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Companies on Thin Ice Due to Digital Transformation: The Role of Digital Skills and Human Characteristics

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Companies on Thin Ice Due to Digital Transformation: The Role of Digital Skills and Human Characteristics

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Abstract

The aim of the research is to provide a survey-based result on the individual digital skills and human characteristics of the workforce influenced by digital transformation. The online questionnaire is completed by managers and white collar workers of Hungarian manufacturing companies in spring 2021 (n=489). Descriptive statistics and relationship tests are used for analysing the results. The main findings are: (1) digital transformation reduced the demand for human labour, the workforces have basic digital skills used in a few parts of companies, and the digital transformation has increased the challenge in the lack of digital skills of the workforce. (2) Human characteristics are important as an impact of the digital transformation. (3) The size of the companies influences human characteristics changed as a result of the digital transformation. Managers have to focus on improving human and digital skills of the workforces needed in increasingly digital work environments, therefore providing adequate training is an urgent need while companies undergo digital transformation. The study investigates an important socio-technical phenomena determining how digital transformation places specific demands on individual digital skills. Significant human characteristics such as critical thinking, complex problem solving, adaptability, resilience and creativity are essential to successfully exploit the digital transformation.

Keywords: digital transformation, digital skills, human characteristics, manufacturing

Empresas en Riesgo por la Transformación Digital: El Rol de las Competencias Digitales y las Características Personales

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Resumen

El objetivo de la presente investigación es proporcionar un resultado basado en una encuesta sobre las habilidades digitales y las características personales de los trabajadores afectados por la transformación digital. El cuestionario en línea fue completado por gerentes y trabajadores de “cuello blanco” de empresas manufactureras húngaras en la primavera de 2021 (n=489). Los resultados fueron generados usando estadística descriptiva y pruebas de asociación. Los resultados más relevantes son: (1) la transformación digital ha reducido la demanda de mano de obra, la fuerza laboral tiene habilidades digitales básicas que solo son empleadas en algunas partes de las empresas, y la transformación digital ha aumentado el desafío por la falta de habilidades digitales en la fuerza laboral. (2) Las características personales juegan un papel relevante en la transformación digital. (3) El tamaño de las empresas influye en el cambio de las características personales como resultado de la transformación digital. Los directivos tienen que enfocarse en mejorar de las competencias personales y digitales de la fuerza laboral en entornos de trabajo cada vez más digitalizados, por lo que proporcionar una formación adecuada es una necesidad urgente a medida que las empresas son sometidas a una transformación digital. El presente estudio investiga un fenómeno socio-técnico importante que determina cómo la transformación digital plantea exigencias específicas en las competencias digitales de los trabajadores, en cuanto a las características personales demandará de un pensamiento cada vez más crítico, la resolución de problemas complejos, la adaptabilidad, la resiliencia y la creatividad serán elementos claves para afrontar con éxito la transformación digital.

Palabras clave: transformación digital, competencias digitales, características personales, empresas manufactureras

Digital transformation is the cultural, organisational and operational change of an organisation or ecosystem in all sectors of society and industry through a smart integration of digital technologies, processes and capabilities across all levels and functions, thus completely altering the way businesses are managed, and how value is created and delivered to stakeholders. Digital transformation is currently an important megatrend that penetrates all industrial and societal domains radically changing business models and operations by new digital technologies such as cloud-based applications (Wang et al., 2019), big data (Wang & Wang, 2016), social media (Li et al., 2021), artificial intelligence (Lee et al., 2018), machine learning (Hwang et al., 2020), internet of things (Wan et al., 2016), autonomous robots (Ingrand & Ghallab, 2017), virtual and augmented reality (Hu et al., 2021), and the platform built with these technologies (Bollard et al., 2017). The implementation of appropriate technological innovations involves the possibility to extend a technological innovation to the overall organisational structure (Birkner & Máhr, 2016), thus facilitating the exploitation of environmental opportunities (Valeri & Baggio, 2021). At the beginning, the main attention concentrates around technological aspects of the implementation and there are numerous existing works that discuss the enabling digital technologies (Kagermann et al., 2013; Kozanoglu & Abedin, 2021). The main priority was process automation, thereby reducing the intervention of humans in the operational process (Lasi et al., 2014).

