder/environmental analysis (opportunities/threats) (R. H. Jung et al., 2018). The decisive factor is how the reality of the company is perceived and evaluated based on the information and data available (Maio, 2024) and how this reality can be transformed into a new reality (Heinemann, 2011) in the sense of ecological and social sustainability in a constant discourse. The decisive factor is how the matter (ESG transformation) is thought about and, above all, how it is debated, because both the non-linguistic and linguistic

elements of the discourse determine how ecological and social aspects are taken into account in the further transformation process (Bruhn & Hadwich, 2024b). The real relevance of the topic lies behind the EU's (European Union's) threat of liability from the CSDDD if ESG aspects are not taken into account in corporate decisions and puts ESG on a par with the management duty to ensure the profitability and continued existence of the company (Neumann & Forthmann, 2024).

The problem is that ESG is often equated with the term "sustainable" in literature and press (Dilg, 2024), but ESG goes far beyond the concept of sustainability as a criterion for sustainable business. ESG combines ecological goals (reducing negative environmental impacts), social goals (assuming social responsibility) and economical goals (compliance with legal requirements and, with the involvement of stakeholders, increasing innovation and competitiveness) (Bruhn & Hadwich, 2024b).

The ESG transformation requires that the learning content and study programs are adapted to the requirements as early as the qualification stage (Pausits et al., 2024). The transformation requires great efforts in research and development in industry, on the one hand to develop new (more recyclable) materials and products that can be used for longer in the spirit of the circular economy (Hayil & Ibrahim, 2023), and on the other hand to redesign work processes in industry, in the further training of employees and the requalification of company management (Neumann & Forthmann, 2024).

The social framework conditions are experiencing a radical change in training, studies and in industry due to the rapid development of digital transformation, because new skills in dealing with and using new digital solutions are necessary in order to use new forms of learning and products (Pausits et al., 2024). In this context, transformation can be understood as the process of transferring technology or technology components and associated knowledge across the boundaries of several social units (Sarala et al., 2024). Artificial intelligence is a part of digitalization and digital transformation that is aimed at using all the potential of digitalization, which in turn is a part of automation, which allows human work to be done by machines (Gethmann et al., 2022). Only a few traditional professions in crafts and agriculture (traditional manufacturing/cultivation) can now do without digitization – all other sectors and many areas of industry are currently moving towards Industry 4.0, where many expect that investments in applications that increase quality and efficiency will reduce costs through networking in the value chain and that the range of services and products can be improved through digitalization (Jacob, 2023). With Industry 4.0, the automation of processes is changing and even

areas of life and work fields, depending on the industry, are subject to changes caused by the technical development of IoT products (networking of applications) (Gethmann et al., 2022). The networking of various IoT products is hoped to lead to more intelligent and energy-saving use, whereby networking also implies a stronger interlinking of economic activities in the sense of globalization – stronger cooperation between different companies/organizations (Jäggi, 2003). The companies that will prevail are those that can use the advantages of digitalization to efficiently use increasingly scarce resources and are thus significantly more energy efficient (Linne, 2003). Innovative business models are usually strategically geared towards growth and are either aimed at changing the type of value creation or at creating new (additional) needs in addition to existing ones (Griese & Schnitker, 2023). Since climate change is not only a scientific problem, but also a social and technical problem, which has been discussed in social science journals for more than 30 years, more and more social and political questions are being addressed (Jankó et al., 2010), meaning that such complex topics can be seen as the basis for ESG transformation at the individual and macroeconomic level (Bruhn & Hadwich, 2024b).

The transformation to a circular economy does not only involve the development of new, more recyclable materials, but also the intensification of benefits and the extension of product life spans pose major challenges for society, as these are not compatible with the growth strategies of many companies (Linne, 2003).

ESG – Challenges

Industry and society are undergoing a major transformation, which is essentially accompanied by ecological, demographical, socio-political and economical megatrends, which is one of the reasons why business environments are constantly changing, and the pressure is constantly growing (Englert & Ternès, 2019). Demographic change is a significant element of the transformation, as current forecasts predict that Germany will be short of 7 million workers or skilled workers by 2035, which will lead to a decline in economic performance and failure to achieve growth targets (Bruhn & Hadwich, 2024b). The ability to promote and invest in innovation is said to have great potential in sustainable development if these innovations are sustainable and forward-looking and are geared to the changed situation (Englert & Ternès,

2019). In the future, digitalization, sustainability and people will be inseparable from one another, as all of these areas are constantly producing new information and therefore more new knowledge must be imparted in a shorter period of time (Bruhn & Hadwich, 2024b).

For this reason, traditional business models should be constantly re-evaluated because Industry 4.0 technologies generate significant benefits from Big Data solutions that enable real-time integration of business processes (sales, production), which influences customer behaviour and product life cycles (Gläß & Leukert, 2017).

Environmental and climate crisis

The environmental and climate crises cannot be viewed in isolation because they are accompanied by health and economical crises (Wittpahl, 2020) and currently also political crises and wars in Europe and the Middle East. Many organizations, institutes, experts, researchers and churches are increasingly pointing out that all the crises mentioned above are closely related to each other (Bándi, 2024). Banks play an important role in both, in the economic crisis and also in the climate crisis because they determine what climate-friendly investments should be and how they are promoted (Schwager et al., 2022). One of the most important questions in terms of ecological sustainability is how a product can be produced in such a way that as few resources (raw materials and energy) as possible are required and how it can be operated in such a way that as few greenhouse gases as possible are released (Jacob, 2023). Not least, the high greenhouse gas emissions are attributed to the increasing need for packaging and transport for consumer goods in online retail (Harwardt, 2023) and the poor recyclability of many products, which is associated with enormous energy requirements (Griese & Schnitker, 2023).

To achieve the climate protection goals, greenhouse gas emissions must be reduced in both, in the industrial sector and in all other sectors (health care, transport, private sector) by reorganizing to CO2-neutral technologies (Schwager et al., 2022). However, the CO2-neutral technologies from wind and solar energy are not always available and weather changes have a direct impact on power supply, which makes demand-oriented supply currently still questionable (Wittpahl, 2020). The effectiveness of the objectives derived from the ESG transformation can be tested using KPIs (key performance indicators), which are determined by measuring

- the CO2 footprint,
- energy consumption (electricity, gas),
- water consumption and
- the amount of waste produced (Bruhn & Hadwich, 2024b).

Social and societal

The previously mentioned megatrends and digitalization are changing the culture of a society, which also initiates a change in values that is interrelated with selected social areas such as individualization and the drive for perfection, mobility, gender roles and diversity, demographic change and, of course, sustainability (Jacob, 2023). The changed everyday behaviours in the so-called "wealthy industrialized countries" are thus contributing significantly to the climate crisis due to the constantly growing mobility (individual transport), the need for new technologies (electronic products) and the significantly increased amounts of household waste (Schwager et al., 2022). The extraordinarily high pressure caused by the constantly new needs of the masses initially falls on the producers, who are happy to pass on all the responsibility to politicians because market share, market dominance and growth are what counts for producers first and foremost (Sigl, 2023).

The ESG transformation is an overall social transformation process affecting society as a whole, which shapes the development of society as a whole and pursues the goal of enabling a fair and good life for all now and in the future (Henkel et al., 2021). Taking digitalization into account, a contemporary theory states that digitalization is a global and social event that has already begun with the restructuring process of society and the economy (Sigl, 2023). The effectiveness of the social goals implemented in the company is also evaluated by means of KPIs, which are determined, for example, by measuring

- the degree of diversity,
- age and origin of employees, employee satisfaction, safety of working conditions
- or expenditure / donations for social projects

(Bruhn & Hadwich, 2024b). Compliance with social goals is one of the key factors in counteracting the disadvantages of digitalization such as

- high workload and lack of time,
- unfair pay,
- bureaucracy and high documentation effort,
- no social prestige of the profession, age discrimination,
- poor working conditions (Jacob, 2023).

Corporate governance

For companies and organizations of all kinds, ESG transformation means a constant process of change with an ever-increasing focus on reducing greenhouse gas emissions and improvement of ecological sustainability (Schwager et al., 2022). With the megatrend of digitalization and artificial intelligence, sustainability has become a success factor and possibly offers one of the most important social and economic opportunities of the present (Lippold, 2024). Megatrends can be spoken of when there is a need for change – here – in the sense of ecological sustainability, which brings about change and the pursuit of improvements that have a broad impact on society and the economy (Jacob, 2023). For this reason, investors are more likely to invest in the shares and funds of companies that invest capital in green technologies and pursue ethical principles in corporate governance and are also given advantages because they are said to have great innovation potential (Linne, 2003). Ultimately, the company's management is responsible for generating profits in order to be able to successfully implement the business model in an economically, ecologically and socially sustainable manner over a longer period of time and to influence the market accordingly (Lippold, 2024). To this end, at the beginning of an ESG transformation, it is necessary for the management to implement future leadership and strategy in a sustainability-oriented manner, in its vision, mission, corporate values and in strategy development, in planning (Bruhn & Hadwich, 2024b). The KPIs of ecological sustainability measure success based on

- the increase in profit and sales,
- the profitability of sustainable investments and
- the reduction of costs and savings in energy and raw materials

based on the implemented economic goals (Bruhn & Hadwich, 2024b).

Objectives and questions

The aim of this study is to use an example to examine the service life of an electrically driven machine (submersible motor pump) from the creation of the need, along the service life to disposal, and to map the ESG aspects and link them to the theoretical approaches of ESG. Since the climate crisis has penetrated the collective awareness, energy and resource efficiency features, which are also important for professional users (companies), have also come to the fore due to social pressure and, on the other hand, due to the Supply Chain Due Diligence Act and other requirements by the legislature (Schwager et al., 2022). The energy industry's goal for the future is the decentralized and demand-oriented provision of energy and, with the help of digitalization, only the amount necessary to carry out a specific job (such as emptying a container) should be used (Jacob, 2023). Changes are often associated with significant adjustments in production plants, including changes to the business model, and therefore offer consistency in the optimization and efficiency strategy to adapt processes to the existing conditions with the help of digitalization (Jacob, 2023).

The following example looks at a normal (everyday) process of TEG (Tsurumi (Europe) GmbH, Düsseldorf, Germany) with the support of the sales and marketing department. With a few exceptions, depending on the industry, sales structure and corporate culture, sales processes are organized very similarly, whereby they are also essentially determined by the customer decoupling point (Uhe, 2002). The customer decoupling point indicates at which point in the product creation process a customer can be assigned to the product in the supply chain (Schenk et al., 2014). This point is at the end of the process at TEG because almost all products are produced anonymously to the customer. As a result, the previously formulated goal is illustrated with the practical example of TEG. Furthermore, an attempt is made to link the ESG aspects and technical possibilities of digitalization along the product life cycle in order to identify possible opportunities and risks. The following questions can be derived from this

- In which phases of the product life cycle can digital technologies help to reduce CO2 emissions?

- In the practical example presented here, can positive effects be achieved between the ESG (Environmental Social Governance) elements, or can they only be considered in isolation from one another for the time being?
- Can possible approaches from the linear economy be found in the circular economy under the given circumstances?

The following hypothesis can be derived from the questions: digital technologies can extend the useful life of certain products, thereby conserving valuable primary raw materials and contributing to ecological sustainability.

Method

In order to answer how digitalization, the Internet of Things and artificial intelligence relate to the ESG transformation, and which limitations still exist in practice, a comprehensive and systematic literature research was chosen as the method. In order to present the theoretical aspects more transparently, supporting examples from the practice of Tsurumi (Europe) GmbH are used.

Literature research

Systematic literature research is most suitable in this work because the research question has already been defined and relevant sources have been searched for using selected search terms. Systematic literature research in selected databases is essential in order to take into account the latest state of research (Döring, 2023), but it is advisable not to consider only the latest sources in this work. The beginnings of digitalization go back to the middle of the 20th century with the ENIAC (Electronic Numerical Integrator and Computer), followed by mainframe computers in the 1960s, personal computers in the 1980s, followed by the Internet and later smartphones, up to today's AI applications, which have influenced both the economy and politics and society ever since (Jäggi, 2023). The search for specialist literature was carried out using the keywords mentioned in the abstract and other search terms as listed in *Figure 1*.

Search terms	Number of hits – Fernuniversität Hagen database	Number of hits – Database of the Technical University of Dortmund	Number of hits – Google Scholar database	Number of hits – Research Gate database
Digitalization ESG	4	45	85	121
ESG-Transformation	66	70	90	76
CSRD ESG	48	32	66	72
Sustainable development ESG	24	21	94	70
environmental crisis	28	59	49	80
climate crisis	16	33	91	50
Renewable energy	49	35	73	75
energy efficiency	69	49	68	42
Artificial intelligence	44	21	23	38

Figure 1: Overview of literature search – Search terms absolute distribution
Source: own illustration

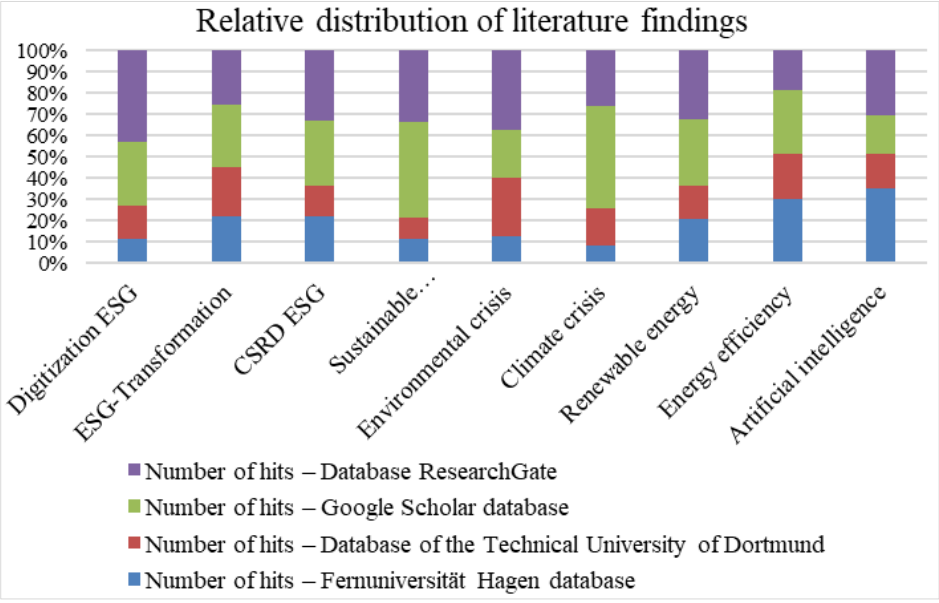

Figure 2: Overview of literature research – search terms relative distribution
Source: own illustration

The relative distribution of the search results in *Figure 2* shows that most possible sources can be found primarily via Google Scholar and secondly via ResearchGate. Some sources are often suggested to various databases and in

most cases the sources can be accessed via a download link directly from the publisher (Springer Fachmedien, Springer Gabler, Springer Berlin and Springer Vieweg). The focus of the selection of sources was on processing the current state of research (Döring, 2023), so the search was specifically for sources from 2023 and 2024. But older sources are also taken into account in this work as long as their content is still current and no newer research results are available, unless they are needed for a historical consideration of the subject of the study (Berger-Grabner, 2016). A very high number of articles were identified in this search and therefore the research was initially restricted to the established publishers mentioned. The publications were then selected based on the relevance of the title to the topic. A total of 2,004 publications were found. After removing duplicates and publications that were not available online, 154 remained. After checking the content of the abstracts, 48 remained.

Case study

The case study of Tsurumi (Europe) GmbH outlined in Chapter 5 does not represent an independent study within the framework of an empirical investigation. All information was provided by TEG's Sales and Marketing Director, Mr. Birger Schmidt, and Senior Product Manager Mr. Stefan Himmelsbach as part of the team of CSRD implementation from May 2024. The aim of applying the case study is to develop practical incentives to identify opportunities that can achieve improvements within the limits of existing processes in terms of ecological sustainability, thus shortening the learning curve for future solutions and accelerating new processes (Bruhn & Hadwich, 2024a).

The company operating in this case study is the subsidiary of the Japanese manufacturer TMC (Tsurumi Manufacturing Co., Ltd.) with headquarters in Kyoto. The European subsidiary sells its products throughout Europe with the support of five subsidiaries and a very well-organized dealer network.

The implementation of the CSRD is, on the one hand, a requirement of the parent company TMC and, on the other hand, a requirement of the CSRD standard. Since TEG, together with its subsidiaries, meets at least two of the criteria (total assets and net sales) across Europe, it will therefore be required to report as early as 2025 (Bruhn & Hadwich, 2024a).

Procedure of the case study

The approach in the case study consists of comprehensive observation of the sales process during CSRD implementation. The analysis of the TEG's business model and the strategy towards risks related to ESG aspects along the supply chain is of great importance because it poses the risk of an increased material footprint or a threat to security of supply (Has, 2022). Since the TEG also still follows the structures of the linear economy (production – use – disposal) because it can always procure resources easily and inexpensively (Hansen et al., 2021), the risks and opportunities in the phases of the product life cycle displayed in *Figure 3* must be examined and new knowledge converted into benefits for the customer (R. H. Jung et al., 2018).

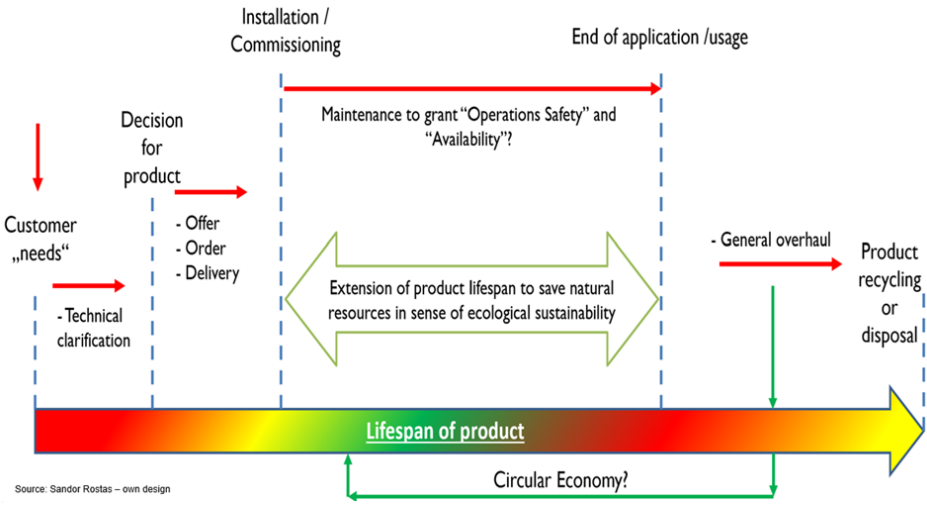

Figure 3, Product lifespan of TEG products: own illustration

For products that are essentially made from primary raw materials, the focus is on long durability and long-term usability (Linne, 2003). The key to success is, on the one hand, identifying the ESG factors for the business model (electricity consumption, water consumption, material consumption) and, on the other hand, assigning these to one of the ESG areas (environmental, social or corporate governance) and identifying the corresponding risks and opportunities and assessing them with the probability of occurrence (Neumann & Forthmann, 2024). The main ESG risks related to climate change and sustainability are divided into strategic, operational, financial and compliance

risks (Gleißner & Romeike, 2020). The present case study identifies operational risks and opportunities, which are then later reflected in the operational management phase in sustainable business models, establishment of the circular economy, novel product-service systems and sustainable innovation (Bruhn & Hadwich, 2024b).

Overview of the product life cycle phases

The following is a summary of the contents of the product life cycle phases in *Figure 3* from the discussions with B. Schmidt and S. Himmelsbach.
When needs for submersible motor pumps arise, end users are often unable to sufficiently specify the situation for which they need the equipment sufficiently, so that they either order from the product catalogues without prior technical clarification or they request offers with little or incorrect technical data. In such cases, there is a risk that the end user will receive incorrect products that are either over- or under-dimensioned. There is a risk that over-dimensioned devices will have an uncalculated energy requirement and that under-dimensioned devices will not be able to deliver the required performance. In both cases, the wrong product selection has a negative impact on the service life, energy and material consumption. An appropriate sustainability marketing concept could offer opportunities to work the relevant market, taking ecological and social aspects into account, in such a way that customer satisfaction and early detection of needs and their correct assessment are the focus (Grunwald & Schwill, 2022).

In the technical clarification phase, the risks lie in the communication skills and the respective communication policy of those involved, which determines a successful outcome. The technical clarification actually only serves the purpose of determining the right product (with the right technical properties) based on the technical conditions of the end user. Communication is considered to be very important, so it also offers an opportunity in this phase to be able to fairly serve specific needs in the various buyer segments (Grunwald & Schwill, 2022).

There must be no risks in the customer and supplier relationship during the phases of product decision, quotation processing, order processing, delivery and installation & commissioning, provided that no significant questions remained unanswered in the previous phases and interim changes and unforeseen events were communicated correctly and in a timely manner. In this phase, the supplier is primarily responsible for ensuring the process capability of its internal processes (Bullinger et al., 2009).

Risks arise in the usage phase when the operating conditions change, which also changes the intended use. Further risks arise in this phase when preventive maintenance work has either not been planned or has not been planned appropriately for the level of difficulty of the application. As already mentioned above, from an ecological and economic point of view, the usage phase should be as long as possible, although these efforts run counter to the growth targets of the suppliers (Kreipl, 2020).

At the end of the usage phase, the options are to overhaul a device or to recycle the device and dispose of the remaining parts that cannot be recycled. There is a risk that due to a lack of capacity, a lack of knowledge or because it is simply uneconomical, devices will be disposed of too quickly without checking whether these devices can be reintroduced into the usage process after a general overhaul in the spirit of the circular economy (Hansen et al., 2021).

Results

The impact of digitalization on ESG transformation is currently still difficult to determine for all areas of the industrial sector. It is important to recognize the differences between digitalization, the Internet of Things and artificial intelligence, because these are important with regard to the implementation and handling of new technologies and the acceptance of change (Henkel, 2023).