Recently, scholars and practitioners have begun emphasising the criticality of integrating and embodying human factors into digitalised workplaces (Longo et al., 2020). Tabrizi et al. (2019), for example, emphasised that digitalisation is not just a matter of technology but rather a matter of strategy in which the human dimension plays a key role. To address this phenomenon, companies and policy makers are shifting their attention towards a human-centred approach. The European Union, for example, has been encouraging research into methodologies that centralise technology design for values that also encircle the socio-cultural and human considerations (de Saille, 2015). By putting humans back into the loop, Industry 5.0—emphasising the human and machine reconcile and work in perfect symbiosis with one another (Longo, 2020)—profoundly restructures human tasks in terms of the challenges of digital transformation. Recent studies demonstrate that digital transformation requires a set of digital skills and capabilities from workforce.

Organisations need to equip their workforce with digital skills to meet the organisational objectives if they want to benefit from their investments in digital technologies (Kane et al., 2019). A number of recent academic research have stressed that the greatest challenge in many organisations in digital transformation is finding a way for re-imagining the workforce' experience and bringing their digital literacy up to date (Kane et al., 2019; Dery et al., 2017). Human workers should be upskilled to use digital technologies on their own, to provide value-added tasks in production, to work alongside an autonomous workforce (Longo, 2020), and to be able to use the contactless digital technologies (Seeber et al., 2020). The digital transformation era thus evokes a need for digitally-skilled workforces emphasising the importance of digital skills and human characteristics for business growth (Scuotto et al., 2021).

Despite this, while practitioners, scholars and policy makers heavily emphasise the importance of the human component as the soft side of digital transformation processes, yet, there is limited understanding of the impacts of digital transformation on workforce's digital skills and how companies can navigate their workforce through the digital transformation journey. In filling this gap, the research aim is to provide a survey-based result on the individual digital skills and human characteristics of the workforce influenced by digital transformation. Three research questions will be guiding the study:

- RQ1: How has the digital transformation changed the following factors in the company, such as (RQ1a) demand for human labour, (RQ1b) digital skills of the workforce and (RQ1c) challenge in the lack of digital skills in the workforce?
- RQ2: How important are human characteristics as an impact of digital transformation?
- RQ3: Does the size of the company affect the human characteristics changed as a result of digital transformation?

Our work adds to existing research in a number of important ways. This paper contributes to the emerging but as of yet limited literature analysing human labour demand related to digital transformation in Hungarian companies. In the last decades, many international companies transferred their practice and IT solutions to Hungary (Ko et al., 2021). Despite the international impacts in Hungary, based on the EU DESI 2022 index

(European Commission, 2022b), Hungary lags behind in the integration of digital technologies. At the same time, the economic growth of the past period in Hungary was largely based on export oriented production primarily on the ground of available high-value-for-money workforce (Nick et al., 2019). Second, this study aims at identifying how the digital transformation changed the level of digital skills of the workforce. Furthermore, our research aims to firstly improve our understanding of what the main challenges are in the lack of digital skills. As Verhoef et al. (2021) stated, human workers with strong digital skills are required to create value for both companies and customers. Third, we propose to analyse the importance of human characteristics in terms of digital transformation. We also identify whether the size of the company influences the human characteristics changed as a result of the digital transformation. The present study therefore contributes to the discussion by exploring interdependences between digital skills and human characteristics, which may jointly shape the organisational success of the digital transformation journey. Fourth, our results are policy-relevant. The study describes the key human characteristics that universities should take into account designing their study programs and student's learning goals. Higher Education Institutions should up-skill their students making them future-ready to face the challenges caused by digital technology advancements.

The rest of this paper is organised as follows. Section 2 provides an overview of digital transformation, digital skills and human characteristics. Section 3 describes the applied data and the proposed methods. This is followed by the section on results and discussion (Section 4). Finally, in Section 5, we discuss the implications of our results for practitioners and highlight the limitations of our study.

Literature Review

Digital transformation connotes critical challenges, radical changes, new demands which are relevant to the survival of organisations. The fourth industrial revolution (Industry 4.0) evolved in 2011 with the concept of smart manufacturing (Maddikunta et al., 2021), connecting physical manufacturing technologies and digital technologies (Fatorachian & Kazemi, 2018). It focuses on maximising mass productivity and achieving mass production using digital technologies (Echchakoui & Barka, 2020). Industry 4.0

nowadays extends beyond the manufacturing industry borders (Culot et al., 2020), and there is no industry that has not been impacted by digital transformation (Shahi & Sinha, 2020). Industrial differences as a determinant of digital transformation often appears in studies (Bohnsack et al., 2018; Härting et al., 2017). Most of them have focused on manufacturing sector (Hermann et al., 2019; Machado et al., 2021), but there is a shift in recent research from a variety of industries (Vial, 2019), like financial sector (Chanas et al., 2019), music industry (Hess et al., 2016) or education (Bilyalova et al., 2020). Industry 4.0 is driven by digital transformation (Ustundag & Cevikcan, 2017), creating a new ecosystem where technology creates and delivers value, enabling the company to adapt more quickly to changing circumstances (Machado et al., 2021).