Digitalization will make sustainability reporting more transparent for stakeholders and their measures to reduce greenhouse gas emissions more comparable, as digital tools will offer the possibility of automatically providing assessments based on defined criteria to interested parties in the future (Herzner & Schmidpeter, 2022). In this context, sustainability reporting is an essential topic for companies that themselves or whose customers are subject to the CSRD, because not only the legislator, but also investors, banks, customers, business partners and other stakeholders can increasingly demand reporting (Has, 2022).

Elements of sustainability reporting such as GHG accounting (Scope 1-3) according to the GHG Protocol (Greenhouse Gas) and LCA (Life Cycle Assessment) have become increasingly important (Bruhn & Hadwich, 2024a). As already discussed in the example case above, the LCA perspective plays an important role with the double materiality assessment, in which

companies assess both their impacts on society and the environment (materiality of impacts) and the impacts of society and the environment on the company (financial materiality) (Has, 2022). GHG accounting (Scope 1-3) assesses the organizational and corporate level

- Scope 1 direct GHG emissions from own company processes,
- Scope 2 indirect emissions from purchased energy and
- Scope 3 from upstream activities (primary and secondary resources) and downstream activities (sales and use) and despite different objects of investigation, LCA or Scope 1-3, environmental or climate impacts are recorded that go far beyond the pure impacts within the company; the entire life cycle of the product or the company is taken into account (Eisele, 2021).

In the above case study, both the different perspectives of life cycle assessment and the aspects of GHG accounting can be illustrated. In practice, however, accounting in both areas still has to contend with major hurdles. The electrical devices from the manufacturer TMC are delivered to Europe ready for use and can be made available directly on the market. Calculating the product-related CO2 footprint is difficult due to information gaps in the supply chain and the fact that many assumptions have to be made in the calculation. Therefore, the upstream activities cannot therefore be controlled by the European subsidiary. Where it can exert influence, however, are the downstream activities of sales and use. An appropriate marketing strategy and measures to extend the product lifespan could help to improve the ecological footprint. This would not least be the case if measures were established to reintegrate devices into the usage process after their useful life has expired due to wear and tear. This would be the first step towards a circular economy, but it would also change the way production is carried out, the supply chain would have to be adapted, which at the same time requires a change in the business model (Kadner et al., 2021).

The establishment of appropriate measures based on reliable eco- and GHG accounting would ensure that the ecological limits are maintained and respected by those involved (Bruhn & Hadwich, 2024b). The necessary changes are fundamentally linked to the problems of changing, designing, managing and controlling processes, because the individual behaviour of the people involved is often not taken into account – but these people decide whether the changes are accepted or boycotted (Bruhn & Hadwich, 2024a).

This group of people primarily includes the people involved (so-called decision-makers) who are characterized by aggressive growth strategies and are less concerned with ecological sustainability and primarily with increasing sales (Jäggi, 2023).

Discussion

A good opportunity to spark a debate is the question of what opportunities and risks arise from the interaction between digitalization and the ESG transformation. Here, too, supporters and opponents of digitalization, IoT and AI face each other, clearly expressing that while they have advantages, they also pose considerable risks (Jäggi, 2023). A challenge for management is to identify corresponding demands from the relevant market and to transform them into a competitive advantage with the necessary speed (Meffert et al., 2024). Digitalization offers considerable advantages, which are based on the fact that physical objects, digital objects and people can be networked with one another (IoT) in order to establish chains of effects and to accelerate the exchange of information (Joisten, 2022).

However, the high transformation costs have a disadvantageous effect on SMEs because there is always the impression that the costs are not proportionate to the benefits and the transformation process is more often characterized by negative future prospects due to political uncertainty and there are still obstacles to digitalization due to a lack of IT knowledge among employees (Brockhaus et al., 2020). From a democratic perspective, challenges in the digital divide are discussed because inequality is justified by the phenomenon of capitalism and technological change, in which the problems of social inequality are spread through digital instruments (Chen, 2024). The ESG criteria Environment (GRI300), Social (GRI400) and Governance (GRI100) are synonymous with sustainable action in the economy for the presentation and evaluation of sustainability The three criteria are used without taking into account the usual KPIs and without calculation methods as a basis for the presentation of some of the opportunities and risks in *Figure 4* that arise from the TEG case study along the product life cycle in Figure 3.

	Chances	Risks
Environmental	• Saving primary materials • Saving secondary materials • Use of recycled materials	• Outdated management method • Inefficient communication with potential customers
Social	• Emergence of new work areas • Emergence of new professional fields • Better Work Life Balance	• Extinction of traditional professions • High effort required to cope with the flood of information • Age discrimination
Governance	• Efficient management methods can be used • More efficient communication tools	• Research and development suffer due to standardized decision-making processes • High effort for the documentation of processes

Figure 4, ESG opportunities and risks in the TEG context
Source: own illustration

TEG has no influence on the production processes at TMC in Kyoto and therefore there is no possibility of discussing concepts for reducing the need for primary and secondary materials and promoting increased use of recycled materials. There is currently a real opportunity for TEG to extend the life of devices by determining the right device and taking measures to extend the life span of the product. Risks in the environmental area arise from outdated management methods in sales, where no attempt is made to serve the relevant markets in a needs-oriented manner. Outdated communication models can lead to these becoming even more prone to errors due to demographic changes, because the methods and types of communication are constantly evolving (Bruhn & Hadwich, 2024b).

In the social sector, digitalization, IoT and AI are creating opportunities for completely new professions and fields of activity, as well as a new attitude to life through an improved work-life balance, which has also been facilitated created by the possibilities of mobile work (free location and time management). On the other hand, there are risks that traditional professions may be completely forgotten and die out. Some people also still have to learn how to handle the large amounts of data that digitalization creates. Otherwise, employees' risk being overworked and having higher levels of sick leave. Another risk factor is age discrimination, because it is assumed that older

employees are no longer capable and cannot handle the new technology (Sigl, 2023).

New opportunities are emerging for company management through modern methods and communication tools that allow them to prepare and distribute information more quickly. Information acquisition is also easier with the help of digitalization, which means that market changes can be registered more quickly. The disadvantage is that digitalization is expected to lead to greater standardization, which can be at the expense of creativity in development. Another disadvantage that is foreseeable is that the documentation efforts will increase. This will certainly be done digitally, but the system must still be kept up to date. The basis of sustainable company management is the circular economy with the primary goal of drastically reducing of waste volumes and minimizing the need for primary and secondary raw materials and reducing GHG emissions by producing energy-efficient devices (Lippold, 2024).

Opportunities of digitalization

Digitalization is changing the world of work, and each professional group is currently affected by the change in different ways and each group learns (Pluzhnikova, 2024) and experiences the opportunities that arise from it differently (Jäggi, 2023). In industry, digitalization is leading to it becoming an independent production factor and ensuring transparency by linking the physical and virtual worlds (Gläß & Leukert, 2017). It is also a fact that digitalization is endangering jobs and professions (jobs in sales, banking, warehousing, etc.) through innovations, but it is not clear whether jobs with a high proportion of women or men are more at risk (Jäggi, 2023). In addition to the negative effects, there are also positive signals from science that the changed working conditions of employees have a positive impact on their health and satisfaction (Gethmann et al., 2022). The Baden-Württemberg Minister for Economic Affairs sees digitalization as a great opportunity to increase resource efficiency and climate protection in the manufacturing industry and, together with AI, it is assigned a key role in climate protection and sustainability (D. Koch et al., 2022).

The automation of functions and machines is also common practice at TEG, but automation is reduced to a few variables without the system being able to meet higher requirements. The term automation stands for the replacement of manual work steps, which is being raised to the level of Industry 4.0

with digitalization, where the focus is on the intelligent networking of processes and machines (Jacob, 2023). In the above case study, an intelligent system can, as a service life-extending measure with appropriate monitoring, warn early on of failures due to wear and tear in a networked system. This would be an advantage in every respect, but it is questionable whether customers are already prepared to invest in the infrastructure for communication.

Conclusion

The question of in which phases of the product life cycle digital technologies can help to reduce CO2 emissions cannot yet be conclusively answered because the product life cycle and the type of product application are different. Digitalization can help to reduce CO2 emissions in every phase of the product life cycle if appropriate digital technologies are procured and implemented for the relevant company functions. However, it is questionable what the relationship is between the investments and the hoped-for benefits. In addition to costs, another key aspect for success is the lived corporate culture, whether the organization is characterized by an open, innovation-friendly culture or whether it relies on resistance across the board (M. Jung & Von Garrel, 2021). For example, traffic systems can be optimized with the use of IoT and AI by equipping them with intelligent emergency systems and a charging infrastructure for electric cars from renewable energy sources with connection the public network systems (Singh et al., 2021).

The second question, whether positive effects can be achieved between the ESG (Environmental Social Governance) elements in the practical example presented here, or whether they can only be considered in isolation from one another for the time being, cannot be easily answered based on the example. It must be checked whether a logical connection can be made between KPIs of the ESG criteria, but it primarily depends on which KPIs are selected by the company management for the evaluations (Erchinger, 2022). In the case study, it would be conceivable that the environmental KPI waste quantity & recycled share could be interrelated with the social KPI expenditure on training and education and the corporate governance KPI ethics & compliance.

The third question, whether possible approaches from the linear economy can be found in the circular economy under the given circumstances, can be easily answered based on the knowledge gained here. For the case study, there are two approaches for establishing the circular economy. The

first approach arises at the end of the useful life due to wear and tear. A refurbished device can be returned to the cycle, which some manufacturers (Apple, Dell) already do. The second approach arises at the spare parts level. If a device has been damaged and cannot be repaired, then there is still the possibility of returning the well-preserved spare parts to the cycle.

The hypothesis derived from the above questions, that digital technologies can extend the service life of certain products so that valuable primary raw materials are conserved and thus contribute to ecological sustainability, can be confirmed based on the new findings. In the automotive industry, comparable systems already exist that have proven themselves in practice and enjoy significant competitive advantages in their market segment.

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A technológiai menedzsment módszeressége és a vállalati eredményesség közötti összefüggés

The relationship between the methodical approach of technology management and corporate performance

***Pekk Letícia*[1] *– Kovács Zoltán*[2] *– Háry András*[3]**

Abstract: In today's dynamically changing environment, it is crucial for companies to adapt to technological advancements in order to maintain their competitiveness and capitalize on growth opportunities. Technology forecasting methods and disruptive technologies are increasingly central to corporate strategy development, as they contribute to long-term success and enhance market adaptability. Examining the methodical approach to technology management can help understand how these factors influence a company's financial performance, including revenue growth and profitability. This study analyzes the impact of technology forecasting and the use of disruptive technologies on corporate performance in Hungarian high-tech companies. The aim of the empirical research is to explore the effectiveness of technology management methods and their relationship with financial performance. The research results indicate a connection between the methodical approach to technology management and corporate profitability: companies with more advanced technology management achieve more predictable and stable. financial performance. Additionally, the application of disruptive technologies can also increase companies' revenue.

Keywords: *Innovation, technology, development, performance*

JEL Codes: *O32, O33, L25*

[1] PEKK, Letícia, K+F projektkoordinátor
Pannon Fejlesztési Alapítvány – ZalaZONE Kutatási és Technológiai Központ (R&D project coordinator, Pannon Development Foundation – ZalaZONE Research and Technology Center) (leticia.pekk@tc.org.hu; https://orcid.org/0000-0003-4634-7790)

[2] Prof. Dr. Kovács Zoltán, egyetemi tanár (Professor)
Pannon Egyetem, Gazdaságtudományi Kar (University of Pannonia, Faculty of Business and Economics)
(kovacs.zoltan@gtk.uni-pannon.hu; https://orcid.org/0000-0003-4169-2923)

[3] Dr. Háry András, ügyvezető
ZalaZONE Tudományos Park Kft. (Managing director, ZalaZONE Science Park Ltd.)
(andras.hary@apnb.hu; https://orcid.org/0009-0001-2097-6815)

Absztrakt: A mai dinamikusan változó környezetben a vállalatok számára létfontosságú a technológiai fejlődéshez való alkalmazkodás, hogy versenyképességüket megőrizzék és növekedési lehetőségeiket kiaknázzák. A technológiai előrejelzési módszerek és a diszruptív technológiák egyre inkább középpontba kerülnek a vállalati stratégia kialakítása során, hozzájárulnak a hosszú távú sikerességhez és a piaci alkalmazkodóképesség javításához. A technológiai menedzsment módszerességének vizsgálata segíthet megérteni, hogyan befolyásolják ezek a tényezők a vállalatok pénzügyi teljesítményét, beleértve az árbevétel növekedését és a profitabilitást. A tanulmány a magyarországi high-tech vállalatok esetében elemzi, hogy a technológiai előrejelzések és a diszruptív technológiák alkalmazása milyen hatással van a vállalati eredményességre. Az empirikus kutatás célja, hogy feltárja a technológiai menedzsment módszereinek hatékonyságát és azok kapcsolatát a pénzügyi teljesítménnyel. A kutatás eredményei alapján kapcsolat mutatható ki a technológiai menedzsment módszeressége és a vállalati profitabilitás között: a fejlettebb technológiai menedzsmenttel rendelkező vállalatok kiszámíthatóbb, stabilabb pénzügyi teljesítményt érnek el. Emellett a diszruptív technológiák alkalmazása is növelheti a vállalatok árbevételét.

Kulcsszavak: *Innováció, technológia, fejlesztés, eredményesség*

JEL-kódok: *O32, O33, L25*

Bevezetés

A modern üzleti környezet folyamatosan változó technológiai és piaci kihívásokkal szembesíti a vállalatokat. Az egyre gyorsabb ütemben fejlődő technológiák és az ezekkel járó innovációk nemcsak új lehetőségeket teremtenek, hanem jelentős kihívásokat is a versenyelőny megőrzésében (Zahra, 1996). Ahhoz, hogy a vállalatok képesek legyenek hosszú távon fennmaradni és sikeresen versenyezni, elengedhetetlen, hogy hatékonyan alkalmazkodjanak ezekhez a változásokhoz és reagáljanak a piaci trendekre.

A diszruptív technológiák figyelemmel kísérése, a technológiai előrejelzési módszerek alkalmazása és a strukturált technológiai menedzsment egyre fontosabb szerepet kapnak a menedzsment döntések előkészítése során, ezáltal hozzájárulnak a vállalatok alkalmazkodóképességéhez és hosszú távú növekedéséhez, ennek révén átalakíthatják az iparágakat, új piacokat létrehozva és megváltoztatva a meglévő piaci struktúrákat (Coccia, 2017). A diszruptív technológiák alkalmazása ugyanakkor komoly kihívásokat is jelent,

mivel folyamatos innovációt és a technológiai változásokkal szembeni nyitottságot követel meg a vállalatoktól.

A technológiai előrejelzési módszerek segítik a vállalatokat, hogy időben felismerjék a jövőbeli trendeket és potenciális kihívásokat, így lehetővé teszik a megfelelő stratégiák kidolgozását és végrehajtását (Liu et al., 2014). A szisztematikus menedzsment folyamatok továbbá hozzájárulnak a technológiai fejlesztések hatékony integrációjához, támogatva a vállalatok stratégiai céljainak elérését (Kunc és O'Brien, 2018). Ezek a tényezők nemcsak a vállalatok versenyképességét befolyásolják, hanem jelentős hatással vannak a pénzügyi eredményességre is, beleértve az árbevétel növekedését és a profitabilitást.

A diszruptív technológiák és a technológiai menedzsment vállalati eredményességre gyakorolt hatásával kapcsolatos szakirodalom széles körű (lásd Ónodi & Répáczki, 2022; Pelser & Prinsloo, 2014; Cetindamar, Wasti, & Beyhan, 2012; Wu, Liang, & Zhang, 2022; KPMG International, 2017 munkáit), azonban viszonylag kevés kutatás fókuszál a diszruptív technológiák és a technológiai előrejelzések módszerességének együttes hatására, főként a vállalati eredményesség, mint az árbevétel növekedése vagy a profitabilitás tekintetében. Továbbá, a kutatások többsége a globális nagyvállalatokat vizsgálja, miközben a kis- és középvállalkozások, valamint a regionális high-tech iparágak sajátos helyzetére kevesebb figyelem jut. Releváns kérdés ezért egyes technológiai menedzsment tényezők és az eredményesség összefüggésének kutatása.

Ezen kutatási résre reagálva a jelen cikk célja, hogy részletesen megvizsgálja a technológiai menedzsment tényezők módszeressége és a vállalati eredményesség közötti kapcsolatot, magyarországi high-tech vállalatokra fókuszálva, benne nagyvállalatokkal, valamint kis- és közepes méretű vállalkozásokkal egyaránt. A kutatás során statisztikai elemzéseket, köztük ANOVA-t és post-hoc teszteket alkalmazunk annak érdekében, hogy meghatározzuk, vajon ezek a technológiai tényezők szignifikáns kapcsolatot mutatnak-e a vállalati eredményesség különböző dimenzióival, mint például az árbevételi trend és az árbevétel-arányos profitabilitás.

Szakirodalmi kitekintés

A logisztikai iparág példáján keresztül Brah és Lim (2006) bemutatják, hogy a technológia és a TQM integrálása hogyan segíti elő a vállalat teljesítményének javítását. Az IT rendszerek és a minőségmenedzsment szisztematikus

alkalmazása javítja a belső és külső integrációt, ezáltal növelve az operatív hatékonyságot. Jeyaraj és Sabherwal (2015) meta-analízise is megerősíti, hogy az IT beruházások üzleti értéke növelhető a rendszerszintű menedzsment és az IT illeszkedés figyelembevételével. Kohli, Devaraj és Ow (2012) kutatása szerint az információs technológiai (IT) beruházások nemcsak a rövid távú pénzügyi teljesítményre hatnak, hanem a vállalat hosszú távú piaci értékét is befolyásolják. A tanulmány kiemeli, hogy az IT-beruházások olyan cégeknél is pozitív hatással lehetnek a vállalat piaci értékére, amelyek nem nyilvánosak, mivel az IT egyre inkább stratégiai jelentőségű szerepet tölt be. Az IT-be való befektetés nem csupán az operatív hatékonyságot, hanem a vállalat értékét is növeli (Kohli et al., 2012).

Liu et al. (2014) szerint a technológiai innovációk pénzügyi sikeressége nagyban függ a vállalat tudás abszorpciós kapacitásától. Azok a vállalatok, amelyek képesek hatékonyan felhalmozni és alkalmazni a tudást, általában nagyobb pénzügyi nyereséget érnek el innovatív termékeik révén. Ezen abszorpciós képesség nemcsak az innováció eredményességére, hanem annak fenntarthatóságára is pozitív hatással lehet. Azok a vállalatok, amelyek erős tudásalapú rendszerekkel rendelkeznek, versenyelőnyben vannak, ha tudásuk hatása széles körben elismert a piacon (Liu et al., 2014).

A diszruptív technológiák – amelyeket radikális innovációknak is hívnak – olyan újítóképességgel rendelkeznek, amely képes alapvetően átalakítani az iparági struktúrákat, új piacokat nyitva meg a vállalatok számára. Coccia (2017) szerint ezek a technológiák az ideiglenes monopólium és a versenyelőny forrásai lehetnek, akkor, ha a vállalat képes gyorsan reagálni a piaci változásokra és kihasználni az innováció előnyeit. Addo-Quaye és Fielt (2019) felhívják a figyelmet arra, hogy a hagyományos vállalatoknak rugalmas stratégiákat kell alkalmazniuk, hogy a diszruptív technológiai változásokkal szemben versenyképesek maradhassanak. Ez magában foglalhatja új üzleti modellek kialakítását vagy a meglévő működési modellek adaptációját, továbbá újfajta technológiai megoldások kifejlesztését és bevezetését.

A technológiai menedzsment szisztematikus megközelítése kulcsfontosságú a vállalatok hosszú távú pénzügyi sikerének biztosításához. Zahra (1996) hangsúlyozza, hogy a technológiai stratégia alkalmazása akkor a leghatékonyabb, ha a vállalat figyelembe veszi a versenykörnyezet sajátosságait, például a dinamizmust és az ellenségességet. A dinamikus környezetben a radikális innovációk hozzájárulhatnak piaci pozíciók megszilárdításához, míg stabilabb környezetben az inkrementális fejlesztések és követő stratégia lehetnek előnyösek. Hitt és szerzőtársai (2000) szerint a technológiai tanulás

és tudásmenedzsment létfontosságú a vállalatok növekedéséhez és eredményességéhez, kifejezetten a dinamikus képességek fejlesztésén keresztül.

A diszruptív innovációk kezelése és a versenyképesség megőrzése érdekében a vállalatoknak olyan képességekre van szükségük, amelyek lehetővé teszik számukra a technológiai fejlődéshez való alkalmazkodást (Teece, 2018). A cikk szerint a vállalatoknak képesnek kell lenniük a gyors innovációkra és a környezethez való adaptációra, hogy fenntartsák hosszú távú versenyelőnyüket, amelynek egyik célterülete a technológiai fejlődés és a technológiai innováció. Gavetti és Levinthal (2000) kutatásukban a kognitív és tapasztalati keresés szerepét elemzik a vállalatok döntéshozatali folyamataiban. A szerzők szerint a szervezetek akkor érik el a legjobb eredményeket, ha képesek egyensúlyt találni a múltbeli tapasztalatok és a jövőbeli lehetőségek keresése között. Az ilyen keresési módok hatékony kombinációja elősegítheti a stratégiai rugalmasságot, amely kulcsfontosságú a gyorsan változó piaci környezetekben (Gavetti & Levinthal, 2000). A diszruptív technológiák megjelenése mellett természetesen nyílik tér az ezekhez esetlegesen (időben) hozzá nem férő vállalkozások számára is, ugyanakkor ez esetükben is a meglevő technológiák, képességek újragondolását és továbbfejlesztését igényli.

A technológiai előrejelzés és a stratégiai adaptáció kérdése szorosan összefügg, főként a dinamikusan változó piaci környezetben. Smith és Mentzer (2010) kutatása kiemeli, hogy az előrejelzési rendszerek hatékony alkalmazása lehetővé teszi a vállalatok számára a gyorsabb alkalmazkodást. Az előrejelzési feladatok és technológiák közötti illeszkedés növeli a vállalatok piaci alkalmazkodóképességét és segít megelőzni a potenciális kockázatokat.