Digital Transformation

The concept of 'digital transformation' is originated from the term 'digitalisation', which can be described as the change in organisations' structure and business models due to the adoption of digital technologies such as Internet of things (IoT), artificial intelligence (AI), machine learning, augmented reality (AR) (Kozanoglu & Abedin, 2021) in order to build innovation in products, services and processes (Annarelli et. al, 2021; Machado et al., 2021). These technologies are being referred to as SAMIT, the acronym for social, mobile, analytics, cloud and internet of things (Sebastian & Mocker, 2017; Shahi & Sinha, 2020). Digital transformation is one of the high priority issues of the organisations (Shahi & Sinha, 2020). A comprehensive definition of digital transformation is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019, p. 121).

Digital transformation consists of three main stages (Verhoef et al., 2019). In the first stage organisations go through digitisation, which involves transferring processes and systems (like paper-based) into digital formats (Tekic & Koroteev, 2019). Next stage is, when digitalisation entails further integration and optimisation of digital technologies and IT-enabled capabilities to improve processes and add value to existing operations and

services. Digital transformation is evolved as the final stage in the process and is triggered by extensive digital capabilities (Verhoef et al., 2019).

Prior theories focused on IT-enabled change (Skog et al., 2018; Wessel et al., 2020), but the recent research has shown that technology itself is only part of the complex ecosystem that must be solved for organisations to remain competitive in a digital world. The impact of digital transformation, the speed and scale of current change and the advent of digital technologies has led to radically transforming workplaces (Brynjolfsson & McAfee, 2014) a decreasing demand of workers performing routine manual and cognitive tasks (Bertani et al., 2020), so the amount of manpower required has been reduced (Szabó-Szentgróti et al., 2021). Based on the literature summarized so far, the following hypothesis was formulated.

H1a: Digital transformation reduced the demand for human labour.

Digital Skills and Human Characteristics

The existing literature on digital transformation is mainly focused on technologies and ignores the role of digital skills and capabilities of workforces (Kozanoglu & Abedin, 2021), however some of them highlighted that digital transformation is not only about technology (Kane et al., 2015) but requires a focus on human factors (Hess et al., 2016), enables questions on the need to develop the skills of existing workers (Hess et al., 2016) as well as the skills required for future workers who will form the digital workforce (Colbert et al., 2016; Watson, 2017). Digital technologies improve the autonomy of workforces, but the demand for advanced digital-skilled workers will rise (Tabarés et al., 2018; Kozanoglu & Abedin, 2021). Industry 5.0 will be focusing on the creativity of humans working together with efficient, intelligent and accurate digital technologies (Maddikunta et al., 2021).

Developing, finding or competing for digital-skilled workforce is often mentioned as a major challenge during digital transformation (Karacay, 2018; Horváth & Szabó, 2019; Obermayer et al., 2022) and also has a high priority in the European Union (European Commission, 2022a). In 2021, only 54% possessed at least basic digital skills and less than one third of Europeans possessed above basic digital skills (26%), which means that a large part of the EU population still lacks basic digital skills, even though most jobs require such skills (European Commission, 2022a).

In the past companies used to handle particular business units, but as the businesses are becoming technology-driven through the digital transformation, they require integration and collaboration from all parts of the company (Sebastian & Mocker, 2017). Achieving benefits through the successful adoption of digital transformation, organisations need to tackle digital skills at different levels of their business (Eller et al., 2020).

Based on the literature presented so far in this chapter, the following hypotheses were formulated.

H1b: The workforces have basic digital skills used in a few parts of companies. H1c: The digital transformation has increased the challenge in the lack of digital skills of the workforce.

Digital transformation requires workforces not only to possess digital skills, moreover to depend more heavily on other individual characteristics (Dremel et al., 2017). Increased uptake of digital-skilled workforce is accompanied by growing skills shortages in the labour market, where reskilling and upskilling workforces is one of the most critical challenges (Trenerry et al., 2021). Leading consulting firms (World Economic Forum, 2020; McKinsey, 2021) predict that most companies have increasing skills gaps, and they need workforces with a range of skills, such as critical thinking, complex problem solving, adaptability and resilience (Trenerry et al., 2021) as top skills needed in today's workforce. There is also a growing emphasis on the importance of soft skills such as problem solving and creativity in technology-driven environments (Börner et al., 2018; Grundke et al., 2018). In the study of Chuang & Graham (2018), alongside greater demand for highly specialised skills employers also emphasised essential human skills like creativity, problem solving skills, and critical thinking. Based on the literature presented in this paragraph, the following hypothesis was formulated.

H2: Human characteristics such as critical thinking, complex problem solving, adaptability, resilience and creativity are important as an impact of the digital transformation.

Digital transformation is believed to provide companies, in particular small and medium-sized enterprises (SMEs), with valuable advantages vital to their future competitiveness and survival (Chen, 2019; Moeuf et al., 2018). The digital transformation process involves multidisciplinary activities, and

requires a large number of experts, which may not be present in all companies, like SMEs (Colli et al., 2018). Several studies investigated large enterprises (Frank et al., 2019) or SMEs (Ghobakhloo & Ng, 2019; Won & Park, 2020) regarding adoption of digital technologies. Härting et al. (2017) found the size of the company as an influencing factor of digitalisation for business. The majority of the experts mentioned that a small sized company is often more flexible and faster, however large companies are more experienced and also have a bigger capital base to digitalisation. DESI 2021 report indicates that the digitalisation of larger businesses is promising, but the vast majority of SMEs are not taking advantage of digital technologies in Europe (European Commission 2022a). Most SMEs suffer from the lack of expert workforces necessary for implementing advanced digital technologies (Horváth & Szabó, 2019; Stentoft et al., 2020). Based on the literature presented in this paragraph, the following hypothesis was formulated.

H3: The size of the company influences the human characteristics changed as a result of the digital transformation.

Methodology

The first subchapter describes the data used for research in the framework of the research model, and the second presents the methods of the analysis.

Data Collection and Research Model

The data used for the analysis come from a primary source, namely an online questionnaire survey conducted in the spring of 2021. 54291 companies were invited to complete the questionnaire, whose email addresses were retrieved from the Orbis database¹. The companies were screened from Orbis in two stages: first the Hungarian companies were selected, then the manufacturing (non-service) companies. The questionnaire was completed by managers and white collar workers of Hungarian manufacturing companies (n=489). The questions analysed are listed in Table 1.

Table 1.

Examined questions of the questionnaire

Category	Variable	Response options and their codes
I	Explanatory variable	
	1 number of employees	1: 1-10 people 2: 11-50 people 3: 51-250 people 4: More than 250 people
II-III	Response variables	
II	How has the digital transformation changed the following factors in the company?	
	2 demand for human labour	1: significantly decreasing 2: moderately decreasing 3: moderately increasing 4: significantly increasing
	3 digital skills of the workforce	1: basic digital skills in one part of the company 2: basic digital skills in a few parts of the company 3: advanced digital skills in a few parts of the company 4: advanced digital skills in many parts of the company
	4 the challenge in the lack of digital skills of the workforce	1: not increased at all 2: slightly increased 3: greatly increased 4: fully increased
III	As an impact of digital transformation, how important are the following human characteristics in the company?	
	5 adaptability	1: not important at all
	6 creativity	2: rather not important
	7 critical thinking	3: rather important
	8 complex problem solving	4: very important
	9 resilience	

Table 1 also serves as a research model, as it groups the questions of the questionnaire according to whether they were considered as explanatory or response variables. In the context of relationship analyses, the research

primarily focuses on whether the size of the company (measured by the number of employees) influences the changes that have taken place in the company as a result of digital transformation. Therefore, the explanatory variable is the number of employees and all other variables are response ones.

Data Analysis Method

Descriptive statistics and relationship tests are used as research methods. For each question, the following descriptive statistics are presented: the typical answers (the modes), the averages and the relative standard deviations, and the frequency of the answers.

All possible relationships between the answers to the 9 closed questions listed in Table 1 were examined, which means a total of 36 relationship tests. The level of measurement of the questions determines what indicator can be used to quantify the relationship that may exist between them. The answers to the closed questions listed in Table 1 can all be measured on an ordinal scale. Each of the questions related to digital transformation can be measured on a Likert scale from 1 to 4. The rank correlations between them can be revealed by the Kendall's Tau (τ) index, which moves in the interval $[-1, 1]$. Relationship analyses are interpreted at a significance level of 5% by SPSS software. In the case of significant relationships, the absolute value of τ gives the strength of the relationship (Sajtos & Mitev, 2007):

- 0: there is no relationship
- $[0, 0.2[$: weak relationship
- $[0.2, 0.7[$: moderate relationship
- $[0.7, 1[$: strong relationship
- 1: deterministic relationship

Since the τ rank correlation coefficient can take both positive and negative values, its sign can also be interpreted as the direction of the relationship. Negative τ means that the higher (lower) the rank of one variable, the lower (higher) the rank of the other variable. Positive τ means that the higher (lower) the rank of one variable, the higher (lower) the rank of the other variable.