A stratégiai előrejelzés fontosságát Haarhaus és Liening (2020) is hangsúlyozza, akik szerint a stratégiai előrejelzés fejleszti a vállalatok dinamikus képességeit, és javítja a bizonytalan környezethez való alkalmazkodóképességet. Vecchiato és Roveda (2010) kifejtik, hogy a technológiai előrejelzés lehetővé teszi a vállalatok számára a felkészülést a technológiai és társadalmi változásokra, így ezek a menedzsment eszközök nemcsak a változások irányát képesek előre jelezni, hanem azok hatásait és a megfelelő vállalati válaszintézkedéseket is.

Altuntas és szerzőtársai (2015) a technológiai sikeresség előrejelzésének fontosságát hangsúlyozzák szabadalmi adatok elemzése alapján. A szerzők négy kritériumot emeltek ki a sikeresség előrejelzéséhez, beleértve a technológia életciklusát és diffúziós sebességét. Ezek az előrejelzési modellek hasznos eszközt nyújtanak a befektetők számára, hogy meghatározzák, mely

technológiák bírnak nagyobb potenciállal. A tanulmány megállapításai alapján az előrejelzési módszerek alkalmazása segíthet a technológiai befektetések optimális időzítésében olyan technológiáknál, amelyek nagy jövőbeli növekedési potenciállal rendelkeznek (Altuntas et al., 2015).

Tsai (2004) kutatásában rámutat, hogy a technológiai képességek, a tudás felhalmozása és alkalmazása, kulcsfontosságú a vállalati teljesítmény növekedéséhez. Az erős technológiai képességekkel rendelkező vállalatok gyakran gyorsabb innovációkra képesek, ami elősegíti a piaci versenyelőny megszerzését. Tsai eredményei szerint a technológiai képességek hosszú távon hozzájárulnak a vállalat termelékenységének és versenyképességének növekedéséhez (Tsai, 2004).

Bouwman és szerzőtársai (2019) szerint a digitális technológiák, mint például a közösségi média és a big data, jelentős változásokat hoztak az üzleti modellekben, főként a KKV-k esetében. Azok a KKV-k, amelyek a digitális átalakulás során kísérleteznek üzleti modelljeikkel, jobb teljesítményt érhetnek el, ha képesek gyorsan alkalmazkodni a digitális trendekhez és kihasználni az ebből adódó új lehetőségeket (Bouwman et al., 2019).

Schmitt et al. (2018) a stratégiai megújulást elemzik, amely lehetővé teszi a vállalatok számára, hogy alkalmazkodjanak a gyorsan változó környezeti feltételekhez. A szerzők kiemelik, hogy a stratégiai megújulás elengedhetetlen a hosszú távú versenyképességhez, mivel segít a vállalatoknak alkalmazkodni a technológiai és gazdasági változásokra. Az ilyen stratégiai rugalmasság fontos a dinamikus piacokon, ahol a gyors változások gyakoriak (Schmitt et al., 2018).

Adegbile és szerzőtársai (2017) kiemelik a stratégiai előrejelzés fontosságát az innovációs teljesítmény fokozásában. Az előrejelzési módszerek segítik a vállalatokat a jövőbeli kihívások azonosításában és a hosszú távú versenyképesség elérésében. Az innovációs teljesítmény növeléséhez a vállalatoknak előre kell látniuk a lehetséges változásokat, és ehhez igazítaniuk kell stratégiáikat és innovációs folyamataikat (Adegbile et al., 2017).

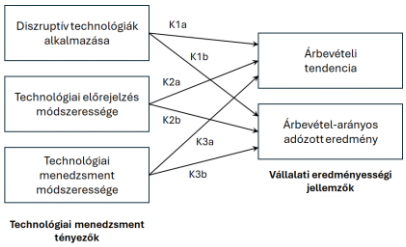
A meglévő irodalom rámutat, hogy a technológiai előrejelzés és a diszruptív technológiák alkalmazásának pénzügyi eredményekre gyakorolt hatása korántsem egyértelmű. Bár számos tanulmány hangsúlyozza a technológiai rendszerek fejlesztésének és alkalmazásának fontosságát, kevés kutatás tér ki arra, hogy ezek a rendszerek miként illeszkednek az előrejelzési feladatokhoz és hogyan javíthatják a vállalati előrejelzési pontosságot és teljesítményt. Ezen felül az információs technológiai beruházások a vállalatok (nem tőzsdei) esetében, inkább a piaci értékre, mint a hagyományos pénzügyi mutatókra gyakorolnak jelentős hatást, ami egy további elemezhető szempont.

A kutatások többsége kevés empirikus bizonyítékkal rendelkezik arra vonatkozóan, hogy az IT és a fejlett technológiai rendszerek (pl. CAD/CAM) hogyan javítják a gyártási rugalmasságot és minőséget, illetve ezek milyen közvetlen hatást gyakorolnak a pénzügyi eredményekre (Theodorou & Florou, 2008). Ezen a téren Belderbos és szerzőtársai (2009) hangsúlyozzák, hogy a technológiai tevékenységek egyensúlyának (exploratív és exploitatív) fenntartása kulcsfontosságú a pénzügyi teljesítmény javításához, főként az olyan iparágakban, ahol az együttműködés kockázatai magasak. Az empirikus eredményeik szerint a vállalatok közepes szintű feltáró tevékenységei vezetnek a legjobb pénzügyi eredményekhez (Belderbos et al., 2009).

A stratégiai előrejelzés és az üzleti modellek innovációja terén is megfigyelhető, hogy a változások versenyelőnyre gyakorolt hatásainak kezelése, valamint a vállalati válaszintézkedések stratégiája nincs kellően kidolgozva. Mindezek alapján elmondható, hogy a technológiai menedzsment hatásainak átfogóbb vizsgálata a vállalati eredményesség szempontjából, szükséges. Ezen összefüggés mélyebb megértése nemcsak az akadémiai közösség számára fontos, hanem gyakorlati szempontból is értékes hozzájárulást jelent a technológia által vezérelt üzleti stratégiák kialakításához.

A kutatás célja, módszere

A kutatás célja annak vizsgálata, hogy a technológiai előrejelzések, illetve a technológiai menedzsment módszeressége összefüggésben áll-e a vállalati eredményességgel. Az 1. ábra mutatja a kutatás modelljét, benne a vizsgált kapcsolatokkal. A kutatás tárgyához illeszkedve, befolyásoló tényezőként három aspektust vontunk be a vizsgálatba; mindenekelőtt a környezetünkben folyó technológiai átalakuláshoz való kapcsolódást, az előrejelzést, mint specifikus módszertani elemet, valamint az átfogó módszerességet. Okozati oldalon a két klasszikus sikerességi csúcsmutató, az árbevétel és az eredmény szerepel.



1. ábra – A kutatás modellje
(Saját szerkesztés)

A kutatás vizsgálati kérdései:

K1. A diszruptív technológiák alkalmazása és a vállalati eredményesség közötti kapcsolat.
K2. A technológiai előrejelzési módszerek alkalmazása és a vállalati eredményesség közötti kapcsolat.
K3. A technológiai menedzsment módszeressége és a vállalati eredményesség közötti kapcsolat.

1. táblázat – A kutatás során felmért jellemzők

Technológiai menedzsment tényezők	Vállalati eredményességi jellemzők
• *Diszruptív technológiák alkalmazása*: A vizsgált vállalatok által alkalmazott újszerű technológiák köre, lásd az 1. melléklet alapján, Dawson (2021), Manning & Fruehan (2021), Deloitte (2021), FTI (2021), PwC (2021) és Goering et al. (2018) (McKinsey) nyomán.	• *Árbevételi tendencia*: A vizsgált vállalatok tíz éves (2012-2021 közötti) árbevételi értékére fektetett lineáris trendvonal meredeksége (normalizált értékkel).
• *Technológiai előrejelzés módszeressége:* A vizsgált vállalkozásnál a technológiai előrejelzési (Technology Forecast, TF) módszerek alkalmazásának értékelése: 4 használ TF módszereket 3 egyszerűsített TF módszere van 2 érti a TF szerepét, egyes elemeket beépít a döntési folyamataiba 1 nem alkalmaz TF módszereket	• *Árbevétel-arányos eredmény:* A vizsgált vállalatok adózás utáni eredménye az árbevételhez viszonyítva, tíz éves (2012-2021 közötti) időszak átlagában.
• *Technológiai menedzsment módszeressége*: A vizsgált vállalkozásnál a technológiai menedzsment módszeressége, négyszintű skálán értékelve: 4 módszeres 3 inkább módszeres 2 inkább nem módszeres 1 nem módszeres	

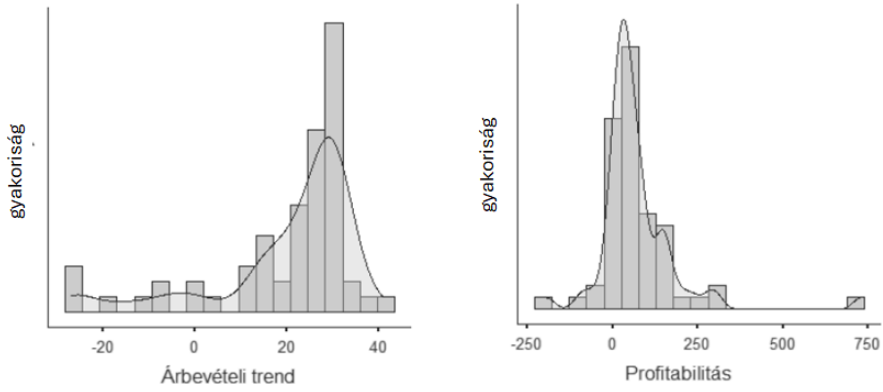
(Saját szerkesztés)

A kutatás célcsoportját olyan magyarországi feldolgozóipari, vagy fejlesztéssel foglalkozó vállalkozások köre adta. A kiválasztás szempontja volt, hogy a vállalkozások fejlett technológiákkal működő, a járműipari, elektronikai vagy gépipari szektorból származó cégek legyenek, gyártó vagy fejlesztő tevékenységgel. A célcsoport lehatárolása épít a szerzők korábbi publikációjának következtetéseire (Pekk et al., 2021).

A kutatás során 61 vállalkozás került személyes interjú útján megkérdezésre, széleskörű témakörben, amelyen belül a jelen témához kapcsolódó interjú kérdéseket az 1. táblázat bal oldala (technológiai menedzsment tényezők) tartalmazza. A vállalati eredményesség jellemzőinek meghatározása a cégek publikus adatbázisban elérhető mérleg-beszámolóinak elemzése útján történt.

A felmérés során gyűjtött adatok adatbázisban kerültek rendezésre, majd a kutatási kérdések mentén vizsgálandó kapcsolatok kiértékeléséhez statisztikai módszereket használtunk. Tekintettel arra, hogy a technológiai menedzsment tényezők intervallumskálán nyugvó adatok, a vállalati eredményességi jellemzők pedig arányskála típusú adatok, az ANOVA módszert használtuk az elemzés során. Ennek segítségével feltárható, hogy a technológiai menedzsment különböző tényezőinek egyes szintjei és a vállalati eredményességi paraméterek között található-e statisztikai értelemben vett kapcsolat.

A statisztikai vizsgálathoz előzetesen megvizsgáltuk az eredményességi paraméterek értékeinek eloszlását, az eredményeket 2. ábra mutatja. Amint az látható, az árbevételi trend értékek megoszlása jobbra eltolódó, míg a profitabilitás viszonylag centrális eloszlású.



2. ábra – Az eredményességi adatok megoszlása
(Saját szerkesztés)

Az értékelés alapja a vállalatok 2012-2021 közötti pénzügyi beszámolóinak adatai voltak. A kissé jobbra húzó árbevételi görbe arra utal, hogy az árbevételi trend inkább növekvő. Bizonyos mértékben ezt befolyásolhatja az infláció is.

Eredmények és diszkusszió

A diszruptív technológiák alkalmazása és a vállalati eredményesség közötti kapcsolat

A vizsgálathoz elvégzett normalitás- és homogenitásvizsgálat eredményeit a 3. ábra foglalja össze. Amint az látható, a normalitásvizsgálat eredménye pozitív, azaz a függő változó mindkét esetben teljesíti a normál eloszlással kapcsolatos elvárást, értéke p<0,001. A szóráshomogenitás feltétele az árbevételi trend esetén teljesül (p=0,694 értéke nem szignifikáns), a profitabilitás esetén meglehetősen alacsony (p=0,06), ám várhatóan ez nem rontja el a következtetést.

Árbevételi trend		Profitabilitás	
Statistic	p	Statistic	p
0.797	< .001	0.791	< .001

Normalitás vizsgálata (Shapiro-Wilk)

F	df1	df2	p
0.485	3	58	0.694

F	df1	df2	p
2.61	3	58	0.060

Homogenitás vizsgálata (Levene's)

3. ábra – Normalitás- és homogenitásvizsgálat (I)

Az ANOVA vizsgálat modelljét a 4. ábra mutatja. Az árbevételi trend esetén az F próba eredménye (p=0,708) nem szignifikáns, azaz a diszruptív technológiák különböző számossági csoportjai között az árbevételi trenddel való kapcsolat tükrében nincs jelentős eltérés. A profitabilitás esetén, bár a p=0,121 érték meglehetősen alacsony, és bár a 0,05 küszöbértéket nem éri el, de a menedzsment döntések kapcsán így is releváns információnak tekinthető.

ANOVA - Árbevételi trend

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	365	3	122	0.465	0.708
Diszruptív technológiák alkalmazása	365	3	122	0.465	0.708

ANOVA - Profitabilitás (10)

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	78758	3	26253	2.02	0.121
Diszruptív technológiák alkalmazása	78758	3	26253	2.02	0.121

4. ábra – A vizsgálat modellje (I)

A post-hoc vizsgálat eredményeit az 5. ábra foglalja össze. Esetünkben elsősorban a Scheffé próbát alkalmaztuk, amely az F mintaeloszláson alapul, és az egyik legbiztosabb próbának számít. A táblázatok az egyes párok átlagait hasonlítják össze. A diszruptív technológiák alkalmazása – árbevételi trend táblázat sorait értelmezve megállapítható, hogy a p értékek mindenhol viszonylag magasak, azaz az egyes párok nem különböznek szignifikánsan egymástól. A diszruptív technológiák alkalmazása – profitabilitás táblázat sorait tekintve, az eredmények kissé vegyesebb képet mutatnak, három esetben 1 közeli, három esetben jelentősen kisebb p értékkel. Ez utóbbiak nem tekinthetők szignifikánsnak, ugyanakkor a menedzsment számára fontosak lehetnek ezek a kiugró értékek. Kontroll számításként mindkét esetben feltüntettük a Tukey módszerrel elvégzett post hoc vizsgálatok eredményeit, amint az adatokból látható, ezek a p értékek sem mutatnak a lényeget tekintve eltérő üzenetet a Scheffé próbáktól.

Árbevételi trend

Diszruptív technológiák alkalmazása		Diszruptív technológiák alkalmazása	Mean Difference	SE	df	t	$P_{scheffe}$
0-5	-	6-10	-4.985	5.89	58.0	-0.847	0.869
	-	11-15	-7.230	6.26	58.0	-1.155	0.722
	-	>15	-5.818	7.07	58.0	-0.824	0.878
6-10	-	11-15	-2.245	5.13	58.0	-0.438	0.979
	-	>15	-0.833	6.09	58.0	-0.137	0.999
11-15	-	>15	1.412	6.44	58.0	0.219	0.997

Post-hoc összehasonlítás (mean difference = közép eltérés)

		0-5	6-10	11-15	>15
0-5	Mean difference	—	-4.98	-7.23	-5.818
	p-value	—	0.832	0.657	0.843
6-10	Mean difference		—	-2.25	-0.833
	p-value		—	0.972	0.999
11-15	Mean difference			—	1.412
	p-value			—	0.996
>15	Mean difference				—
	p-value				—

Tukey post-hoc teszt összehasonlítás (mean difference = közép eltérés)

Profitabilitás

Diszruptív technológiák alkalmazása		Diszruptív technológiák alkalmazása	Mean Difference	SE	df	t	$P_{scheffe}$
0-5	-	6-10	-3.45	41.5	58.0	-0.0833	1.000
	-	11-15	-81.34	44.1	58.0	-1.8444	0.343
	-	>15	1.35	49.8	58.0	0.0270	1.000
6-10	-	11-15	-77.88	36.1	58.0	-2.1558	0.212
	-	>15	4.80	42.9	58.0	0.1119	1.000
11-15	-	>15	82.68	45.4	58.0	1.8205	0.355

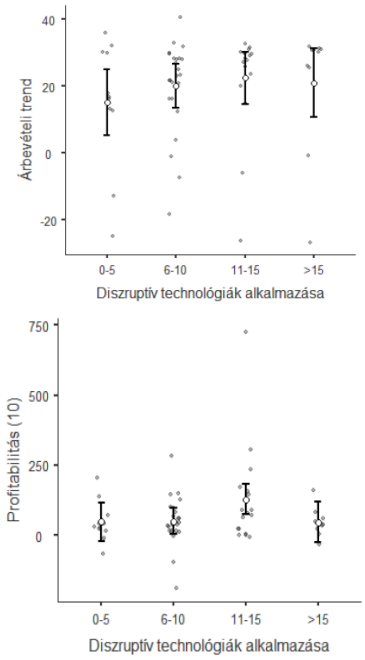
Post-hoc összehasonlítás (mean difference = közép eltérés)

		0-5	6-10	11-15	>15
0-5	Mean difference	—	-3.45	-81.3	1.35
	p-value	—	1.000	0.263	1.000
6-10	Mean difference		—	-77.9	4.80
	p-value		—	0.148	0.999
11-15	Mean difference			—	82.68
	p-value			—	0.274
>15	Mean difference				—
	p-value				—

Tukey post-hoc teszt (mean difference = közép eltérés)

5. ábra – A post-hoc vizsgálat eredményei (I)

A négy csoport vizuális képét a 6. ábra mutatja (alatta a számszerű leíró adatokkal), amelyen a fentiekhez hasonlóan látható, hogy az egyes csoportok mintázata viszonylag hasonló. Felfelé – mind az árbevételi trend, mind a profitabilitás esetén – a 11-15 darab diszruptív technológiát alkalmazó vállalkozások köre adja a szélső értéket, azaz váltja ki a legerősebb kapcsolatot.



Becsült határközép (Estimated Marginal Means), 95% konfidencia intervallumra
Mean=középérték, Lower=alsó, Upper= felső

Árbevételi trend

Diszruptív technológiák alkalmazása	Mean	SE	Lower	Upper
0-5	15.2	4.88	5.42	24.9
6-10	20.2	3.30	13.56	26.8
11-15	22.4	3.92	14.56	30.3
>15	21.0	5.11	10.76	31.2

Profitabilitás

Diszruptív technológiák alkalmazása	Mean	SE	Lower	Upper
0-5	46.5	34.4	-22.24	115.3
6-10	50.0	23.3	3.43	96.6
11-15	127.9	27.6	72.55	183.2
>15	45.2	36.0	-26.94	117.3

6. ábra – ANOVA elemzés eredményei (I)

Az eredmények alapján a diszruptív technológiák alkalmazása és a vállalati eredményesség közötti kapcsolat nem mutatott szignifikáns összefüggést az árbevételi trend tekintetében. Ez arra utalhat, hogy ezek a technológiák közvetlenül nem feltétlenül járulnak hozzá az árbevétel növekedéséhez, hanem inkább hosszabb távon, vagy más tényezőkön keresztül érvényesülhetnek.

A profitabilitás tekintetében vegyes képet kaptunk. Bár a kapott érték nem éri el a statisztikai szignifikancia szintjét, az egyes csoportok közötti kiugró értékek arra engednek következtetni, hogy a diszruptív technológiák mértéke – főként magasabb alkalmazási szinteken – releváns információval szolgálhat a menedzsment számára. Ezek az eredmények megerősítik, hogy a diszruptív technológiák alkalmazásának értékeléséhez nemcsak rövid távú pénzügyi mutatók, hanem hosszabb távú stratégiai célok figyelembevétele is szükséges lehet. Ugyancsak azt sugallja, hogy a vállalatoknak érdemes lehet fókuszálnia ezen technológiák hosszú távú bevezetésére, mivel potenciálisan kedvezően hathatnak a nyereségességre.

A technológiai előrejelzési módszerek alkalmazása és a vállalati eredményesség közötti kapcsolat

A vizsgálathoz elvégzett normalitás- és homogenitásvizsgálat eredményeit a 7. ábra foglalja össze. Amint az látható, a normalitásvizsgálat eredménye pozitív, azaz a függő változó mindkét esetben teljesíti a normál eloszlással kapcsolatos elvárást, értéke $p<0{,}001$. A szóráshomogenitás feltétele a profitabilitás esetén teljesül ($p=0{,}502$ értéke nem szignifikáns), az árbevételi trend esetén ugyanakkor meglehetősen alacsony ($p=0{,}01$), de várhatóan ez nem rontja el a következtetést.

Árbevételi trend		Profitabilitás	
Statistic	p	Statistic	p
0.862	< .001	0.751	< .001

Normalitás vizsgálata (Shapiro-Wilk)

F	df1	df2	p
4.02	3	58	0.011

F	df1	df2	p
0.794	3	58	0.502

Homogenitás vizsgálata (Levene's)

7. ábra – Normalitás- és homogenitásvizsgálat (II)

Az ANOVA vizsgálat modelljét a 8. ábra mutatja. Az árbevételi trend esetén az F próba eredménye (p=0,310) nem szignifikáns, azaz a TF módszerek különböző alkalmazási szintjei között az árbevételi trenddel való kapcsolat tükrében nincs jelentős eltérés. A profitabilitás esetén, szintén ez a következtetés a p=0,628 érték alapján.