Findings and Discussion

In this section, first descriptive statistics is presented, then the results of the relationship analysis are introduced.

Descriptive Statistics

The sample contains 489 evaluable responses (n=489). 11% of the respondents are white collar workers, and 89% are managers (72% top managers, 14% middle managers and 3% lower-level managers). In the first step, the typical (Mode) and average (Mean) responses to the questions listed in the research model (Table 1) are examined, as well as the dispersion of the answers relative to its mean (RSD: Relative standard deviation). The results are summarised in Table 2.

Table 2.

Descriptive statistics (n=489)

Variables	Mode (1-4)	Mean (1-4)	RSD (%)
I 1 number of employees	2	2.24	37.78
II How has the digital transformation changed the following factors in the company?			
2 demand for human labour	2	2.15	26.55
3 digital skills of the workforce	2	1.91	43.55
4 the challenge in the lack of digital skills of the workforce	3	2.70	27.96
III As an impact of digital transformation, how important are the following human characteristics in the company?			
5 adaptability	4	3.52	19.01
6 creativity	4	3.54	19.46
7 critical thinking	3	3.19	24.05
8 complex problem solving	4	3.61	17.31
9 resilience	4	3.47	20.60

RSD: Relative standard deviation

Colour Key by columns: the lower  the higher values

The columns of Table 2 were coloured from red background (low value) to green background (high value). Regarding the importance of each characteristic and the difficulty of finding such workforces, the majority of responses were relatively similar. Based on the modes, it can be concluded that the majority of respondents consider that all human characteristics are very important (code 4) or important (code 3). The average responses also indicate the same, and the opinions of the respondents deviated relatively less from the mean (relative variance less than 30%).

In the second step figures illustrate the frequency of the responses for each question. In case of the explanatory variable, i.e. the size of the company measured by the number of employees: more than half of the respondents (53%) are small companies with 11-50 workforce, 20% are medium-sized companies with 51-250 workforce, 17% are micro-enterprises with up to 10 workforce, 10% are large enterprises with more than 250 workforce (see Figure 1). This reflects the entire Hungarian corporate sector in view of the predominance of small and medium-sized companies.

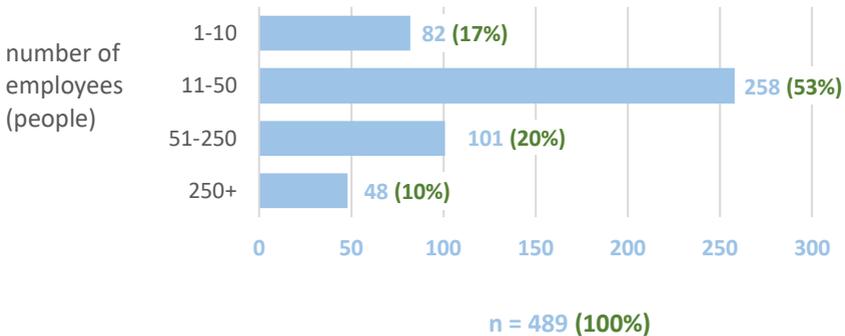


Figure 1. Number of employees

The responses on how the company's demand for human labour has changed as a result of digital transformation are presented in Figure 2.

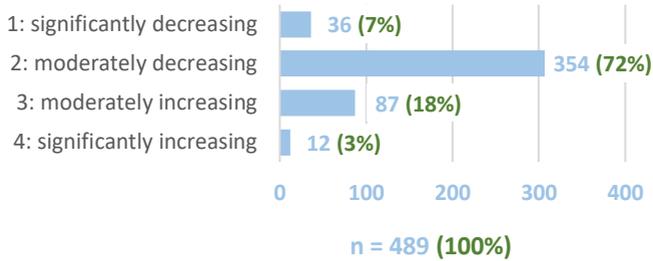


Figure 2. How has the digital transformation changed the demand for human labour?

The results show that 21% of the respondents considered that the demand for human labour in their company has increased. According to 79% the demand for human labour has decreased, but only moderately.

Based on these results, hypothesis H1a (digital transformation reduced the demand for human labour) is acceptable. This result is consistent with the theory of Bertani et al. (2020) and Szabó-Szentgróti et al. (2021) as the need for human workforces whose task is mainly manual, routine work is decreased.

Figure 3 shows the level of digital skills of the workforce horizontally dispersed within the company. 75% of the companies have workforces with basic digital skills in one or few parts of the company and 25% have advanced digital skills.

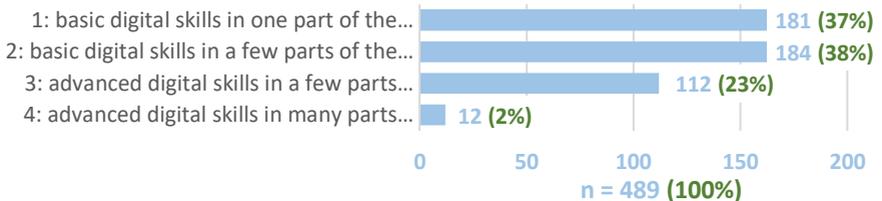


Figure 3. How has the digital transformation changed the digital skills of the workforce?

Based on these, hypothesis H1b (the workforces have basic digital skills used in a few parts of companies) is acceptable. Analyses have shown that the majority of respondents have only basic digital skills in line with the statistics

of the European Commission (2022a), however our result is higher than the EU average (56%), even the Hungarian one, where only 49% of the population possess basic digital skills (European Commission, 2022b). It means that the workforces of the Hungarian manufacturing companies have basic digital skills above the average. From the point of view of the parts of the company, contradicts the results of the following authors: Sebastian & Mocker (2017) and Eller et al. (2020) as they emphasised that in the era of digital transformation, companies require digital skills in all parts of the company, but the Hungarian manufacturing companies lag behind and have workforces with basic skills only a few parts of the company.

According to Figure 4, the lack of digital skills in the workforce is seen as a major challenge to the company by the majority of respondents. 95% of them consider that the challenge is increased slightly, greatly or fully in relation to the lack of digital skills of the workforce.

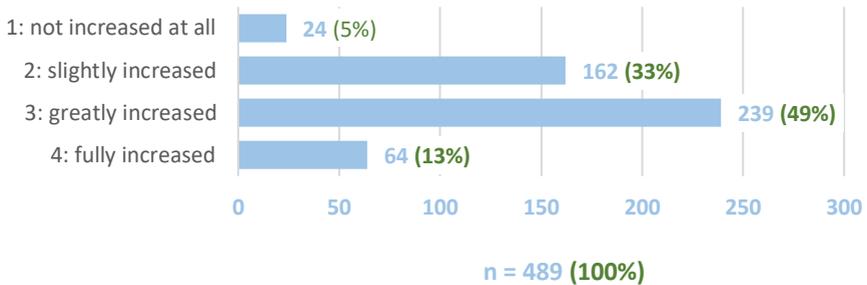


Figure 4. How has the digital transformation changed the challenge in the lack of digital skills of the workforce?

Based on these, hypothesis H1c (the digital transformation has increased the challenge in the lack of digital skills of the workforce) is acceptable. According to the analysis, our findings are also consistent with previous studies (Obermayer et al., 2021; Karacay, 2018; Horváth & Szabó, 2019) as one of the biggest challenges in digital transformation is that companies do not have or do not find a workforce with digital skills.

Figure 5 illustrates the importance of the examined human characteristics.

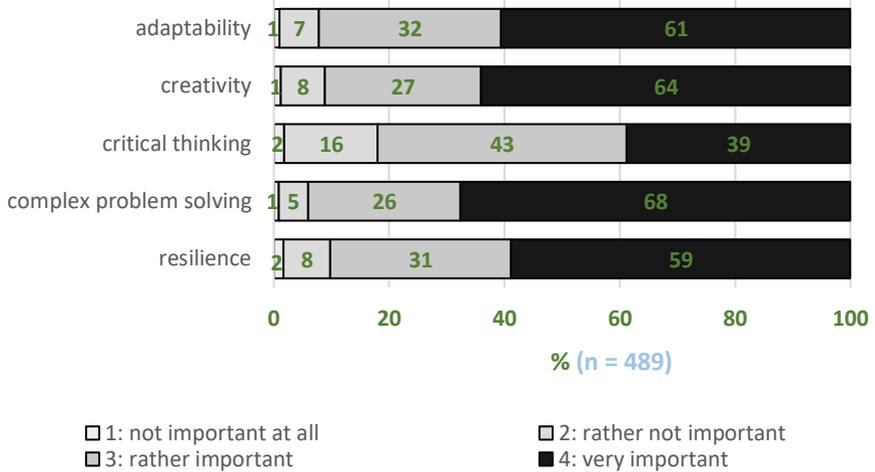


Figure 5. As an impact of digital transformation, how important are the following human characteristics in the company?