ANOVA - Árbevételi trend

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	923	3	308	1.22	0.310
TF módszerek alkalmazása	923	3	308	1.22	0.310

ANOVA - Profitabilitás (10)

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	24359	3	8120	0.583	0.628
TF módszerek alkalmazása	24359	3	8120	0.583	0.628

8. ábra – A vizsgálat modellje (II)

A post-hoc vizsgálat eredményeit a 9-13. ábrák foglalják össze, a Scheffé próba alapján. A „TF módszerek alkalmazása – árbevételi trend" táblázat sorait értelmezve megállapítható, hogy a p értékek, egy párt leszámítva, mindenhol viszonylag magasak, azaz az egyes párok ezen egyetlen kivételtől eltekintve, nem különböznek szignifikánsan egymástól. A TF módszerek alkalmazása – profitabilitás adatok (9. ábra) sorait tekintve, az eredmények ugyanígy értékelhetők, mindegyik p érték magas, azaz ezek a párok sem különböznek szignifikánsan egymástól. A kontroll számításként feltüntetett Tukey módszerrel elvégzett post hoc vizsgálatok eredményei megerősítik a Scheffé próbák következtetéseit.

Árbevételi trend

TF módszerek alkalmazása		TF módszerek alkalmazása	Mean Difference	SE	df	t	$P_{scheffe}$
1	-	2	-0.694	5.77	58.0	-0.120	1.000
	-	3	7.750	6.79	58.0	1.141	0.730
	-	4	-4.722	7.29	58.0	-0.648	0.936
2	-	3	8.444	5.40	58.0	1.565	0.490
	-	4	-4.029	6.01	58.0	-0.670	0.929
3	-	4	-12.472	7.00	58.0	-1.782	0.374

Post-hoc összehasonlítás (mean difference = közép eltérés)

		1	2	3	4
1	Mean difference	—	-0.694	7.75	-4.72
	p-value	—	0.999	0.666	0.916
2	Mean difference		—	8.44	-4.03
	p-value		—	0.406	0.908
3	Mean difference			—	-12.47
	p-value			—	0.292
4	Mean difference				—
	p-value				—

Tukey post-hoc teszt (mean difference = közép eltérés)

Profitabilitás

TF módszerek alkalmazása		TF módszerek alkalmazása	Mean Difference	SE	df	t	$P_{scheffe}$
1	-	2	-36.10	42.9	58.0	-0.8413	0.871
	-	3	-39.87	50.5	58.0	-0.7890	0.891
	-	4	11.02	54.2	58.0	0.2033	0.998
2	-	3	-3.76	40.1	58.0	-0.0938	1.000
	-	4	47.13	44.7	58.0	1.0547	0.774
3	-	4	50.89	52.0	58.0	0.9780	0.812

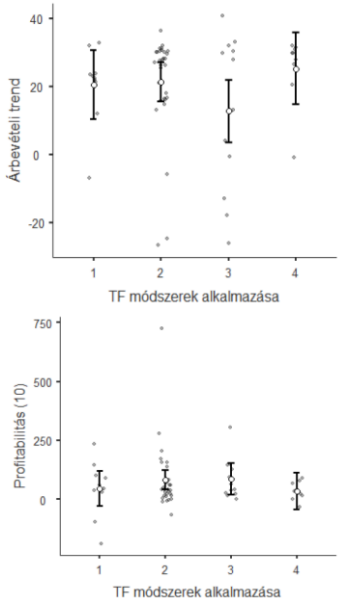
Post-hoc összehasonlítás (mean difference = közép eltérés)

		1	2	3	4
1	Mean difference	—	-36.1	-39.87	11.0
	p-value	—	0.835	0.859	0.997
2	Mean difference		—	-3.76	47.1
	p-value		—	1.000	0.718
3	Mean difference			—	50.9
	p-value			—	0.762
4	Mean difference				—
	p-value				—

Tukey post-hoc teszt (mean difference = közép eltérés)

9. ábra – A post-hoc vizsgálat eredményei (II)

A négy csoport vizuális képét a 10. ábra mutatja (alatta a számszerű leíró adatokkal), amely a fentiekhez hasonlóan kimutatja, hogy az egyes csoportok mintázata viszonylag hasonló. Az árbevételi trendhez kapcsolódó vizsgálatnál a 3 TF módszerek alkalmazási szint kissé jelentősebben lefelé tér el.



Becsült határközép (Estimated Marginal Means), 95% konfidencia intervallumra
Mean=középérték, Lower=alsó, Upper= felső

Árbevételi trend

TF módszerek alkalmazása	Mean	SE	Lower	Upper
1	20.5	5.02	10.45	30.5
2	21.2	2.85	15.49	26.9
3	12.8	4.58	3.58	21.9
4	25.2	5.29	14.63	35.8

Profitabilitás

TF módszerek alkalmazása	Mean	SE	Lower	Upper
1	45.8	37.3	-28.9	120
2	81.9	21.2	39.5	124
3	85.7	34.1	17.5	154
4	34.8	39.3	-44.0	114

10. ábra – ANOVA elemzés eredményei (II)

A technológiai előrejelzési módszerek alkalmazása az árbevételi trend és a profitabilitás szempontjából nem eredményezett statisztikailag szignifikáns eltéréseket. Ez arra utalhat, hogy az előrejelzési módszerek közvetlen hatása nem domináns, kiemelten akkor, ha azok alkalmazási szintje korlátozott. Ugyanakkor a vizsgálat során megfigyelt tendenciák alapján kijelenthető, hogy a fejlettebb előrejelzési technikák hozzájárulhatnak a vállalat stabilitásához, főként egy dinamikus piaci környezetben. Az ilyen módszerek lehetővé tehetik a kockázatok korai felismerését, és támogathatják a stratégiai döntéseket, még ha ezek a hatások statisztikai értelemben nem is mindig kimutathatók.

A technológiai menedzsment módszeressége és a vállalati eredményesség közötti kapcsolat

A vizsgálathoz elvégzett normalitás- és homogenitásvizsgálat eredményeit a 11. ábra foglalja össze. Amint az látható, a normalitásvizsgálat eredménye pozitív, azaz a függő változó mindkét esetben teljesíti a normál eloszlással kapcsolatos elvárást, értéke p<0,001. A szóráshomogenitás feltétele az árbevételi trend esetén teljesül (p=0,908 értéke nem szignifikáns), a profitabilitás esetén viszont ez a feltétel nem teljesül (p<0,001), ezért erre a következtetések során tekintettel kell lenni.

Árbevételi trend		Profitabilitás	
Statistic	p	Statistic	p
0.772	< .001	0.852	< .001

Normalitás vizsgálata (Shapiro-Wilk)

F	df1	df2	p	F	df1	df2	p
0.182	3	58	0.908	14.8	3	58	< .001

Homogenitás vizsgálata (Levene's)

11. ábra – Normalitás- és homogenitásvizsgálat (III)

Az ANOVA vizsgálat modelljét a 12. ábra mutatja. Az árbevételi trend esetén az F próba eredménye (p=0,0,574) nem szignifikáns, azaz TM módszerek alkalmazásának különböző szintjei között az árbevételi trenddel való kapcsolat tükrében nincs jelentős eltérés. A profitabilitás esetén, a p=0,019 érték tel-

jesíti a 0,05 küszöbértéket, ezért itt a TM módszerek alkalmazásának különböző szintjei más és más módon mutatnak kapcsolatot a vállalkozás árbevétel-arányos profitabilitásával.

ANOVA - Árbevételi trend

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	520	3	173	0.670	0.574
TM módszeressége	520	3	173	0.670	0.574

ANOVA - Profitabilitás (10)

	Négyzetösszeg	df	Négyzetközép	F	p
Átfogó modell	130469	3	43490	3.60	0.019
TM módszeressége	130469	3	43490	3.60	0.019

12. ábra – A vizsgálat modellje (III)

A TM módszeressége - árbevételi trend táblázat sorait értelmezve megállapítható, hogy a p értékek mindenhol viszonylag magasak, azaz az egyes párok ezen egyetlen kivételtől eltekintve, nem különböznek szignifikánsan egymástól. A 13. ábra (A TM módszeressége alkalmazása – profitabilitás) adatait tekintve viszont van három olyan pár, amelynél a statisztikai eredmény jelentősebben alacsony, valamint másik két esetben is 0,5 körüli. Itt tehát van esély, hogy ezek a párok szignifikánsan különböznek egymástól. A kontroll számításként feltüntetett Tukey módszerrel elvégzett post hoc vizsgálatok eredményei itt is megerősítik a Scheffé próbák következtetéseit.

Árbevételi trend

TM módszeressége		TM módszeressége	Mean Difference	SE	df	t	$P_{scheffe}$
1	-	2	-9.155	7.97	58.0	-1.149	0.725
	-	3	-9.779	8.09	58.0	-1.209	0.692
	-	4	-11.575	8.24	58.0	-1.404	0.582
2	-	3	-0.624	5.04	58.0	-0.124	0.999
	-	4	-2.420	5.29	58.0	-0.458	0.976
3	-	4	-1.796	5.46	58.0	-0.329	0.991

Post-hoc összehasonlítás (mean difference = közép eltérés)

		1	2	3	4
1	Mean difference	—	-9.15	-9.779	-11.57
	p-value	—	0.661	0.623	0.502
2	Mean difference		—	-0.624	-2.42
	p-value		—	0.999	0.968
3	Mean difference			—	-1.80
	p-value			—	0.988
4	Mean difference				—
	p-value				—

Tukey post-hoc teszt (mean difference = közép eltérés)

Profitablitás

TM módszeressége		TM módszeressége	Mean Difference	SE	df	t	$P_{scheffe}$
1	-	2	107.34	54.5	58.0	1.9699	0.285
	-	3	160.15	55.3	58.0	2.8970	0.048
	-	4	163.01	56.3	58.0	2.8929	0.048
2	-	3	52.81	34.4	58.0	1.5332	0.508
	-	4	55.68	36.1	58.0	1.5407	0.504
3	-	4	2.87	37.3	58.0	0.0768	1.000

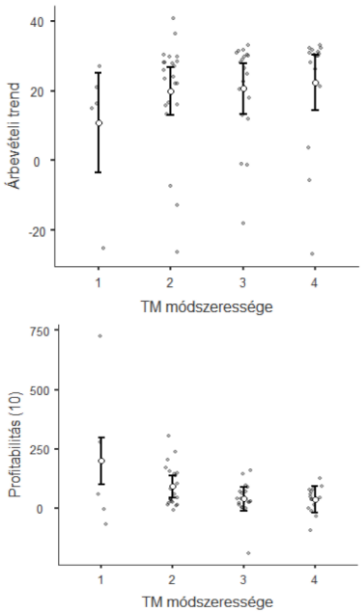
Post-hoc összehasonlítás (mean difference = közép eltérés)

		1	2	3	4
1	Mean difference	—	107	160.1	163.01
	p-value	—	0.211	0.027	0.027
2	Mean difference		—	52.8	55.68
	p-value		—	0.425	0.420
3	Mean difference			—	2.87
	p-value			—	1.000
4	Mean difference				—
	p-value				—

Tukey post-hoc teszt (mean difference = közép eltérés)

13. ábra – A post-hoc vizsgálat eredményei (III)

A négy csoport vizuális képét a 14. ábra mutatja (alatta a számszerű leíró adatokkal), amely a fentiekhez hasonlóan kimutatja az egyes csoportok mintázatát. Az árbevételi trendhez kapcsolódó vizsgálatnál a TM módszeressége és az árbevételi trend között a kvartilisek nyomán pozitív kapcsolat látszik, ugyanakkor a jelentősen szóródó adatpontok ezt elrontják, ahogy a fenti összegzésben szerepelt, így érdemben nem beszélhetünk szignifikáns kapcsolatról. A TM módszerek alkalmazása és a profitabilitás között azonban jól látható kapcsolat mutatkozik.



Becsült határközép (Estimated Marginal Means), 95% konfidencia intervallumra
Mean=középérték, Lower=alsó, Upper= felső

Árbevételi trend

TM módszeressége	Mean	SE	Lower	Upper
1	10.8	7.19	-3.60	25.2
2	20.0	3.43	13.09	26.8
3	20.6	3.69	13.19	28.0
4	22.4	4.02	14.32	30.4

Profitabilitás

TM módszeressége	Mean	SE	Lower	Upper
1	199.2	49.2	100.7	297.7
2	91.9	23.4	44.9	138.8
3	39.1	25.2	-11.5	89.6
4	36.2	27.5	-18.9	91.2

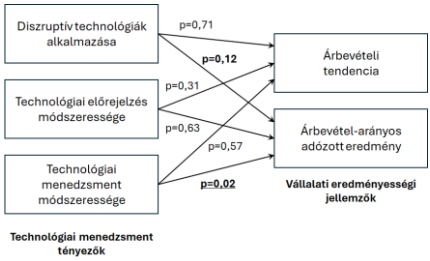
14. ábra – ANOVA elemzés eredményei (III)

A technológiai menedzsment módszeressége és az árbevételi trend között nem mutatkozott szignifikáns kapcsolat. Ez arra utalhat, hogy az árbevétel növekedése szempontjából más tényezők is szerepet játszhatnak, amelyek nem közvetlenül kapcsolódnak a módszeresség szintjéhez. Ugyanakkor magasabb módszerességi szinteken az árbevétel szórása csökken, ami a vállalat működésének stabilitására utalhat. A profitabilitás esetében a módszeresség szignifikáns hatása kimutatható. Ez azt jelenti, hogy a módszeres megközelítés nemcsak növelheti a nyereségesség kiszámíthatóságát, hanem hozzájárulhat annak hosszú távú fenntarthatóságához is. Az eredmények alapján a módszeresség fejlesztése fontos lehet olyan vállalkozások számára, amelyek a technológiai innovációra és fejlesztésre alapozzák működésüket.

Az eredmények összeségében azt mutatják, hogy a technológiai menedzsment tényezői eltérő módon hatnak a vállalati eredményesség különböző mutatóira. A diszruptív technológiák alkalmazása nem mutatott közvetlen kapcsolatot az árbevétellel, de kiemelt jelentőségű lehet a profitabilitás hosszú távú növelésében. A technológiai előrejelzési módszerek közvetlen hatása nem bizonyított, de a stabilitás és stratégiai döntések támogatásában szerepük fontos lehet. A módszeresség pedig egyértelműen hozzájárulhat a profitabilitás stabilabbá tételéhez és a vállalati fenntarthatósághoz.

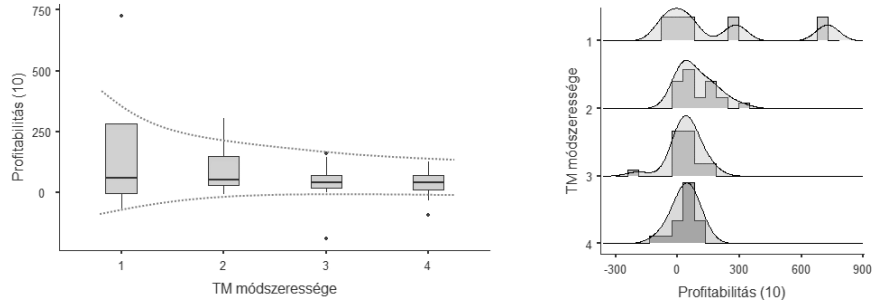
Következtetések

A 15. ábra foglalja össze a kutatás eredményeit. Az ANOVA elemzés alapján az ábrán feltüntetésre került az egyes kapcsolatokhoz tartozó p érték, amely utal az adott kapcsolat erősségére. Amint az látható, a vizsgált vállalatok körében a technológiai menedzsment módszeressége és az árbevétel-arányos adózott eredmény (profitabilitás) között sikerült kimutatni statisztikai szempontból is szignifikáns kapcsolatot. Emellett, a diszruptív technológiák alkalmazása és a profitabilitás közötti kapcsolat is viszonylag alacsony, esetleg említhető még a technológiai előrejelzés módszeressége és az árbevételi tendencia összefüggése.

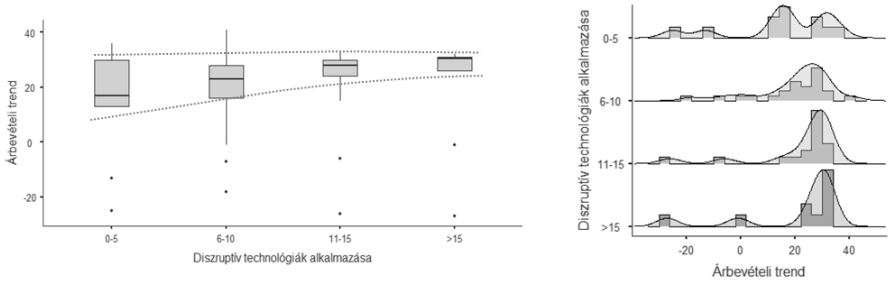


15. ábra – Az eredmények összefoglalása

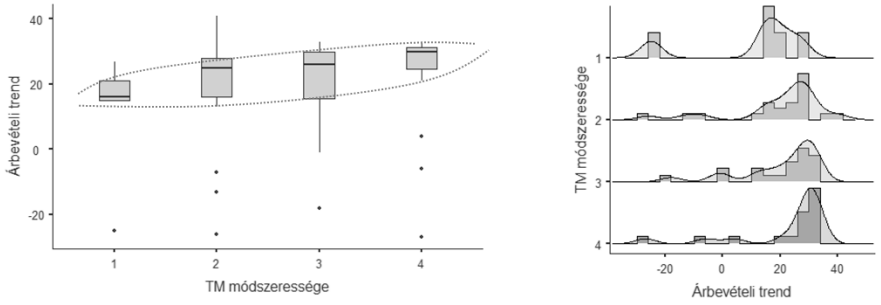
A 16-17-18. ábrákon megjelenítésre kerültek az egyes kategóriákban az adatok szóródásához kapcsolódó statisztikai jellemzők, valamint a jobb oldalon a függő változó hisztogramja az egyes paraméter szinteken. Ennek alapján további következtetések tehetők a megvizsgált minta eredményei tükrében. A három ábra alapján megtehetők a kutatás végkövetkeztetései.



16. ábra – A technológiai menedzsment módszeressége és a profitabilitás közötti kapcsolat



17. ábra – A diszruptív technológiák alkalmazása és az árbevételi trend közötti kapcsolat



18. ábra – A technológiai menedzsment módszeressége és az árbevételi trend közötti kapcsolat

A kutatás egyik fő végkövetkeztetése, hogy az elvégzett felmérés és a megvizsgált publikus gazdálkodási adatok alapján megállapítható, hogy a vállalkozások technológiai menedzsmentjének módszeressége és az árbevétel-arányos eredmény között meghatározott kapcsolat mutatkozik. A profitabilitás mértéke – nem várt módon – a technológiai menedzsment módszerességével csökken, viszont szóródása is csökken. Azaz, a fejlettebb technológiai menedzsmenttel rendelkező cégeknél a profitabilitás mértéke hosszú távon kiszámíthatóbb.

A diszruptív technológiák alkalmazása és az árbevételi trend között statisztikai kapcsolat nem volt kimutatható, viszont jellegét tekintve, a diszruptív technológiák alkalmazásának számával a vállalkozások árbevétele is nő, ráadásul az árbevétel szóródása csökken. Vagyis, az előremutató technológiák alkalmazása kiszámíthatóbb és magasabb árbevételhez vezethet. A nyereségesség csökkenését eredményezheti a beruházásigényesség és az erősebb verseny, de ennek igazolása további vizsgálatokat igényel.

A technológiai menedzsment módszeressége és az árbevételi trend közötti kapcsolat statisztikai szempontból szintén nem túl szoros, viszont az adatok jellegét tekintve, „hordós" minta rajzolódik ki. Azaz, kisebb technológiai módszerességhez tartozik a kisebb árbevétel, a magasabb szintekhez pedig magasabb árbevétel. Ugyanakkor, a közepes technológiai menedzsment módszerességet felmutató cégeknél az árbevétel szóródása nagyobb mértékű. Ez arra enged következtetni, hogy a magasabb technológiai menedzsment képességekkel rendelkező vállalkozások esetén az árbevétel úgy magasabb, hogy egyúttal annak szóródása szűkebb. Ennek menedzsment oldali jelentősége, hogy a technológiai menedzsment módszerességének fejlődése minden bizonnyal kedvező a vállalkozás egyéb eredményei, illetve a működési stabilitás tekintetében is.

A cikkben bemutatásra került egy 61 vállalkozást érintő empirikus vizsgálat alapján a technológiai menedzsment különböző aspektusai (diszruptív technológiák alkalmazása, előrejelzési módszerek alkalmazása, technológiai menedzsment módszeressége), illetve a vállalkozások eredményessége (árbevételi trend, hosszútávú profitabilitás) közötti kapcsolat elemzése. Az elemzésnek lehetnek a mintaszámból eredő korlátai, ezért a vizsgálat kiterjesztése nagyobb mintára további következtetések levonását teszi lehetővé, jövőbeni kutatások során. Összegzésként, a kutatás megerősíti, hogy a különböző menedzsment területek (ez a technológiai menedzsmentre is igaz) nem önmagukban, hanem más területekkel integrált módon tudnak igazán eredményesekké válni.

Köszönetnyilvánítás

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Melléklet

Diszruptív technológiák a kutatásban

Applied	LIST OF ELEMENTARY EMERGING TECHNOLOGIES
	Technologies with Production
	3D Printing
	4D Printing
	Bio Manufacturing
	Self Assembling Components
	Mass customization
	Scanning lidar
	Sensor fusion
	Smart sensors
	Power storage
	Technologies with Robotics
	Robotic Process Automation
	Advanced Robotics
	Robot knowledge sharing
	Robot interactive interface
	Personal robots
	Smart robots
	Technologies with Internet of Things
	Online tools
	Wireless solutions
	Video conferencing
	Virtual education
	Digital Twins
	Connected machines
	Technologies with Cloud Computing
	Cloud storage
	Cloud applications as a Service
	Technologies with Autonomous Agents
	Auotnomous vehicles
	Autonomous trucks
	Autonomous mobile robots
	Warehouse robots
	Light cargo delivery robots
	Light cargo delivery drones
	Commercial drones
	Drone management platforms
	Drone countermeasures
	Drone traffic control systems
	Technologies with Spatial Computing
	Augmented Reality
	Virtual Reality
	Mixed Reality

Applied	
	Technologies with Big Data
	Big data / data analytics
	Hadoop Ecosystem, Spark, R
	Data Lakes, NoSQL Databases
	Big Data Governance Solutions
	Technologies with Artificial Intelligence Applications
	Identification (Facial Recognition, fingerprints, voice, gait)
	Process analysis/optimisation
	Monitoring, Surveillance, Computer vision
	Deep Fakes
	Natural Language Generation
	Digital/Intelligence Systems
	Conversational Interfaces
	AI-driven innovation
	AI-augmented design
	Technologies with Artificial Intelligence Tools
	Machine Learning
	Cognitive Computing
	Generative Adversarial Networks
	Natural Language Processing
	Technologies with Micro-nano solutions
	Micro fuel cells
	Nanotech
	Solid-state MEMS
	Designed materials
	Optical computers
	Micro machines
	Technologies with Symbiotic Applications
	CoBot Robots
	Wearables
	Brain-Computer Interfaces (intelligent interfaces)
	Smart Prosthetics
	Human Machine Convergence
	Technologies with Encryption/Privacy
	Digital Ledgers
	Blockchain
	Distributed Ledgers
	Homomorphic encryption
	Wearable two-factor authentication

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Presenteeism and home-based Telework across the Visegrad countries during the COVID-19 Pandemic: A Multivariate Analysis Approach

Markus Dulhofer[1]

Abstract:

Objective: The purpose of this study is to analyse the factors that contribute to presenteeism in the Visegrad countries during the COVID-19 pandemic. The study specifically focuses on the influence of different levels of telework utilization (no telework, occasional telework, and frequent telework) on the probability of presenteeism.

Methods: The analysis included data from the European Working Condition Telephone Survey (EWCTS) carried out in 2021, which involved 1806 individuals from the Visegrad nations. Logistic regression models were used for calculation.

Main results: The study discovered that regular telework increases the chances of presenteeism, where those who frequently or consistently telework are more likely to work while being ill. Emotional exhaustion, managerial support, and collegial support was found to be a significant indicator of presenteeism. Furthermore, the combination of working at high speed and facing tight deadlines was found to be linked to increased presenteeism, particularly for individuals who often or always telework.

Conclusion: The results emphasize the intricate connection between telework and presenteeism in the Visegrad nations during the pandemic. This study highlights the significance of dealing with these aspects, especially in the context of the growing adoption of telework, in order to uphold employee well-being and productivity.

Keywords: *Presenteeism, COVID-19, work, telework, Visegrad countries*

JEL Codes: *I12, I14, I31, J24, M12*

[1] DULHOFER, Markus
Doctorate Center "Doctorate Paneuropean Studies. Joint PhD Programmes.", Eisenstadt, Austria | E-mail: mdulhofer@outlook.com

Introduction

Teleworking is gaining significance in the delivery of work services. It has especially increased in importance during the COVID-19 pandemic compared to its pre-pandemic significance (Steidelmüller et al., 2020, p. 998). Telework or telecommuting is seen as a working arrangement in which employees of an organization do (at least) part of their regular working hours remotely – primarily at home (Allen et al., 2015).

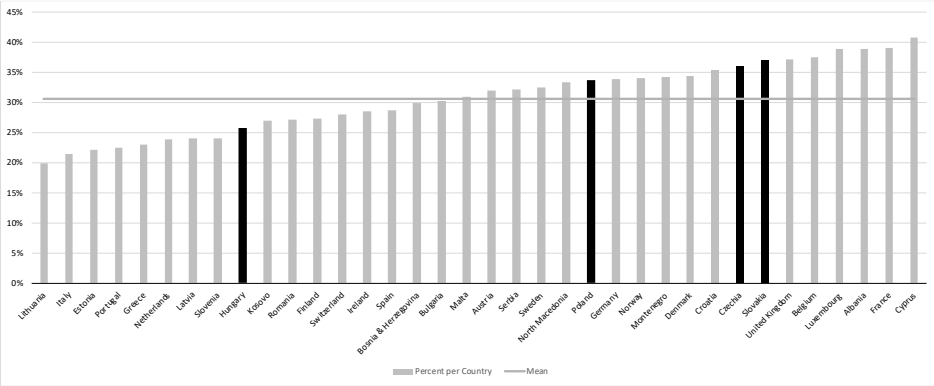
Prior to the pandemic, it was discovered that the prevalence of telecommuting in Visegrad countries was quite low (between 1.2% and 4.6% who usually telework). The prevalence of this phenomenon has escalated in the majority of regions due to the COVID-19 pandemic (Eurostat, 2024).

During the height of the COVID-19 epidemic, forecasts suggested that even after the pandemic recedes, it is expected that around 25% – 30% of people will persist in working remotely for multiple days each week (Global Workplace Analytics, 2021 as cited in Ruhle & Schmoll, 2021). In contrast, the data for the Visegrad Group countries reveals that the proportion of telecommuting in these nations is lower than the previously anticipated level. Despite a significant increase in the use of telework, the number of individuals practicing has declined since reaching its peak in 2021. Nevertheless, it continues to exist at a level that surpasses what was previously observed prior to the pandemic.

The investigation of the relationship between presenteeism, the situation in which an employee goes to work despite illness, and telework, is still an under-researched area (Ruhle & Schmoll, 2021; Schmitz et al., 2023; Steidelmüller et al., 2020). This is particularly relevant for the Visegrad countries, as there is currently no study that examines this relationship. In general there are only a few studies that deal with the overall occurrence of presenteeism (Juszczyk et al., 2018; Kotomska et al., 2023; Landovská & Karbanová, 2023; Mikos et al., 2020; Olejniczak et al., 2023).

An analysis of presenteeism rates in the Visegrad Group nations, compared to other countries participating in the European Working Condition Survey in 2021, revealed that Hungary had the lowest presenteeism rates among the Visegrad Group countries. The Czech Republic and Slovakia exhibit comparably elevated figures, above the average for all countries.

Graph 1: Rates of presenteeism per country 2021



Source: (Eurofund, 2024)

There are currently a number of studies that have analysed presenteeism, often in on-site settings. However, the relationship between telework and presenteeism has not yet been analysed. This is particularly true for the countries of the Visegrad Group. The importance of this issue is demonstrated by the fact that presenteeism has an impact on the health and well-being of employees, their productivity and ability to work, and on the organisations themselves (Demerouti et al., 2009; Hansen & Andersen, 2009; Lu, Lin, et al., 2013; Niven & Ciborowska, 2015). The aim of this study is to identify the particular attributes that raise the probability of presenteeism in the Visegrad countries. As mentioned above, there are only a few studies on presenteeism for the Visegrad Group. There are no studies at all on the relationship between presenteeism and telework. This study therefore attempts to close this research gap and in addition in analysing the variations in these parameters among different groups with different telework arrangements. This was especially significant considering the widespread presence of the COVID-19 epidemic during that period.

Literature Review

Presenteeism

Presenteeism as a subject of research became more relevant at the beginning of the 1980s. The scope of the studies varied in terms of the definition of the

phenomenon of presenteeism. What they had in common, however, was that they focused on people physically attending work despite being ill (Lohaus & Habermann, 2018). Presenteeism is seen as the opposite of absenteeism: That is, the phenomenon of not showing up at work due to illness, but going on sick leave (Gerich, 2016). In contrast to the US research tradition, which tends to focus on the influence of illness on work productivity, European presenteeism research is primarily interested in investigating the motives for this behaviour. European studies primarily examine personal, work-related and organisational factors that may have an influence on the likelihood of presenteeism occurring (Lohaus & Habermann, 2018).

The relevance of this topic – considering the prevailing COVID-19 pandemic at the time – shows that presenteeism can have a major impact on employees. This is demonstrated by various studies that have shown that the phenomenon of presenteeism can have a lasting impact on the future health of employees (Bergström et al., 2009; Gustafsson & Marklund, 2011; Skagen & Collins, 2016). An employee's presenteeism also affects their colleagues by possibly compensating for reduced performance or through possible infection. Presenteeism also harbours risks for society as a whole through possible increased payments of sickness benefits as a result of a deteriorating state of health in the future (Lohaus & Habermann, 2018).

Influencing factors on presenteeism

Various studies dealing with the topic of presenteeism have analysed different influencing factors. Against the background of teleworking during the pandemic in particular, the factors that could potentially have an influence on the likelihood of presenteeism occurring are discussed below.

Job demands, especially long working hours and other potentially stress-inducing working conditions such as time pressure, can also cause employees to work sick (Hansen & Andersen, 2008; Lu & Cooper, 2022; McGregor et al., 2016; Merrill et al., 2012). Employees who are confronted with challenging circumstances with high job demands (e.g. deadlines, working at high speed) feel obliged to be present even in the event of illness. Studies have shown that autonomy has a cushioning effect in everyday working life for employees who have a high level of job control. People who are able to better meet existing job demands through existing autonomy in the workplace can utilise this flexibility as a resource (Johansson et al., 2015). If employees are not equipped with job control, this can lead to them using presenteeism as a

possible coping strategy to react to high workloads and keep their productivity levels high (Caverley et al., 2007).

High workload and working conditions also influence the perception of emotional exhaustion. The relationship between emotional exhaustion and presenteeism was also analysed in a meta-analysis (Miraglia & Johns, 2016) as well as in a cross-cultural context for China and the UK (Lu et al., 2013). One study showed that emotional exhaustion and presenteeism are related and furthermore, the authors were able to show that work engagement mediates this relationship and reduces the negative effects from productivity loss due to presenteeism (Ferreira et al., 2019). However, the studies on the relationship between presenteeism and work engagement are ambiguous. People who have a high level of work engagement are characterised by high energy levels, resilience and high attachment, among other things (Mazzetti et al., 2023). Some studies have shown that presenteeism is positively related to work engagement (Kinman & Wray, 2018; Miraglia & Johns, 2016). In this context, people with high work engagement levels show more presenteeism due to their high attachment and energy levels and are also at work during illness. Other studies found, that employees with higher levels of work engagement show less presenteeism compared to employees with medium or lower levels of work engagement (Burton et al., 2017).

Job insecurity is seen as a predictor that has been analyzed in some studies. These studies were able to show that the insecurities experienced in their own job can influence the presenteeism behaviour of employees (Kim et al., 2020; Miraglia & Johns, 2016; Schmidt & Pförtner, 2020). A study by Reuter et al. calculated an influence of job insecurity from the perspective of regional unemployment on the basis of 232 regions in Europe (NUTS-2). Presenteeism was particularly the case for people with low salaries and low skill-level positions (Reuter et al., 2021). The insecurity experienced by employees is compensated for by increased presenteeism behaviour. This leads people to go to work even when they are ill.

Support and workplace social capital as a job resource play a major role in this context, as various studies have shown that support in the workplace can reduce the risk of presenteeism (Janssens et al., 2015; Schmitz et al., 2023). Thus, the manager also plays an important role in the presenteeism behaviour of employees. If the relationship between employees and managers is perceived as strained, this can potentially increase presenteeism (Ruhle & Schmoll, 2021). The manager plays a moderating role here and influences the relationship between employees and presenteeism. If people

report low levels of support from the manager, and employees are unable to utilise workplace social capital as a ressource, this leads to increased presenteeism compared to employees who report higher levels of support (Caers et al., 2021; Mazzetti et al., 2019; Mori et al., 2022). However, it is not only managers who can exert an influence here, but also cooperation with colleagues (Goto et al., 2020; Miraglia & Johns, 2016). Experienced support from colleagues is seen as reducing the feeling of pressure and therefore reduce the occurrence of presenteeism (Baeriswyl et al., 2017; Gosselin et al., 2013; Leineweber et al., 2011).

In addition to the variables just mentioned, socio-demographic factors were researched in prior studies. However, the results are ambiguous. The influence of gender on the probability of presenteeism was analysed in the study by Luksyte et al. show that men are more inclined to work sick in order to safeguard their performance. Women, on the other hand, protect their health more than men and show a higher health protective motive, which leads to less presenteeism (Luksyte et al., 2023). Other studies have found a higher tendency for presenteeism in women (Aronsson et al, 2000; Aronsson & Gustafsson, 2005; Cho et al, 2016; Gustafsson Sendén et al, 2016; Leineweber et al, 2011). Some studies have found no effect of gender on the occurrence of presenteeism (Gosselin et al., 2013; Gustafsson & Marklund, 2011).

The influence of age on the occurrence of presenteeism has also come to different conclusions in various studies. Leineweber et al. (2011) found an increased probability of presenteeism in the 35-54 age group. A similar result was found in Cho et al. (2016) were discovered for those aged 30 and over. This contrasts with the result of Allemann et al. (2019) who were able to show that the probability of presenteeism decreases with increasing age. A similar conclusion was reached by Aronsson & Gustafsson (2005) came to the conclusion that presenteeism occurs more frequently in the 16-35 age group.

Finally, the influence of the education level on the occurrence of presenteeism is discussed. Some studies have shown that presenteeism tends to be associated with people who have fewer years of education (Cho et al., 2016; Gustafsson & Marklund, 2011; Preisendörfer, 2010). Other studies were unable to prove the influence of education on presenteeism: The comparative study by Johansen (2012) was able to calculate an influence of education in Norway, but not for Sweden. Likewise Caers et al. (2021) found no influence of education on presenteeism in their study of employees in Belgium.

Telework and presenteeism

In general the relationship between telework and the health of employees varies according to different job characteristics and different contextual and technological variables. Teleworking can have a positive effect on the health of employees (e.g. lower blood pressure and lower general health risks). However, it has been shown that longer working hours or working at atypical working hours can lead to increased stress levels. The reduced social networking caused by teleworking can also have a negative impact on employees' well-being. It should also be noted that the blurring of boundaries between work and private life, which tends to be more difficult to maintain in the case of teleworking, can also lead to an increased perception of stress (Beckel & Fisher, 2022). Other studies have found, that home-based telework leads to a change in the employee behaviour (e.g. working in leisure time or working despite illness). The design and organisation of telework also influences the well-being of employees (Goñi-Legaz et al., 2024; Miglioretti et al., 2023).

With focus on the relationship between presenteeism and telework there is a small number of studies. Studies were able to prove that there is a positive correlation between home-based telework and (virtual) presenteeism for all participating countries by analysing the EWCS data from 2015. The incidence of presenteeism increases with the intensity of telework (Eurofund, 2020; Steidelmüller et al., 2020). A further study for german employees was able to prove that presenteeism is a widespread phenomenon among those who utilize telework options. People find it easier to work despite sick leave if they work from home. The authors conclude that employees are more inclined to presenteeism when they work remotely than when they have to work on-site. It also shows that a lack of support from supervisors is associated with more presenteeism (Schmitz et al., 2023). The importance of social interactions during telework was also identified in another study. Especially during peak phases of the pandemic and social isolation, this can increase presenteeism (Otsuka et al., 2024). Similarly, a greater workload in times of remote working is fuelling an increase in presenteeism (Fiorini, 2024).

Derivation of the hypotheses

Presenteeism, the behaviour of employees to go to work despite illness, is influenced by a variety of job demands (e.g. time pressure, workloads), as well as job resources (e.g. job control, social support). These results relate

primarily to on-site settings. There are only a few studies that deal with the relationship between telework and presenteeism. Especially, there is a lack of studies investigating this issue for the Visegrad countries.

The aim of this article is to analyse the user groups of telework arrangements in order to calculate which influencing factors increase the probability of presenteeism for the group of the Visegrad countries. The data set of the European Working Condition Telephone Survey (EWCTS) from 2021 was used for this purpose. The following hypotheses were formulated for the statistical calculation on the basis of the analyses presented above:

H1: There is a statistically significant relationship between the degree of telework utilization and presenteeism.
H2: There is a statistically significant relationship between support from the manager and the likelihood of presenteeism occurring.
H3: There is a statistically significant relationship between support from colleagues and the likelihood of presenteeism occurring.
H4: There is a statistically significant relationship between the weekly working hours and the probability of presenteeism occurring.
H5: There is a statistically significant relationship between the necessary speed of work (tempo) and the probability of presenteeism occurring.
H6: There is a statistically significant relationship between the existence of tight deadlines and the probability of presenteeism occurring.
H7: There is a statistically significant relationship between the extent of job control and the probability of presenteeism occurring.
H8: There is a statistically significant relationship between emotional exhaustion and the likelihood of presenteeism occurring.
H9: There is a statistically significant relationship between work engagement and the probability of presenteeism occurring.
H10: There is a statistically significant relationship between the job insecurity experienced and the probability of presenteeism occurring.

In addition, three control variables are also utilized to compute an additional model: gender, age and education level

Method

Datasets and Participants

Instruments

The analysis was conducted using data from the European Working Condition Telephone Survey (EWCTS) performed from March to November 2021. The dataset consists of a total of 8476 people, including 1990 from the Czech Republic, 1792 from Hungary, 2900 from Poland, and 1794 from Slovakia. After data screening the working sample included 1806 participants.

Dependent variable

With regard to presenteeism, participants were asked the following questions: "Over the past 12 months did you work when you were sick?" or, if the employment relationship had lasted less than 12 months, "Since you started your job, have you worked when you were sick?" ("Yes", "No", "I was not sick", "Don't know" and "Refused"). The variable "Presenteeism" was dichotomized (1=yes, 0=no presenteeism); the following items were excluded from the analysis: "I was not sick", "Don't know" and "Refused".

Independent variables

The EWCTS contains a series of questions that are used to answer the previously established hypotheses.

The degree of home-based telework was computed by recoding the variable "loc_home". The following categories were formed: 1="no/rarely telework", 2="occasional telework", and 3="often/always telework". The category "don't know" was excluded from the analysis.

Support from one's own manager was categorized by the statement "Your manager helps and support you" (from "never" to "always"); whereby "don't know", "refused" and "not applicable" were not taken into account for the calculation. The categories were then recoded and summarized as follows: 1="never or rarely", 2="sometimes", 3="often or always".

The variable "Support from colleagues" was treated in a similar way: The statement "Your colleagues help and support you" (from "never" to "always"); "don't know", "refused" and "not applicable" were not taken into

account for the calculation, was used to determine the degree of support from colleagues. The answer options were subsequently recoded and summarized: 1="never or rarely", 2="sometimes", 3="often or always".

The number of hours usually worked per week was asked by means of the following question: "How many hours do you usually work per week in your main paid job" (in hours per week). The categories "Don't know" and "Refused" were not included in the analysis.

To investigate the question of whether a fast pace of work and the existence of tight deadlines have an influence on the probability of presenteeism occurring, the following questions were asked: "[...] does your (main) job involve working at very high speed?" and "[...] does your (main) job involve working to tight deadlines?" (from "never" to "always"); "don't know" and "refused" were not taken into account for the calculation. The response options were subsequently recoded and summarized: 1="never or rarely", 2="sometimes", 3="often or always".

To calculate the influence of job control (α=0.746), three variables were combined to form an index that measures the respective autonomy of the employees. Job control was measured by the ability to influence the work process, the choice of methods for completing work and the adjustment of work speed. The scale for these three items ranges from 1 to 5. The measurement instrument from Breaugh (1985) was used.

The degree of experienced emotional stress was assessed using the following statement: "I feel emotionally drained by my work" (from "never" to "always"); "don't know" and "refused" were not taken into account for the calculation. The answer options were subsequently recoded and summarized: 1="never or rarely", 2="sometimes", 3="often or always".

The degree of work engagement was measured by creating an index variable (α=0.654). Three statements were presented: "At my work I feel full of energy", "I am enthusiastic about my job" and "Time flies when I am working" (from "never" to "always"); "don't know" and "refused" were not taken into account for the calculation. The scale for these three items ranges from 1 to 5. The creation of the index is based on the valid and reliable instrument from Schaufeli et al. (2019).

The degree of job insecurity experienced was measured using the following statement: "I might lose my job in the next 6 months." ("strongly agree" to "strongly disagree"); "don't know" and "refused" were not taken into account for the calculation. The response options were subsequently recoded and summarized: 1="(strongly) agree", 2="neither agree nor disagree", 3="(strongly) disagree".

Furthermore, "Gender" with 1="Men" and 2 "Woman", age by "Age in years", whereby "don't know" and "refused" were not taken into account in the analysis, as well as "Education". The highest completed level was recorded for "Education". The answers were collected using the ISCED 2011 logic: 2="Secondary education" and 3="Tertiary education". Category 1="Primary education" was not included in the analysis due to the insufficient number of cases.

Data Analysis

First, the relationship between presenteeism and the respective degree of telework utilization was calculated for a group comparison using a chi-square test. In a further step, logistic regressions were calculated to determine the probability of occurrence. The SPSS statistics programme (Version 29) was used for this. The items used for the analysis were recoded in a first step and prepared for the calculation using logistic regression. In order to check the data for collinearity and Mahalanobis, a linear regression was calculated in advance. Outliers and missing variables were excluded. At the end of this process, 1806 people were included in the analysis. Different logistic regression models were calculated (M0 to M5): In addition to a zero model (M0), a telework model (M1), an overall model (M2) and a separate model for each telework utilisation group were calculated (M3-M5).

Results

Preliminary Analyses

The descriptive data Table 1. indicates that approximately 31% of the interviewees exhibited presenteeism within the last 12 months. More than 50% never or rarely used telework, almost 13% sometimes and more then 36% used often or always home-based telework. The average rating for the support received from superiors and colleagues was deemed satisfactory. The average number of hours worked per week, as reported by the survey participants, is 41.

Typically, a greater number of individuals are impacted by fast work pace and strict time limits. The Cronbach's α coefficient of job control is 0.746, indicating that the interviewees had a greater average level of job control. The interviews exhibit emotional stress levels that are below normal, with

an average score of 1.78. The average work engagement score (Cronbach's α = 0.654) is 3.86. This signifies a level of work involvement that is higher than normal.

The following table shows the descriptive statistics of the variables used.

Table 1: Descriptive analysis (range, means, standard deviation and Cronbach's α)

	Range	Mean	SD	Cronbach's α
Presenteeism (Yes/No)	0-1	0.3138	0.46418	-
Telework (Degree of Utilization)	1-3	1.8544	0.92187	
Support of manager	1-3	2.5997	0.70060	-
Support of colleagues	1-3	2.7307	0.59635	-
Usual working hours per week	1-168	40.1748	9.93074	-
Working high speed	1-3	2.2547	0.80654	-
Working tight deadlines	1-3	2.2881	0.81851	-
Job control (Index)	1-5	3.2508	1.13520	0.746
Emotional exhaustion	1-3	1.7855	0.79975	-
Work engagement (Index)	1-5	3.8078	0.75089	0.654
Job insecurity	1-3	2.5877	0.71838	-
Gender	1-2	1.52	0.501	-
Age	16-88	41.0945	11.32879	-
Education	2-3	2.5981	0.49041	-

Note: Own calculation based on the EWCTS 2021

The participants are nearly equally distributed between males and females, with a slight majority of 51% being men and 49% being women. The respondents had an average age of approximately 42 years. Approximately 58% of the population have a tertiary education

Comparative analysis of telework utilization and presenteeism

When comparing the three groups in terms of telework utilization, statistically significant differences were found between the three groups:

A chi-square test of independence was performed to evaluate the relationship between presenteeism and the degree of telework utilization. The relationship between these variables was significant [$\chi 2$ [(2], N = [1806]) = [16.598], p = <0.001].