The more important a characteristic is, the darker the background colour. According to the vast majority of responses all human characteristics are very important (or important). Based on the mean of Table 2, the most important human characteristic is complex problem solving, the second one is creativity, the third is adaptability, the fourth one is resilience and last one in this survey is critical thinking.

Based on these, hypothesis H2 (human characteristics such as critical thinking, complex problem solving, adaptability, resilience and creativity are important as an impact of the digital transformation) is acceptable.

Our findings are consistent with previous studies, such as Trenerry et al. (2021), World Economic Forum (2020), McKinsey (2021), Börner et al. (2018), Grundke et al. (2018), and Chuang & Graham (2018), that a greater demand for workforces with such human characteristics are emphasised.

Relationship Analysis

After reviewing the answers to each question, this section presents the results of the relationship analyses (Table 3).

Table 3.

The results of the relationship analysis: the significant Kendall’s tau (τ) correlation coefficients

			I	II How has the digital transformation changed the following factors in the company?				III As a result of digital transformation, how important are the following human characteristics in the company?				
			1	2	3	4	5	6	7	8	9	
I	1	number of employees			.261		.109					
II	2	demand for human labour						.119	.109			
	3	digital skills	.261				.172			.101		
	4	the challenge in the lack of digital skills					.146	.118	.116	.119	.108	
III	5	adaptability	.109		.172	.146		.407	.272	.413	.271	
	6	creativity		.119		.118	.407		.476	.502	.414	
	7	critical thinking		.109		.116	.272	.476		.405	.395	
	8	complex problem solving			.101	.119	.413	.502	.405		.474	
	9	resilience				.108	.271	.414	.395	.474		

Colour Key: the strength of the significant results is:

weak	$0 < \tau \leq 0.2$
moderate	$0.2 < \tau \leq 0.7$
strong	$0.7 < \tau < 1$
deterministic	$ \tau = 1$

The diagonal of Table 3 shows the deterministic relationships with a black background (this means the perfect correlation of each variable with itself). No significant relationship was detected in the empty cells. For significant relationships, cells with a yellow background indicate a weak relationship,

and those with a blue background mark a moderate relationship.

All τ values are positive, which means that if one of the questions was answered with a higher (lower) code, the respondents of the questionnaire were given a higher (lower) code (the coding of the answers is given in the last column of Table 1).

The relationship analysis primarily seeks to answer whether the size of the company significantly influences the response variables (RQ3). There were two significant relationships (Table 3), one moderate and one weak (there was no strong correlation). These significant relationships mean that the more workforces a company have,

- the more parts of the company have more advanced digital skills,
- the more important the adaptability of the workforce is.

Based on the results of the relationship tests presented so far, hypothesis H3 (the size of the company influences the human characteristics changed as a result of the digital transformation) is only partially acceptable as of the 5 characteristics examined, it is only confirmed for adaptability.

Our finding is unique in that sense, no one examined the relationship between these characteristics and the size of the company. We can conclude that adaptability is the most important human characteristic for the larger companies. As new technology evolves, companies established in the traditional ways may have difficulty competing with major competitors, so they are looking for workforces who can demonstrate strong adaptability skills.

In addition, the relationships between the response variables were also examined. The changes perceived by the company due to digital transformation correlates significantly (weakly) with the importance of human characteristics in half of the possible relationships:

- The more the respondents consider that the demand for human labour has increased as a result of digital transformation, the more important it is to have workforces with the following characteristics: creativity and critical thinking.
- The more parts of the company have advanced digital skills, the more important it is to have workforces with the following characteristics: adaptability and complex problem solving.

- The bigger the challenge in the lack of digital skills of the workforce considered by the respondents, the more important all of the human characteristics are.

Within the category III all relationships are significant and moderate. This means, the more important one human characteristic is, the more important the other one is. The strongest relationship is between the importance of creativity and complex problem solving. This means that in the case of these 2 of the 5 human characteristics examined, it is most likely that the more important one is valued, the more important the other is also valued.

Our results are similar to those reported by Trenerry et al. (2021), World Economic Forum (2020), McKinsey (2021), Börner et al. (2018), Grundke et al. (2018), and Chuang & Graham (2018), that these human characteristics are very important as companies must ensure that their workforces have the right skills as they undergo digital transformation, where human labours are one of the most important resources available. Our finding is however significant as it seems that all characteristics are standing together. That is why it is necessary to focus on the right training and upskilling of the workforces.

Summary and Conclusions

The aim of the research was to provide a survey-based result on the individual digital skills and human characteristics of the workforce influenced by digital transformation.