The analysis shows that people who use telework at least occasionally show presenteeism more often than the group of people who never do so.

A logistic regression was conducted to determine if the degree of telework utilization is a predictor of presenteeism. Data screening led to the elimination of several outliers. Regression results indicated that the overall

model fit of the predictor got better in comparison with the zero model (-2 Log likelihood = 2232.432, zero model = -2 Log likelihood = 2255.888) and was statistically reliable in distinguishing between presenteeism [$\chi^2(2)$ = 16.615, p <0.001]. The model correctly classified 68.5% of the cases. Regression coefficients are presented in Table 2. Wald statistics indicated that the degree of telework utilization predict presenteeism.

Table 2: Logistic Regression – Model 1 (degree of telework utilization as only independent variable)

	B	Wald	df	p	Odds Ratio
Degree of telework utilization					
No/rarely telework	Ref.	Ref.	Ref.	Ref.	Ref.
Occasional telework	0.411	6.910	1	0.009**	1.509
Often or always telework	0.415	14.220	1	<0.001**	1.515

Note: Own calculation based on the EWCTS 2021; (*) Correlation is significant at the 0.1 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed); N = 1806; Nagelkerke R^2 = 0.013

Factors influencing presenteeism – categorized based on telework utilization

A second logistic regression was conducted to determine which independent variables are predictors of presenteeism. Data screening led to the elimination of several outliers. Regression results indicated that the overall model fit of the predictors was better compared to the zero model (-2 Log likelihood = 2059.962, zero model = -2 Log likelihood = 2255.888) and was statistically reliable in distinguishing between presenteeism [$\chi^2(20)$ = 189.084, p <0.001]. The model correctly classified 69.5% of the cases. Regression coefficients are presented in Table 3. Wald statistics indicated that degree of telework utilization, support of manager, support of colleagues, working high speed, working tight deadlines, experience of emotional exhaustion, and age significantly predict presenteeism.

A third logistic regression was conducted to determine which independent variables are predictors for presenteeism for those who do not (or cannot) telework. Data screening led to the elimination of several outliers. Regression results indicated that the overall model fit of the predictors was better compared to the zero model (-2 Log likelihood = 989.956, zero model = -2 Log likelihood = 2255.888) and was statistically reliable in distinguishing

Table 3: Logistic Regression – Model 2 (Overall model)

	B	Wald	df	p	Odds Ratio
Degree of telework utilization					
No telework	Ref.	Ref.	Ref.	Ref.	Ref.
Occasional telework	0.397	5.425	1	0.020**	1.487
Often or always telework	0.371	0.127	1	0.003**	1.449
Support of Manager					
Never of rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.107	0.282	1	0.595	0.899
Often or always	-0.360	4.045	1	0.044*	0.698
Support of Colleagues					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.283	1.368	1	0.242	1.327
Often or always	-0.220	1.115	1	0.291	0.802
Usual working hours	0.004	0.580	1	0.446	1.004
Working high speed					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.209	1.516	1	0.218	1.233
Often or always	0.493	9.469	1	0.002**	1.638
Working tight deadlines					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.270	2.381	1	0.123	1.310
Often or always	0.337	3.201	1	0.036*	1.401
Job control (Index)	-0.090	3.201	1	0.074(*)	0.914
Experience of emotional exhaustion					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.744	32.887	1	<0.001**	2.104
Often or always	1.007	48.796	1	<0.001**	2.738
Work engagement (Index)	-0.096	1.577	1	0.209	0.908
Experience of job insecurity					
(Strongly) agree	Ref.	Ref.	Ref.	Ref.	Ref.
Neither agree nor disagree	0.099	0.236	1	0.627	1.104
(Strongly) disagree	0.074	0.210	1	0.647	1.077
Gender					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-0.061	0.297	1	0.586	0.941
Age	-0.010	4.347	1	0.037*	0.990
Education					
Secondary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	0.008	0.005	1	0.945	1.008

Note: Own calculation based on the EWCTS 2021; (*) Correlation is significant at the 0.1 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed), N = 1806; Nagelkerke $R^2 = 0.140$

between presenteeism [$\chi^2(18) = 96.059$, $p < 0.001$]. The model correctly classified 72.9 % of the cases. Regression coefficients are presented in Table 4. Wald statistics indicated that support of managers, working high speed, and experience of emotional exhaustion significantly predict presenteeism for non-teleworkers.

Table 4: Logistic Regression – Model 3 (no telework)

	B	Wald	df	p	Odds Ratio
Support of Manager					
Never of rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.341	1.431	1	0.232	0.711
Often or always	-0.638	6.378	1	0.012*	0.528
Support of Colleagues					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.581	2.853	1	0.091(*)	1.787
Often or always	0.117	0.16	1	0.689	1.124
Usual working hours	0.021	6.029	1	0.014*	1.021
Working high speed					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.494	3.936	1	0.047*	1.638
Often or always	0.513	4.851	1	0.028*	1.670
Working tight deadlines					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.201	0.673	1	0.412	1.222
Often or always	0.306	1.926	1	0.165	1.358
Job control (Index)	-0.009	0.016	1	0.898	0.991
Experience of emotional exhaustion					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.824	18.758	1	<0.001**	2.280
Often or always	1.042	24.907	1	<0.001**	2.835
Work engagement (Index)	-0.011	0.01	1	0.919	0.989
Experience of job insecurity					
(Strongly) agree	Ref.	Ref.	Ref.	Ref.	Ref.
Neither agree nor disagree	0.125	0.194	1	0.659	1.133
(Strongly) disagree	-0.042	0.035	1	0.853	0.959
Gender					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	0.038	0.054	1	0.817	1.039
Age	-0.007	1.027	1	0.311	0.993
Education					
Secondary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	0.077	0.222	1	0.638	1.080

Note: Own calculation based on the EWCTS 2021; (*) Correlation is significant at the 0.1 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed); N = 929; Nagelkerke $R^2 = 0.143$

Table 5: Logistic Regression – Model 4 (occasional telework)

	B	Wald	df	p	Odds Ratio
Support of Manager					
Never of rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.318	0.287	1	0.592	1.374
Often or always	-0.362	0.406	1	0.524	0.697
Support of Colleagues					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.795	1.101	1	0.294	2.214
Often or always	0.936	1.981	1	0.159	2.550
Usual working hours	0.012	0.433	1	0.510	1.012
Working high speed					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.289	0.349	1	0.555	0.749
Often or always	0.215	0.181	1	0.670	1.240
Working tight deadlines					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.701	1.901	1	0.168	0.496
Often or always	-0.135	0.077	1	0.781	0.874
Job control (Index)	0.017	0.011	1	0.915	1.018
Experience of emotional exhaustion					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	1.421	14.224	1	<0.001**	4.143
Often or always	1.993	18.891	1	<0.001**	7.338
Work engagement (Index)	-0.095	0.158	1	0.691	0.91
Experience of job insecurity					
(Strongly) agree	Ref.	Ref.	Ref.	Ref.	Ref.
Neither agree nor disagree	-0.06	0.009	1	0.925	0.942
(Strongly) disagree	-0.523	0.883	1	0.347	0.593
Gender					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-0.477	1.893	1	0.169	0.62
Age	0.008	0.261	1	0.610	1.008
Education					
Secondary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	-0.162	0.205	1	0.651	0.851

Note: Own calculation based on the EWCTS 2021; (*) Correlation is significant at the 0.1 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed); N = 228; Nagelkerke $R^2 = 0.247$

A fourth logistic regression was conducted to determine which independent variables are predictors for presenteeism for those who occasionally telework. Data screening led to the elimination of several outliers. Regression results indicated that the overall model fit of the predictors was better compared to the zero model (-2 Log likelihood = 252.498, zero model = -2 Log

likelihood = 2255.888) and was statistically reliable in distinguishing between presenteeism [$\chi^2(18) = 45.369$, $p < 0.001$]. The model correctly classified 74.1% of the cases. Regression coefficients are presented in Table 5.

Table 6: Logistic Regression – Model 5 (often or always telework)

	B	Wald	df	p	Odds Ratio
Support of Manager					
Never of rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.234	0.404	1	0.525	0.791
Often or always	-0.056	0.034	1	0.854	0.945
Support of Colleagues					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	-0.145	0.104	1	0.747	0.865
Often or always	-1.109	7.578	1	0.006**	0.33
Usual working hours	-0.017	3.221	1	0.073(*)	0.983
Working high speed					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.157	0.314	1	0.575	1.170
Often or always	0.675	6.645	1	0.010**	1.963
Working tight deadlines					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.737	5.349	1	0.021*	2.090
Often or always	0.689	5.435	1	0.02*	1.991
Job control (Index)	-0.226	6.895	1	0.009**	0.798
Experience of emotional exhaustion					
Never or rarely	Ref.	Ref.	Ref.	Ref.	Ref.
Sometimes	0.465	4.707	1	0.03*	1.592
Often or always	0.717	9.268	1	0.002**	2.049
Work engagement (Index)	-0.206	2.429	1	0.119	0.814
Experience of job insecurity					
(Strongly) agree	Ref.	Ref.	Ref.	Ref.	Ref.
Neither agree nor disagree	0.03	0.007	1	0.932	1.030
(Strongly) disagree	0.259	0.911	1	0.340	1.296
Gender					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-0.141	0.605	1	0.437	0.869
Age	-0.02	4.736	1	0.030*	0.981
Education					
Secondary	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary	-0.009	0.002	1	0.968	0.991

Note: Own calculation based on the EWCTS 2021; Dependent dichotomous variable: Presenteeism; (*) Correlation is significant at the 0.1 level (two-tailed); *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed); N = 649; Nagelkerke $R^2 = 0.162$

Wald statistics indicated that experience of emotional exhaustion significantly predict presenteeism for those who occasionally telework.

A final logistic regression was conducted to determine which independent variables are predictors for presenteeism for those who often or always telework. Data screening led to the elimination of several outliers. Regression results indicated that the overall model fit of the predictors was better compared to the zero model (-2 Log likelihood = 766.798, zero model = -2 Log likelihood = 2255.888) and was statistically reliable in distinguishing between presenteeism [$\chi^2(18) = 81.752$, $p < 0.001$]. The model correctly classified 69.2% of the cases. Regression coefficients are presented in Table 6. Wald statistics indicated that support of colleagues, working high speed, working tight deadlines, job control, experience of emotional exhaustion, and age significantly predict presenteeism for those who often or always telework.

Discussion

The EWCTS data from 2021 was utilized to analyse the elements that influence the prevalence of presenteeism, categorized based on the extent of telework utilization. To achieve this objective, logistic regression models were computed.

The degree of telework use has an influence on the occurrence of presenteeism. People who often or always home-based telework are 1.5 times more likely to show presenteeism. The fact that telework is associated with presenteeism is also consistent with the studies by Steidelmüller et al. (2020) and Schmitz et al. (2023).

A separate analysis of the different groups of telework users showed that the experience of emotional exhaustion increases the probability of presenteeism in all groups. This result is in line with previous studies (Ferreira et al., 2019; Lu, L. Cooper, et al., 2013; Miraglia & Johns, 2016). In all applicable models, people who often or alwayse experience emotional exhaustion show a higher chance for presenteeism than people, who never or rarely experience emotional exhaustion.

It also emerged that the experience of support from the manager has an influence on the occurrence of presenteeism in the overall model as well as for the non-teleworkers. This result confirms previous studies that were able to demonstrate an increased probability of presenteeism in the perceived lack of support from the manager (Caers et al., 2021; Janssens et al., 2015; Mori

et al., 2022; Schmitz et al., 2023). Support from the manager had no influence on the occurrence of presenteeism for other groups.

Analogue to previous studies (Goto et al., 2020; Miraglia & Johns, 2016) the experience of support from colleagues was only a significant factor for people who often or always telework. Experiencing support from colleagues in these groups had a mitigating effect on presenteeism.

Weekly working hours also showed to have an influencing effect on presenteeism. For non-teleworkers as well as employees who often or always telework, increasing weekly working hours were associated with an increase in the occurrence of presenteeism. This result is supported by the results of Lu & Cooper (2022).

Working high speed showed to have an influence overall as well as for non-teleworkers and employees who often or always telework. As well as be confronted with tight deadlines showed to be in relationship with presenteeism for the overall model as well as for people who often or always telework. These results are in line with the findings of Caverley et al. (2007) where presenteeism is described as a possible coping strategy when facing high workloads and deadlines.

Job control, as the ability to determine the speed of work or the order in which work tasks are completed, also proved to be a mitigating factor in the overall model and for those who telework often or always. The higher the degree of job control, the lower the probability of presenteeism occurring. This result is in line with those of Miraglia & Johns (2016).

Socio-demographic factors show a partial influence on the probability of occurrence. For example, age in M2 and M5 shows a reduction in the probability of presenteeism occurring with increasing age. This result is in line with the findings of Allemann et al. (2019).

No effects could be calculated for job engagement, the experience of job insecurity, gender, and education for any model.

Conclusion

The aim of this article was to investigate the relationship between telework and presenteeism and to determine which potentially influential factors affect this relationship in the context of the COVID-19 pandemic. This study focussed on the Visegrad countries due to the lack of research for this group of

countries. Data from the European Working Conditions Telephone Survey from 2021 was used to calculate the logistic regression models.

Key findings

The findings indicated that the occurrence of emotional exhaustion, was linked to presenteeism across all telework groups. Furthermore, the presence of managerial and colleague support, a high work tempo, strict deadlines, and job control – albeit not universally – were significant contributors to the prevalence of presenteeism. Within the realm of socio-demographic characteristics, certain groups exhibited minimal explanatory power when considering age.

Contribution

In terms of scientific contribution, this article provides insights into the topic of presenteeism and telework for the Visegrad Countries, for which there has been no previous research. This article specifically explores elements that impact the occurrence of presenteeism and investigates the factors that influence presenteeism in various telework user groups.

In terms of practical contribution the significance of telework will continue to grow in the forthcoming years. Consequently, it is crucial to examine how organisations might establish circumstances that facilitate employees' ability to maintain good health and high levels of productivity. When planning working circumstances, it is crucial to consider the function of managers and the impact of emotional stress on employees' productivity. Social relationships are particularly important for employees who often or always work from home in order to reduce the risk of presenteeism. Organisations and managers can create the conditions to promote social interaction between employees.

Limitations and further research

This analysis utilized the EWCTS data set from 2021, which was gathered within the ongoing pandemic. When analysing the findings, it is crucial to consistently consider them within the framework of these particular situations.

This study conducted a comparative analysis by aggregating a cluster of countries, specifically the Czech Republic, Slovakia, Hungary, and Poland, known as the Visegrad Group. It is important to consider this factor when adapting the results to specific regional variations. In order to uncover regional disparities, future studies should focus on analysing individual countries.

The proportion of explained variance in the calculated models was weak to moderate (14%-24.7%). Other variables that were not included in the models presented here can further enhance the explanatory power.

Disclosure

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The Role of CEO Characteristics in Driving Innovation Performance

A Literature Review of Theories and Empirical Evidence

Lena Lotta Sticken[1]

Abstract: Innovation has long been considered the essence of competitiveness and essential part of economic growth. Internal as well as external indicators that encourage the innovativeness of companies have been researched world-wide for several years. This literature review explores the impact of CEO characteristics on the innovation performance of firms. Drawing from psychological, organisational, and strategic management literature, this paper examines how CEO personality influence the strategic decisions that foster innovation. It reviews established theories, such as Upper Echelons Theory to highlight the role of leadership in shaping innovation outcomes. By using a systematic literature search on international studies between 2000 and 2024 the aim of this paper is to highlight key trends in the current literature and identify research gaps for future investigations. The findings reflect the interaction between CEO psychological profiles, firm dynamics and the external environment to further elucidate the mechanisms CEOs use to contribute to innovation success. Ultimately, this literature review provides a comprehensive perspective on the central role of CEO characteristics in driving innovation performance and provides valuable insights into the underlying management theories and their relevance for scholars and practitioners both.

Keywords: *Innovation, CEO, Personality traits, Leadership, Upper Echelons Theory*

JEL Codes: *M12, E01, E03, E052*

[1] STICKEN, Lena Lotta (PhD Student)
University of Sopron, Alexandre Lamfalussy Faculty of Economics, István Széchenyi Economics and Management Doctoral School, Sopron, Hungary
(lenasticken@yahoo.de)

Introduction

In recent years, there has been growing interest in management research examining how the characteristics of the Chief Executive Officer (CEO) (Carpenter et al., 2004) influence strategic decisions and firm performance (Chatterjee & Hambrick, 2007, Colbert et al., 2014, Herrmann & Nadkarni, 2014, Hambrick et al., 1987, Quigley & Hambrick, 2015, König et al., 2020). Hambrick and Mason (1984) argued for further research on the link between top management characteristics and organisational outcomes (Zajac & Kellogg, 1990). Upper Echelons Theory (UET) suggests the impact of the strategic management particular on innovation performance (hereinafter IP), since they influence organizational attention, resource commitment, strategic choices und implementation strategies (Kaplan et al., 2012; Sanders & Hambrick, 2004). Today, innovation capability is considered one of the most important determinants of firm performance (Mone et al., 1998). Innovation acts as a key source of sustainable development, increasingly recognised as crucial for a company's survival and growth (Berraies & Rejeb, 2019; Y. Chen et al., 2014; W. He & Shen, 2019).

This paper aims to give readers an insight into the characteristics that enable some CEOs to lead successful, innovative companies more effectively than others. If innovation signifies corporate success in the future, this paper aims to provide an overview of the CEO characteristics already studied in relation to innovation and to explore whether, and to what extent, these traits contribute to a CEO's success. To reach this aim, a systematic literature review (SLR) has been carried out that systematically examines existing research and underlying management theories that investigate the impact of the CEO on IP worldwide.

Through the SLR, this paper seeks to identify gaps in the existing literature on the human side of innovation and to inspire further research that builds upon these findings. Finally, resulting from the findings, a conceptual model is presented that visualises the interplay of the CEO's influence, providing an impetus for constructive further research.

Theoretical foundations on research topic

According to Drucker (2004), the CEO is the individual with ultimate responsibility for a company's strategic direction and operational management. The CEO is accountable for setting the company's objectives, using resources effectively, and guiding the organisation towards the future. Drucker emphasises that the CEO's role extends beyond internal operations to include representing the company to the public and ensuring corporate social responsibility is upheld.

Upper Echelons Theory (UET) suggests that organisational outcomes, including innovation, are significantly shaped by the characteristics of top executives, such as the CEO. Academic literature highlights the importance of the CEO as a key influence on firm performance (e.g. Crossland & Hambrick, 2011; Hambrick et al., 1989). UET posits that individual characteristics of executives – including personality, values, skills, and experience – affect their decisions and behaviour, thereby impacting organisational performance (Hambrick & Mason, 1984). Further theories deal with the influence of executives on firm outcomes. Agency Theory (AT) underlines the importance of these characteristics, given the assumption that agents act in their own interests. CEO characteristics also affect the degree to which CEOs submit to monitoring and control mechanisms. AT addresses conflicts of interest and information asymmetry in relationships e.g. between owners and managers (M. C. Jensen & Meckling, 1976). Expanding on AT, Behavioural Agency Theory (BAT) assumptions provide insight into CEO behaviour regarding innovation. The BAT redefines agents' risk preferences by replacing the traditional notion of risk aversion with the empirically supported concept of loss aversion, which posits that individuals prioritise potential losses over gains when making decisions under uncertainty (Kahneman & Tversky', 1979).

Innovation and behavior in dealing with risk and uncertainty are closely related. The concept of Entrepreneurial Orientation (EO) has gained prominence in the entrepreneurship literature over recent decades (Anderson et al., 2015; Rauch et al., 2009). According to Miller (1983), EO comprises three main components: innovativeness, risk-taking propensity, and proactivity. This construct is used at the organizational level (Bernoster et al., 2020) though a construct for individual-level EO has more recently been developed (Bolton & Lane, 2012).

The personality of the CEO is defined as the individual and relatively stable collection of traits, attitudes, behaviour patterns, and emotional responses (Allport & Odbert, 1936; Cattell, 1966; McCrae, 2010). Most past research on personality has focused on the Big Five personality traits, based on the Five Factor Model (FFM) (McCrae, 2010). These five major dimensions – conscientiousness, neuroticism, agreeableness, extraversion, and openness to experience – represent the primary structure of personality (Barrick & Mount, 1991; Peterson et al., 2003). Despite some limitations (Paunonen & Jackson, 2000) the FFM has become a standard tool for assessing individual personality across research fields including management research over the past five decades (Colbert et al., 2014). Research has found a plausible relationship between individual EO and the Big Five personality traits (Covin & Slevin, 1989).

Empirical evidence

Materials and method

A structured and transparent method was selected to identify and analyse the most relevant scholarly work on CEO characteristics and their influence on the IP of companies. This SLR aims to provide a comprehensive overview of the current research landscape and systematically identify research gaps (Mark Petticrew, 2006; Moher et al., 2009). The databases chosen for the literature search were *EBSCOhost*, *JSTOR*, *ScienceDirect*, and *Google Scholar*. Studies were selected according to predefined inclusion and exclusion criteria to ensure that only high-quality and relevant research was incorporated into the analysis. Evaluation criteria included the clarity of the research questions, the appropriateness of the methodology, the sample's size and representativeness, and the transparency of data collection and analysis (Higgins et al., 2020, Kitchenham, 2007).

Peer-reviewed studies from a sufficiently extended publication period between 2000 and 2024 were considered. The period from 2000 to the present and 2014 to the present is intended to enable a comparison of the research efforts of recent years. While emphasis was placed on the most recent studies available, the limited availability of sources necessitated a review spanning a longer period. The limited number of studies on IP also led to the inclusion of those examining not only the CEO but also other executives or board members more generally. This systematic approach ensured that only high-quality and relevant studies were included in the analysis (Kitchenham,

2007). This SLR involves four interrelated steps, visualised in *Figure 1*. The results in regard to firm performance, IP and to individual CEO characteristics are shown in *Table 1*. A number of 59 relevant studies can be identified for further analysis.

Journals consulted for this SLR included, for example are *Academy of Management Journal, Journal of Product Innovation Management, Strategic Management Journal, Leadership Quarterly, Technovation, Journal of Business Research, Quarterly Journal of Economics* and *Academy of Management Review.*

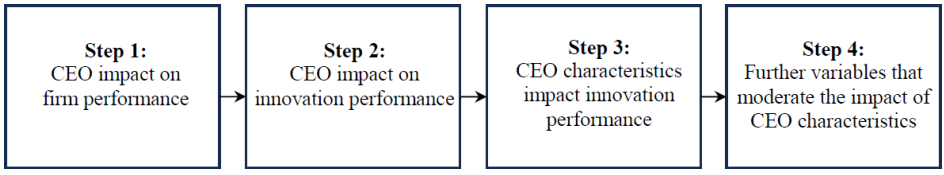


Figure 1: Research model of the SLR
Source: own elaboration.

Table 1: SLR on CEO impact and firm- and innovation performance.

Search strings	EBSCOhost		JSTOR		ScienceDirect		Google Scholar		
	2000-	*2014-*	*2000-*	*2014-*	*2000-*	*2014-*	*2000-*	*2014-*	
Step 1: General									
"CEO characteristics", "firm performance"	495	39	5.611	811	269	156	559	482	
"CEO impact/influence", "firm performance"	606/ 548	188/ 156	6.685/ 7.211	1.066 /963	308/ 319	161/ 165	22/ 82	18/60	
"CEO personality traits", "firm performance"	2	5	484	269	72	46	24	25	
Step 2: Specific									
"CEO characteristics", "innovation performance"	132	103	44	39	146	83	134	123	
"CEO impact/influence", "innovation performance"	140/ 133	101/ 104	4.717/ 4001	748/6 70	151/ 152	89/90	6/7	4/6	
"CEO personality traits", "innovation performance"	3	4	11	117	54	53	61	25	
Step 3: Characteristics									
Gender	14		16		60		398		3
Age	19		66		48		576		12

* Final Sample (Empirical, reliable studies that analyse the specified variables in the correct scientific context. Chosen from journals with a high impact factor).
** Educational-, financial-, cultural- background
Source: own elaboration.

Results

Step 1: CEO impact on firm performance

In recent years, studies have closely analysed the characteristics of CEOs and their influence on firms. Considering UET, researchers have examined CEOs' demographic characteristics to understand how these impact corporate governance strategies and firm performance. A range of studies have explored demographic factors, such as gender differences and diversity (Aabo, Hansen, et al., 2024; Dezsö & Ross, 2012; Khan & Vieito, 2013; Malhotra et al., 2018; Virtanen, 2012), age (Bertrand & Schoar, 2003; Korablev & Podukhovich, 2022), tenure (Jensen et al., 2020; Wang et al., 2016) and height (Adams et al., 2018). For example research by Wang et al. (2016) indicates that CEO age and tenure are positively associated with future firm performance, with longer-tenured CEOs tending to be more resistant to change and risk-averse. Beyond demographic characteristics, CEO remuneration has also been identified as an influencing factor on firm performance, with some studies finding a positive relationship between CEO remuneration and firm performance (Afrifa & Adesina, 2018; Akter et al., 2020; Azim et al., 2011). Costa et al. (2023) demonstrate that various aspects of CEO remuneration can contribute to enhancing the firm's financial performance.

Studies examining the personal experiences of CEOs and their impact on firm outcomes have identified educational (Buyl et al., 2011; Nguyen et al., 2023), financial (Yan et al., 2024) and multicultural backgrounds as important factors. For example, He et al. (2021) found that firms with a higher proportion of senior executives with academic backgrounds tend to invest more significantly in innovation. Similarly, Wang et al (2016) suggests that CEOs' formal education is positively related to future firm performance.

In recent years, studies have examined the direct and indirect influence of CEO personality on firm performance. Current notable research has focused on traits such as overconfidence (Ham et al., 2018; M. Jensen et al., 2020b; Salmony & Kanbach, 2022) and humility (Ou et al., 2018; Wang et al., 2016). Traits associated with the dark triad (machiavellianism, narcissism, and psychopathy) have also attracted considerable attention. Studies on the effects of CEO psychopathy (Klotz & Neubaum, 2016; Van Scotter & Roglio, 2020; Zuberi & Khattak, 2024) and narcissism (Chatterjee & Hambrick, 2007; Cragun et al., 2020; Gupta et al., 2019; Ham et al., 2018) can be found. A few studies exploring CEO personality incorporate the Big Five personality traits (Aabo et al., 2024; Barrick & Mount, 1991; Peterson et al.,

2003). For example, Harrison et al. (2020) identified a significant negative effect on firm returns for the interaction between equity risk and CEO agreeableness, while finding no effect for the interaction with CEO openness. Aabo et al. (2024) concluded that CEO conscientiousness and neuroticism affect the firm's ability to leverage increased volatility. Malhotra et al. (2018) found that extraverted CEOs are more likely to engage in mergers and acquisitions (M&As) than less extraverted CEOs.

The relationship between CEO personality and behaviour is closely intertwined. Recent studies have examined CEO behaviours such as locus of control and risk attitudes (EO) and their impact on firm performance (Korablev & Podukhovich, 2022; Malhotra et al., 2018). Bandiera et al. (2020) demonstrate that CEOs exhibit behavioural variation across several dimensions and differentiate between 'Leaders' and 'Managers' based on these distinctions. Drawing from Bandiera's conclusions, the present study posits that the executive's behaviour determines the style of leadership and its subsequent impact on firm performance.

Numerous studies have examined the influence of CEO leadership style on firm performance (De Hoogh et al., 2005; García-Morales et al., 2008; Sattayaraksa & Boon-itt, 2016), nevertheless, much of the literature is limited to the early 2000s. De Hoogh et al. (2005) assume that charismatic leadership is more effective than transactional leadership but found no significant association. Ling et al. (2008) found that CEO transformational leadership is positively associated with firm performance of SMEs.

Step 2: CEO impact on IP

While many scholars emphasise the importance of focusing on innovation (Benner & Tushman, 2002; Feinberg & Gupta, 2004), limited research has explored the influence of CEO characteristics on IP (Aabo et al., 2024; Mai et al., 2022; Mairesse et al., 2007; Peterson et al., 2003). The management literature identifies two types of innovation strategies, exploration and exploitation (Benner & Tushman, 2002). Exploration involves trying new technologies and to meet disruption, exploitation refers to the enhancement and expansion of current technologies and paradigms (March, 1991). Studies in recent years have defined several proxies for measuring innovation performance including research and development (R&D) expenditure, R&D intensity and number of patents (Jalles, 2010). The importance of innovation, particularly within the realm of digital technologies, has garnered increasing attention in

academic literature (Bajari et al., 2019; Bornhausen & Wulf, 2021; Menth & Hnilica, 2023; Wang Tai, 2023; Zhao et al., 2024). Agility and speed in possessing digital information are crucial for anticipating emerging threats and seizing new market opportunities before competitors even become aware of them (Chen et al., 2022). Nevertheless, few studies explore the driving forces behind digital technology innovation, especially from the perspective of internal human capital, such as through the lens of top management.

Around the early 2000s, the literature presented mixed views on whether CEOs play a leading role in driving innovation within their organisations (Yadav, 2007). Hambrick et al. (2003) argue that top management roles come with extremely high-performance expectations and stress, which may limit the time and cognitive resources available for creativity (Hambrick et al.,

Table 2: CEO characteristics impacting IP.

CEO characteristics	Example study	N*	Country	Theory**
CEO demographics				
Age	Wang et al., 2016	315	WW*	UET
Tenure	Garcia-Blandon et al., 2019	100	USA	x
Gender	Hassan et al., 2024	1204	USA	UET, RBV
CEO background				
Financial	Yan et al., 2024	2317	ASIA	UET
Formal Education	Lee & Moon, 2016	500	USA	UET
(Multi-) Cultural	Yan et al., 2024	2317	ASIA	UET
CEO personality				
Overconfidence	Mehraein et al., 2023	106	WW	AT, TAT, FFM
Big Five	Ling et al., 2011	550	ASIA	FFM
Narcism	Mai et al., 2022	638	ASIA	RBV
Behaviour				
Entrepreneur Orientation	De Massis et al., 2018	35	EUR	IT
Flexibility	Nadkarni & Herrmann, 2010	217	ASIA	BT
Curiosity	Liu et al., 2023	563	ASIA	UET
Attention	Li et al., 2013	61	USA	TOA
Power	Blagoeva, et al., 2020	241	USA	BTF
Leadership style				
Leadership	Chaithanapat, 2022	283	ASIA	x
Transformational L.	Sattayaraksa & Boon-itt, 2016	269	ASIA	LT
Other				
ADHD symptoms	Artamoshina et al., 2023	367	ASIA	LT, TAT

* N= Partipicants, WW= Worldwide

** TAT= Trait Activation Theory, FFM= Five Factor Model, UET= Upper Echelons Theory, RBV= Resourced Based View, AT= Agency Theory, LT= Leadership Theory, BT= Behavioral Theory

Source: own elaboration

2005). Some authors suggest that innovation is driven from the middle of the organisation, specifically through the actions and processes of middle management (Burgelman, 1994; Christensen, 1997), not the top management. Grove & Meehl (1996) support the notion that CEOs can steer innovation, asserting that a key role of CEOs is to set the company's overall direction and to focus the attention of employees on specific areas such as innovation. Current studies can identify a link between individual CEO characteristics (see *Table 2*) and IP. However, inconsistencies remain in the findings, not only in general but also in relation to various CEO characteristics (e.g., age, ownership). These inconsistencies can be explained by e.g. different proxies for IP, different approaches to control for extraneous variables (e.g. firm size, industry), lack of consideration of endogeneity between CEO characteristics and IP and different influence mechanisms (considering moderators or mediators).

Step 3: Specific CEO characteristics impacting IP

According to several studies, CEO age has the greatest influence on the drive for innovation within organisations (Cline & Yore, 2016; Serfling, 2014). Barker & Mueller (2002) found that R&D expenditure tends to be higher in publicly listed companies where CEOs are younger and have substantial investments in company shares. Further studies show that CEOs' ability to adapt to unforeseen circumstances diminishes with age (Serfling, 2014). Studies examining the impact of CEO gender diversity on IP are scarce. Mansour et al. (2024) found a significant, positive correlation between female CEOs and green innovation in Asia. Hassan et al. (2024) used CEO gender as a moderator in the relationship between ESG and IP, finding no significant effect. The influence of CEO tenure on IP has been studied; however, there is little evidence to support a clear link in the current literature (Determining Which CEO Candidates Will Lead growththrough Innovation, 2023). Barker & Mueller (2002) observed that relative R&D expenditure increases with CEO tenure. McClelland et al. (2012) found that CEOs with longer tenures have a positive impact on performance in less dynamic industries, but a negative impact in highly dynamic industries.

The level of formal education held by a CEO does not significantly correlate with R&D spending, provided the CEO holds a university degree (You et al., 2020). However, there is a notable relationship between CEOs with advanced science degrees and increased R&D expenditure. CEOs with

higher education levels may be more open-minded and confident in developing innovative R&D plans and initiatives (Lee & Moon, 2016; You et al., 2020). While recent studies on CEO age, gender, and tenure remain rare, there has been some recent research on CEO experience. Ener (2022) found that in publicly listed companies, CEOs with technical expertise are less likely to delegate externally. His research shows that differences in the CEO's technical experience affect the firm's innovation behavior, e.g. licensing and out-licensing of patents. Cao et al. (2022) identified a positive effect of CEOs' international experience on firms' R&D investment and IP. Similarly, Koyuncu et al. (2010) and Zhu et al. (2023) examined the effects of executives' functional, environmental, and cultural backgrounds on companies. (Zhao et al., 2024) investigate the influence of CEOs with IT backgrounds on digital technology innovation, finding that such CEOs are particularly effective in fostering these innovations.

Although certain personality traits show predictive value for innovation, few studies have directly linked CEO personality and behaviour with IP. Liu et al. (2023) found that CEO curiosity plays a crucial role in driving firm innovation, while De et al. (2009) identified a significant positive correlation between CEO optimism and innovation. Three studies have investigated the relationship between the FFM traits and IP. Runst et al. (2022) found that emotional stability correlates positively with innovation. Weele, (2013) found no significant correlation between CEO personality traits and IP but noted that openness to experience, along with extraversion, plays an essential role in distinguishing between exploration and exploitation. Park & Kim (2022) investigated on personality traits and leader support as a moderating role on impacting IP and found a significant positive relation. Overconfidence is described by Sunder et al. (2014) as a CEO characteristic that fosters innovation; similarly, the findings of Saesen et al., (2024) demonstrate a positive relationship between overconfidence and the digital orientation of a company.

CEOs' attitudes towards innovation can be a strong indicator of their intent to adopt innovative practices (Rangus et al., 2017). Several studies have explored the impact of CEO innovativeness, risk tolerance, and proactivity (EO) on IP (Kiss & Herrmann, 2022; Najar & Dhaouadi, 2020). Najar & Dhaouadi (2020) found that CEO-EO has a positive and significant effect on open innovation. Di Minin et al. (2010) argue that EO among executives is a crucial factor for enhancing innovation strategies and fostering an innovation propensity. The study by KissCortes & Herrmann (2022) showed that proactive CEOs primarily influence exploitative innovation, with some effect on exploratory innovation as well.

Leadership behaviours, such as inspirational motivation and intellectual stimulation, are crucial for organisational innovation (Elkins & Keller, 2004). Specific CEO behaviours (e.g., behaviours that include encouragement of individual initiatives, clarification of individual responsibilities) define an innovative leadership style (Carmeli et al., 2010).

Both transformational and transactional leadership styles promote innovation, with transformational leadership being particularly effective in dynamic environments (Prasad & Junni, 2017). Transformational leadership has emerged as a significant area of research in innovation, attracting growing attention (Cortes & Herrmann, 2020; Di Benedetto et al., 2013; Yin et al., 2023). Sattayaraksa & Boon-itt (2016) found a significant and positive correlation between transformational leadership and innovation culture. Although various studies support the positive effects of transformational leadership on organisational factors of innovation (Y. Chen et al., 2014; García-Morales et al., 2008; Gumusluoglu & Ilsev, 2009), there is limited recent research on how other CEOs' leadership styles impact IP. For example, Chen et al. (2022) find a positive and significant relationship between a well-connected CEO and innovation efficiency, given the prerequisite of agile leadership, Tho et al. (2025) examine ambidextrous leadership behaviours in relation to innovation.

Step 4: Further variables that moderate the influence of CEO characteristics

In investigating the CEO's impact on firm performance and IP, further factors have been identified that significantly affect this impact structure. Differences in ownership structure, corporate governance, country influence the strength or direction of the association between CEO characteristics and IP. Firm characteristics, such as size and industry, must be considered in order not to falsify the association. Studies investigating variations in ownership (Gamache et al., 2015; Lai et al., 2017; Mackey, 2008; McClelland et al., 2012) show mixed findings when examining CEO characteristics and IP, with most of these studies using data from the USA or the UK. Differences in the legal and institutional environment have been frequently analysed in comparative corporate governance research (F. M. B. Barca, 2002; Blair & Roe, 1999; La Porta et al., 1999) and must be considered within this research. Studies indicate that ownership concentration is higher in continental Europe than in the USA or UK (Amdys et al., 1988; Becht & Mayer, 2002). Formal

and informal power mechanisms can explain this influence, which varies by country. Since powerful CEOs tend to make most key strategic decisions, they also exert greater influence over decisions to invest in innovative projects (Aghion et al., 2013; Cefis & Marsili, 2006; Geroski et al., 2013).

There is literature addressing IP within owner-managed or family-run firms (De Massis et al., 2014, 2018). The success of owner CEOs and the alignment of interests between shareholders and management have also been analysed by Kaserer & Moldenhauer (2008). They found evidence of a positive and significant association between firm performance and insider ownership in Germany CDAX companies. De Massis et al. (2014) posit that family firms possess an unusual capacity to innovate, due to concentrated family ownership.

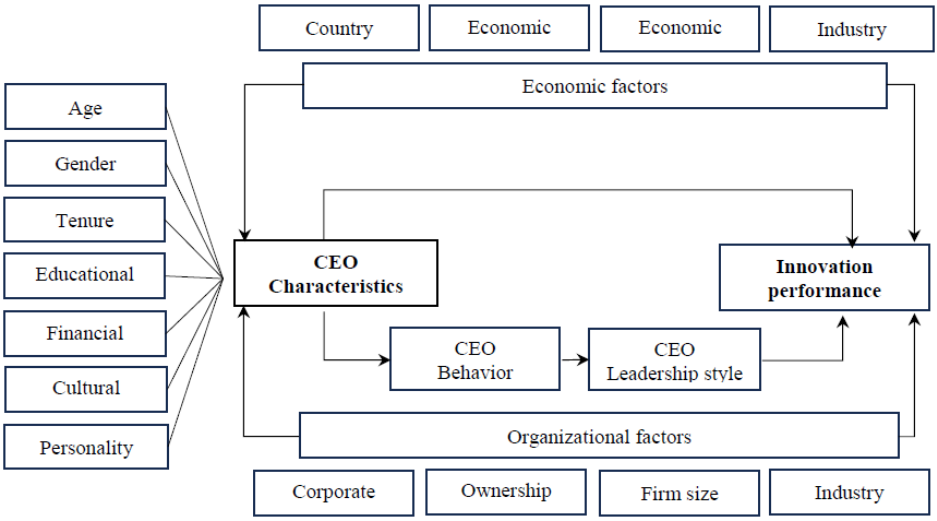
Additionally, firm size affects differences in IP. Agle et al. (2006) highlight that CEOs of larger companies are often more involved in public relations and capital allocation, whereas CEOs of smaller companies focus more on managing day-to-day operations. Hall & Ziedonis (2001) and Atanassov (2013) found that larger companies tend to innovate more, benefitting from information advantages as well as economies of scale and scope in R&D and patenting processes. Brown et al. (2009) and Faleye et al. (2011) argue that financial leverage restricts innovation by increasing managers' aversion to riskier long-term projects.

Firm industry characteristics can also impact the CEO's influence on IP, although few studies have explored this link. Most empirical studies use multi-industry samples, with only a few specialising by industry. Runst & Thomä (2022) for example, focused on the automotive industry in Germany. Other studies compare low- and high-tech industries (You et al., 2020).

Country differences are another influential variable. Cross-cultural personality research has revealed consistent personality trait differences among executives across countries (Bloom & Reenen, 2010; Hofstede, 1993; Kajonius & Giolla, 2017). Large-scale studies suggest that country-specific variations in personality traits are significant and linked to societal values (Bartram, 2013). Although some studies use global samples (e.g. Mehraein et al., 2023; Wang et al., 2016), most research is country-specific. Further factors that influence the effectiveness of CEO characteristics include economic motivations for innovation (driven by the organisation or business model) and the organisational capacities for innovation (D. H. Zhu et al., 2024). Studies on CEOs' attention to the external and internal environment have shown mixed results. Yadav (2007) found that firms led by CEOs who focus more on the

external environment are quicker at identifying new technological opportunities compared to those whose CEOs are less externally focused. Zhu et al. (2024) expand upon the factors identified in this SLR through their recently developed mechanism-centred review framework by adding 'economic motivations' and 'organisational capacity'. These findings have been integrated into the conceptual model proposed for this research (*Figure 2*).

Figure 2: The purposed conceptional model for this SLR.



Source: Own elaboration

Possible future research directions

Identifiable research gaps present an opportunity for future researchers to generate new insights. While there is some research on the characteristics of entrepreneurs and their influence, the role of the CEO remains far less explored. Limited research exists on the direct influence of CEO characteristics, particularly personality traits, on an organisation's IP, with this gap being especially apparent in Europe. While much existing research focuses on SMEs, there has been comparatively little investigation into publicly listed companies. Another gap pertains to the influence of CEO gender differences, largely attributed to the general lack of gender diversity at the upper echelons of corporate leadership. Although firm innovation has been extensively studied, the CEO's influence is often assessed through innovative behaviour or

organisational culture rather than direct indicators such as R&D expenditures or patent activity. Existing studies are frequently based in the USA or Asia, where research and development operate under fundamentally different conditions compared to Europe or Germany, which faces unique challenges such as stringent data protection and bureaucracy. Additionally, cross-cultural differences impacting the relationship between CEO characteristics, behaviour, and personality must be considered. There is broad consensus in current research that CEO characteristics rarely influence IP in isolation. Distinctive factors such as company size, ownership structure, corporate governance, industry, and country context must also be considered. These elements affect the transferability of existing research, underscoring the need for researchers to produce further diverse findings in this area. Furthermore, there is limited understanding of how these factors interact with one another.

Further research could critically assess the diverse methodologies employed in existing studies on CEO characteristics and innovation. CEO traits are often measured through questionnaires, while alternative methods are seldom used. Many existing studies yield contradictory findings regarding CEO characteristics, reinforcing the need for continued research that considers additional influencing factors to achieve consistent results or elucidate these variations. A lack of statistical significance in some cases may stem from sample sizes that are too small. Although studies generally agree that CEO motivations, cognitions, and leadership behaviours influence a company's innovation potential (Zhu et al., 2024), little research explores the extent to which these factors interact, despite their interconnected nature. Moreover, only a limited number of studies address the issue of endogeneity in the analysis of the relationship between CEO characteristics and IP (e.g. Sheikh, 2018). Georgakakis et al. (2015) deal in detail with the problem of reverse causality and endogeneity in UET studies and found a small number of studies on this issue.