There were three main research questions, the first two were descriptive and the third was related to relationship tests. The first research question and the accompanying hypothesis were as follows:

RQ1: How has the digital transformation changed the following factors in the company, such as (RQ1a) demand for human labour, (RQ1b) digital skills of the workforce and (RQ1c) challenge in the lack of digital skills in the workforce?

H1: Digital transformation reduced the demand for human labour (H1a), the workforces have basic digital skills used in a few parts of companies (H1b), and the digital transformation has increased the challenge in the lack of digital skills of the workforce (H1c).

Based on the analyses, H1 was accepted, because

- 79% of the respondents had found that the demand for human labour in their company has decreased, but only moderately (72%) rather than significantly (7%).
- 75% of the companies, there are basic digital skills in one (37%), or a few parts of the companies (38%).
- 95% of them consider that the challenge is increased slightly, greatly or fully in relation to the lack of digital skills of the workforce.

The second research question and the accompanying hypothesis was as follows:

RQ2: How important are human characteristics as an impact of digital transformation?

H2: Human characteristics such as critical thinking, complex problem solving, adaptability, resilience and creativity are important as an impact of the digital transformation.

Based on the analyses, H2 was accepted, because according to the vast majority of responses all human characteristics are very important (or important): in case of

- complex problem solving: 94%
- adaptability: 92%
- creativity: 91%
- resilience: 90%
- critical thinking: 82%

The third research question and the accompanying hypothesis were as follows:

RQ3: Does the size of the company affect the human characteristics changed as a result of digital transformation?

H3: The size of the company influences human characteristics changed as a result of the digital transformation.

Based on the analysis H3 was only partially accepted because company size (variable 1) was significant in only 2 of the 8 possible relationships. The larger the company,

- there are advanced digital skills at more parts of the company ($\tau = 0.119$), and
- the more important the workforce with adaptability ($\tau = 0.109$).

Practical Implications

The ability of workforces to acquire new digital skills and develop human characteristics is a high priority. Digital transformations mean change and uncertainty for the companies and their workforces. Thus, it is seen that resilience and adaptability will be key skills for digital transformation, as both of them are about adapting and coping with significant changes or difficulties. Workforces with such skills can be more successful during the transformation process as they are more proactive and take responsibility for adapting to changing situations. A company that informs, develops, and engages workforces has the advantage of leveraging their in-depth knowledge to be automated and preparing retraining. Supporting workforces feel confident that they can develop digital skills needed to succeed in the era of digital transformation is critical. Upskilling or retraining is an important precursor to the digital transformation, as studies and our results have shown that workforces need human and digital skills in increasingly digital work environments. It means that providing adequate training is an urgent need while companies undergo digital transformation. In Hungary the government has launched the “National Digitalisation Strategy 2021-2030”, which lists three priority areas for digital skills: developing digital competence (based on the DigComp framework); increasing the number and qualifications of IT professionals and engineers; and supporting the structural change needed to develop digital skills in education and vocational training. This strategy provides a framework to upgrade digital skills of citizens, the workforce and IT professionals. As part of the Operational Programme Digital Renewal (DIMOP) Plus, in the priority project “Development of basic digital competence for citizens”, Hungary will organise trainings for 110 000 people with no digital skills. The programme focuses on developing the digital skills of the working age population through both upskilling and reskilling. This large-scale training scheme has had more than 250 thousand participants (European Commission, 2022b).

Limitation and Future Work

Despite these contributions, the current study has certain limitations that offer opportunities for further research. First, only manufacturing companies are

examined. Thus, the results should not be directly applied to, for example, service companies. Therefore, future research would be useful to investigate the service sector. Second, data is from a single country, which is a constraint of generalisation. As further research, since the topic is relevant and under-researched, other countries should be analysed. Thus, the conclusions of this paper can be testified in different country contexts and can be compared and extended. This would provide further validity of our study.

Third, given the quantitative nature, further qualitative research may be needed to produce more nuanced insights. A case study method, for example, allows investigating the phenomenon of interest within its broad context (Yin, 2014). The case study is suitable for exploring corporate good practises, especially in terms of improving workers' digital skills and human characteristics, which can be used to overcome the challenges mentioned and to achieve digital transformation successfully.

Despite these limitations, we have provided a timely discussion on an important socio-technical phenomena and emphasised how digital transformation places specific demands on individual digital skills and human characteristics. We hope that this research will stimulate future research on digital transformation exploring and analysing specific digital skills and human characteristics needed to successfully exploit the digital transformation.

Notes

¹ Orbis is a non-free database of Bureau van Dijk (Moody's Analytics since 2017) that manages the financial data of nearly 400 million companies worldwide.

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