Most studies frame IP through leadership behaviour and intra-organisational dynamics, with only a few addressing leadership behaviour alongside strategic decisions as part of a causal chain. Additionally, there are few longitudinal studies examining CEO characteristics and innovation potential in relation to sustained long-term performance.

Conclusion

This paper set out to provide an overview of the characteristics that enable some CEOs to lead successful, innovative companies more effectively than others, exploring their relationship to corporate success through innovation. By conducting a SLR, this study sought to identify gaps in existing research on the human side of innovation and to inspire further investigation into this field. The findings highlight that while the influence of CEO characteristics on IP is widely acknowledged, recent research in this area remains limited, with many studies relying on older data. Nevertheless, the review demonstrate that CEO characteristics significantly affect IP by shaping behaviour, leadership styles, power dynamics, and strategic decision-making processes. This aligns with the objective of offering insights into the traits contributing to a CEO's success. Importantly, the study has identified gaps in the literature, particularly in the lack of recent, comprehensive evidence on the specific CEO characteristics that drive innovation. While some traits have been clearly identified as influential, further research is needed to examine these relationships in greater depth, particularly when considering the interplay of economic and organisational factors. By addressing these gaps, this paper contributes to strategic management considerations, providing companies with a foundation for enhancing innovation capabilities through informed leadership selection and development. Ultimately, the findings aim to support organisations in navigating current economic challenges and achieving sustained success through innovation.

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KÖNYVISMERTETÉS / BOOK REVIEW

Gazdaság & Társadalom / Journal of Economy & Society
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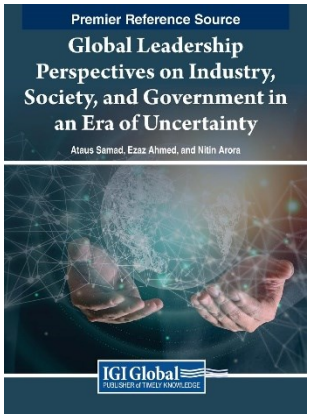
Global Leadership Perspectives on Industry, Society and Gov-ernment in an Era of Uncertainty: A critical Review

***Mike Weiß*[1]**

[Samad, A., Ahmed, E., & Arora, N. (eds, 2023). Global Leadership Perspectives on Industry, Society, and Government in an Era of Uncertainty. IGI Global. 378 pp. ISBN13: 9781668482575; ISBN10: 1668482576; ISBN13 Softcover: 9781668482582; EISBN13: 9781668482599; DOI: 10.4018/978-1-6684-8257-5]



Global Leadership Perspectives on Industry, Society, and Government in an Era of Uncertainty, edited by Ataus Samad, Ezaz Ahmed and Nitin Arora, is a text in the *Advances in Logistics, Operations and Management Science* (ALOMS) book series published in 2023. Spanning 378 pages, this collective volume brings together a diverse array of authors including scholars, practitioners and researchers from various fields. These contributors offer a wide range of perspectives on leadership, drawing from their expertise in different domains such as business, education, politics and social sciences. The book aims to address the complexities and challenges of leadership in the modern era characterized by the aronym VUCA (Volatility, Uncertainty, Complexity and Ambiguity).

Through its six sections, the book delves into the (1) concept of leadership, (2) leadership and gender, (3) leadership in an organizational context, (4) the interplay between leadership, work-life conflict, wellbeing and happiness, (5) the dark side of leadership and (6) emerging leadership paradigms. Notably, it scrutinizes leadership's pivotal role during crises, especially highlighted by the COVID-19 pandemic, offering insights into effective crisis management and decision-making across different cultures and national settings. It

[1] WEIß, Mike PhD student,
University of Sopron, István Széchenyi Economics and Management Doctoral School, Hungary
(WeissMike@phd.uni-sopron.hu; https://orcid.org/0009-0000-9681-9421)

aims to enrich the discourse on evolving leadership theories, management distinction and its broader implications, thereby serving as a comprehensive resource for managers, academics, researchers and policymakers alike.

In the evolving discourse on leadership within VUCA environments, the book at hand emerges as a pivotal text. This volume positions itself by broadening the scope of inquiry beyond the confines of traditional leadership studies with a practical attitude. Through its rich compilation of chapters, the book traverses the wide range of leadership challenges and strategies across diverse sectors against the backdrop of global unpredictability, which is a theme that has become more relevant than ever due to the COVID-19 pandemic. The book's scientific value is underlined by its contribution to the ongoing debate on coping strategies for organizations navigating VUCA environments. It does so by not only encapsulating but also advancing the dialogues initiated by well-known works in the field, such as those by Hameed & Sharma (2020), Rimita et al. (2019) and Setiawati (2021). Hameed & Sharma's exploration of Generation Z's leadership competencies within a VUCA setting reveals a gap between inherent leadership capabilities and the requisite global leadership competencies for such turbulent times. Rimita et al.'s hermeneutic study of Nigerian executives presents insights into the experiences and strategic responses to VUCA challenges, emphasizing a blend of chaos theory and complexity leadership theories. Meanwhile, Setiawati's investigation into agile leadership and its impact on performance of millennials in uncertain environments highlights the critical role of agility and adaptability in enhancing organizational performance.

The book at hand extends these discussions by providing a panoramic view of leadership roles in steering organizations through crises, offering empirical evidence and theoretical insights into effective leadership practices across different cultural and national contexts. It critically examines the adequacy of existing leadership models in addressing the multifaceted challenges posed by VUCA environments and proposes an integrated framework for understanding and implementing leadership strategies that are both resilient and adaptable.

In conclusion, this volume not only enhances the existing body of research by Hameed & Sharma, Rimita et al. and Setiawati but also advances the academic dialogue by offering a more practice-orientated and comprehensive exploration of leadership in VUCA environments. The interdisciplinary approach, combining theoretical frameworks with practical insights, makes it a good basis for researchers, practitioners and policymakers alike, aiming to navigate the complexities of contemporary leadership challenges.

A major strength of the book is its coverage of contemporary leadership issues such as gender dynamics, organizational well-being and crisis management. The section on "The Dark Side of Leadership" is particularly powerful as it explores toxic behaviors and their organizational consequences, a topic often underexplored in leadership studies. Similarly, the analysis of leadership during the COVID-19 pandemic offers valuable lessons on resilience and adaptability in high-pressure scenarios, supported by empirical evidence from diverse cultural contexts.

While the diversity of perspectives is enriching, it also leads to inconsistencies in the depth and methodological stringency of the chapters. Some contributions provide excellent empirical insights and actionable strategies, while others rely more on theoretical speculation, leaving gaps in practical applicability. For example, the section on "Emerging Leadership Concepts" presents innovative ideas on leadership concepts, but occasionally lacks robust empirical validation that could strengthen its practical relevance.

The book's contribution to the academic dialogue needs to be underlined, particularly its integration of agility and complexity theories with leadership practices. It builds on foundational work while addressing gaps, such as the global competencies needed to navigate uncertainty, as highlighted by Hameed & Sharma and others. Nevertheless, a more critical evaluation of established leadership models would have advanced the discourse by challenging existing assumptions and proposing alternative frameworks.

Overall, the volume succeeds in presenting leadership as a dynamic and multifaceted phenomenon. Its interdisciplinary approach, although at times inconsistent, makes it a valuable resource especially for practitioners. By combining theoretical depth with practical insights, it makes a significant contribution to the ongoing exploration of leadership in a rapidly changing world.

The relevance of *Global Leadership Perspectives on Industry, Society and Government in an Era of Uncertainty* extends beyond academic discourse and offers essential insights for business practitioners navigating complex and unpredictable business landscapes. Focusing on leadership in VUCA environments, the book provides actionable strategies and frameworks that address the challenges facing modern organizations.

One of the most practical aspects of the book is its exploration of leadership in crisis, particularly in the wake of the COVID-19 pandemic. Business leaders can use these insights to improve decision-making, foster organizational resilience and enhance crisis management strategies. For example, the emphasis on agility and adaptability discussed in the "Emerging Leadership

Concepts" section is directly applicable to organizations seeking to remain competitive in rapidly evolving markets. The frameworks provided can help organizations implement adaptive strategies especially in industries where rapid innovation and responsiveness are critical for the organizational success.

The book also addresses the intersection of leadership and employee well-being, which is a topic of increasing importance in corporate environments. The section on "Leadership, Work-Life Conflict, Wellbeing, and Happiness" offers practical guidelines for creating supportive workplace cultures that prioritize employee satisfaction and mental health. These insights are valuable to human ressource professionals and business leaders who want to increase productivity while fostering a positive work environment.

Another area of direct applicability is the discussion of the "Dark Side of Leadership". By identifying behaviors and patterns that decrease organizational effectiveness, the book provides a cautionary tool for organizations to evaluate and refine their leadership development programs. Organizations can use these insights to identify and mitigate toxic leadership tendencies, thereby improving overall organizational health.

Moreover, the book's interdisciplinary approach when combining insights from business, education and social sciences, provides business leaders with a holistic understanding of leadership. This makes it a practical resource for training programs, executive coaching and strategic planning. Further to that it can enable organizations to build leadership capabilities that are both resilient and forward-looking.

In summary, the book serves as a valuable guide for corporate practitioners, offering practical tools and strategies for navigating the complexities of modern leadership in dynamic and uncertain environments.

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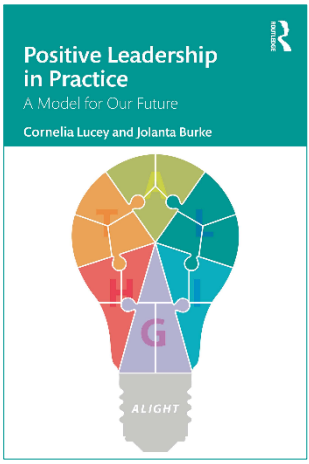
Pozitív vezetés a gyakorlatban: Egy modell a jövőnkhöz
Könyvismertertő

Positive Leadership in Practice: A Model for Our Future
Book Review

Szántó Dóra[1]

[Lucey, C., & Burke J. (2022). Positive Leadership in Practice: A Model for Our Future. Routledge, New York. 236 pp. eBook ISBN 9781003170433; DOI: 10.4324/9781003170433]



Alábbi írásomban a Cornelia Lucey és Jolanta Burke szerzőpáros által megalkotott írást fogom ismertetni, amely 2022-ben jelent meg Positive Leadership in Practice címmel.

A könyv legfőbb célja, hogy segítséget nyújtson a vezetőknek abban, hogy a lehető legjobbat hozzák ki magukból, ezáltal rendkívüli eredmények elérésére legyenek képesek. Mindemellett az írás segít a csapatuk támogatásában is, hogy ők is hasonló sikereket érhessenek el. A kutatásokkal alátámasztott tanácsok mellett olyan valós életből származó gyakorlati tanácsokkal találkozhatunk az olvasás során, amelyek valódi pozitív vezetőktől származnak, így átfogó képet kapunk arról, mi is valójában a magas teljesítményű vezetés, és ez hogyan is érhető el.

A Positive Leadership in Practice, amit magyarul Pozitív Vezetés a Gyakorlatban címre fordíthatunk le, egy kiváló forrás ahhoz, hogy a vezetők képessé váljanak hatékonyságuk növelésére. A könyvben bemutatásra kerül egy modell, melyet ALIGHT modellnek nevezett el a szerzőpáros. A modell 6 alapvető erőforrást említ a vezetők számára a saját és a csapatuk motivá-

[1] SZÁNTÓ Dóra PhD hallgató [PhD Student]
Soproni Egyetem Lámfalussy Sándor Közgazdaságtudományi Kar Széchenyi István Doktori Iskola [University of Sopron Alexandre Lamfalussy Faculty of Economics István Széchenyi Doctoral School]
(szantodora@phd.uni-sopron.hu)

lására, ezáltal magas szintre emelve a teljesítményüket. A 6 erőforrás bontásra került 18 összetevőre, amik további segítséget nyújtanak a fejlődésre. Olvasás közben találkozhatunk egy kérdőívvel is, melynek segítségével a vezetők egy önértékelés elvégzése során képet kapnak arról, hogy jelenleg milyen szinten van a pozitív vezetési értékük, rávilágítva arra, hogy ezek az erőforrások milyen fejlesztésre szorulnak. Gyakorlati stratégiák is bemutatásra kerülnek, melyek alkalmazásával a vezetők a lehető legjobb pozitív vezetővé válhatnak.

A könyv elején olvashatjuk annak a 8 személynek a rövid bemutatását, akik gyakorlati tapasztalataikat megosztva a szerzőkkel hozzájárultak a könyv megírásához. A téma aktualitására és fontosságára rávilágít a résztvevők alacsony száma, mivel a pozitív vezetés irányelvei nem annyira elterjedtek még napjainkban a vezetői körökben.

A szerzőpáros az írást 10 különálló fejezetre bontotta, azonban a fejezeteken belül több alfejezetre tagolódnak az információk. Érdekesség, hogy az első 6 fejezet a modellt alkotó erőforrások neveit viseli, ha sorban elolvassuk a kezdőbetűket, megkapjuk az ALIGHT kifejezést. Mindegyik fejezet végén találunk egy összefoglalást is, ami segítséget nyújt az olvasó számára az olvasottak átgondolásában. Érdemes további erényként kiemelni, hogy minden alfejezetnél megtaláljuk a már említett kérdőív kérdéseit, amik segítségével folyamatosan végezhetjük az önreflexiónkat. Különleges jellemző még ezen kívül, hogy fejezetenként találjuk meg a felhasznált forrásokat is, ezzel is megkönnyítve azok dolgát, akik el szeretnének jobban mélyülni az érintett témakörben vagy szekunder kutatást szeretnének végezni.

A bevezetésben a szerzők leírják, hogy számos, az egész világot érintő problémával küzd a társadalom. Legyen ez akár természeti, akár iskolai vagy vállalkozásokat érintő, a vezetők minden esetben fontos szerepet játszanak ennek ellensúlyozásában és egy pozitív jövő megteremtésében. Kiemelt fontosságú célként említik az emberek jólétét, amihez nagyban hozzájárul a munkakörnyezet is, mivel ott töltjük életünk folyamán a legtöbb időt, így az emberek elvárásai fokozatosan nőnek a munkahelyekkel kapcsolatban. A fejezetben összefoglalva áttekinthetjük a pozitív pszichológia elveit, majd röviden bemutatásra kerül a szerzők által megalkotott ALIGHT modell is. Fontosnak tartják, hogy a vezetés túlmutasson a hagyományos siker mérőszámain, és célja legyen a csapataik jóllétének és optimális teljesítményének elősegítése.

A könyv első fejezetében a szerzők a vezetés azon aspektusára összpontosítanak, amely a bőség szemléletét támogatja a munkahelyi környezetben.

Felhívják a vezetők figyelmét arra, hogy ne csak a korlátozásokra összpontosítsanak, hanem a lehetőségekre és az erőforrásokra is, melyek segítik az innovációt és a jólétet. A fejezetben részletesen olvashatjuk, hogyan lehet a bőség szemléletét alkalmazni a vezetésben, hozzájárulva ezzel a munkavállalók virágzásához.

A második fejezetben a rugalmasságot, mint a pozitív vezetés egyik alapvető elemét fejtik ki a szerzők. A vezetők számára elengedhetetlen, hogy tudjanak alkalmazkodni, érzelmileg agilisak legyenek és rugalmasan kezeljék a változó körülményeket. A fejezet hangsúlyozza, hogy a rugalmasság fejlesztése kifejezetten fontos a modern vezetők számára, ezért gyakorlati tanácsokat és eszközöket is kínál alkalmazásra.

Az inspiráló forrás a legtörékenyebb, mivel az érzelmi alapokon nyugszik, amik rövid életűek, derül ki a harmadik fejezetből. Egy kimondott szó pár másodperc alatt képes megváltoztatni a teljes munkahelyi légkört, motiváló és demotiváló irányba egyaránt. Megtanítják a vezetőknek, hogyan lehetnek példaképek a beosztottaik számára és hogyan tudják a pozitív példáikat átültetni a mindennapi gyakorlatba.

A pozitív vezetők nagyszabású tervezéssel értékes és céltudatos munkahelyi légkört tudnak teremteni maguknak és csapatuknak egyaránt, ami túlmutat a vízió és a küldetés szavain, fogalmazza meg a szerzőpáros a negyedik fejezet keretein belül. Ez a fajta tervezés összekapcsolja a pozitív vezetőnek saját magára és csapatára is vonatkozó cél és értéktudatosság szükségességét, kialakítva egy kapcsolatot a közösség és a hosszú távú stratégiai prioritásai között.

Az ötödik fejezet az egészség fontosságára hívja fel az olvasó figyelmét, hiszen ebből merítenek erőt a vezetők is, hogy képesek legyenek teljes életet élni, és mindemellett élvezzék is munkájukat. A fejezet segítséget nyújt a felismeréshez, hogy csak egészségesen válnak a vezetők lehető legjobb önmagukká, és csak így tudják legjobban szolgálni családjukat, barátaikat. Kiderül, hogy nemcsak saját, hanem csapatuk egészségére is befolyással vannak döntéseikkel, hatalmas részük van a csapatuk jóllétének megteremtésében.

A modell hatodik erőforrását tárgyaló fejezetben a szerzők a törzsi vezetők jellemzőit fejtik ki, hangsúlyozva a kapcsolatteremtés meglétét, a konfliktusok és az összetűzések pozitív módon való kezelését, elkerülve ezáltal a csoporton belüli megingásokat. Olvashatunk lehetőségekről, hogyan lehet még jobban támogatni a kollégákat, milyen viselkedésmódok preferáltak egy vezető számára.

Az alkotóelemek egyenkénti bemutatását követően a következő fejezetekben láthatjuk, hogyan is működnek együtt az erőforrások és hogyan tudjuk az egyensúlyt megtalálni a pozitív és a negatív dolgok között. Ezt követően találunk egy 31 elemből álló kérdéssort az írás végén, melynek segítségével az olvasónak lehetősége nyílik felmérni készségeit a modellel kapcsolatban.

A könyv felépítése könnyen átlátható és követhető az olvasó számára, a fejezetek végén található rövid összefoglalók remek áttekinthetőséget biztosítanak az utólagos összegzéshez is. Az írás alapvetően szaknyelvet használ, így elsősorban a szakemberek és kutatók számára értelmezhető a legkönnyebben, de a témában kezdő olvasónak is bátran lehet ajánlani. Forrásokkal való ellátottsága miatt kiváló alapot jelent egy kutatás elkezdéséhez is.

A KÉZIRATOK FORMAI ÉS SZERKEZETI KÖVETELMÉNYEI

1. Kéziratokat kizárólag elektronikus formában, e-mailen fogadunk.
2. A kéziratok Microsoft Word vagy azzal teljesen kompatibilis szövegszerkesztővel készüljenek!
3. A képek, ábrák, térképek, táblázatok a mellékletben szerepelnek, a szövegben csak jelölni kell a körülbelüli helyüket. Pl. „A 18. táblázat körülbelül ide".
4. A kiadványba – a mérete miatt – maximum 12,25 cm széles ábra/táblázat/kép illeszthető be. Amennyiben A4-es méretben szerkesztik, ellenőrizzék, hogy a megadott szélességben is értelmezhető marad-e. Az ábrákat és a táblázatokat szerkeszthető formában küldjék meg (ne képként)! Az eredeti forrásfájlt mindenképpen kérjük mellékelni!
5. Az alkalmazott betűtípus és méret: **Times New Roman 12. Sortávolság: 1,5.**
6. A formai és irodalmi hivatkozásoknál a kötelezően alkalmazott stílus az **APA**. Lásd részletesen: https://journal.uni-sopron.hu/index.php/gt/szerzoi-utmutato.
7. A kéziratok terjedelme táblázatokkal, ábrákkal stb. együtt nem haladhatja meg a 20 A4-es oldalt (1,5 sortávolság, 12-es betűméret).
8. A cikkek **kötelező** szerkezete:
   a. cím, szerző(k) – titulus, név, beosztás, intézmény **– angolul is kötelező –, csak a kapcsolattartó szerző e-mail elérhetősége**;
   b. magyar nyelvű absztrakt (maximum 200 szó címmel együtt) és maximum **5 kulcsszó/kötelező, JEL kódok/kötelező**;
   c. angol nyelvű cím és absztrakt (maximum 200 szó címmel együtt) és maximum **5 kulcsszó/kötelező**;
   d. bevezetés, célok;
   e. a téma felvezetése, a vonatkozó szakirodalom bemutatása, értékelése;
   f. az alkalmazott módszerek (ha értelmezhető);
   g. a téma tárgyalása/kutatási eredmények (ha értelmezhető);
   h. következtetések/összefoglaló;
   i. irodalomjegyzék (**csak APA stílus**), ha felhasznált forrásművek **DOI szám**mal rendelkeznek, kérjük azokat is feltüntetni (az ISBN vagy ISSN számon túl)!
9. A könyvismertetések terjedelme nem haladhatja meg a hat A4 oldalt (Times New Roman, 1,5 sortávolság, 12-es betűméret). Az ismertetés címe és a szerző neve után szögletes zárójelben meg kell adni az ismertetett könyv, kiadvány teljes bibliográfiai adatait, beleértve az ISBN, ISSN és DOI számot.
10. A követelményekkel nem egyező kéziratokat a szerkesztőség visszaküldi.
11. A szerkesztő fenntartja a jogot a kézirat terjedelmi és minőségi változtatására.
12. Korábbi számok: http://gt.uni-sopron.hu.

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1. Send manuscript by email to gazdasag.tarsadalom@uni-sopron.hu. Email attachments are acceptable.
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5. Papers have to follow the next structure:
   a. Title, completed with the name(s), host institute(s) and academic position(s) of the author(s) or authoress(es) and **one e-mail address of the corresponding author** for further communication;
   b. An abstract in the language of study (not more than 200 words) and a title and an abstract in English too (see APA style). plus 5 keywords maximum and JEL codes;
   c. Introduction, objectives;
   d. Explaining the issue and relevant literature;
   e. Methodology, data sources (if relevant);
   f. Description, findings;
   g. Summary / Conclusions;
   h. References (**we accept APA style only**). See https://journal.uni-sopron.hu/index.php/gt/szerzoi-utmutato.
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9. References should be presented in alphabetical order. See **APA** style.
10. The editor reserves the right to edit all submissions for clarity and length.
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