Different Approach of the Digital Transformation at SME

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Abstract: The spread of Industry 4.0 technological solutions is fundamentally transforming the value creation processes of for-profit organisations in technology-intensive and non technology-intensive industries alike. An analysis of the transition (digital transformation) from Industry 3.0 to Industry 4.0 requires understanding the various factors that come into play in the establishment of the ICT infrastructure and the inter-relatedness of the various infrastructural elements of Industry 4.0 and its previous generations. Since in Hungary, digital transformation processes were previously only assessed with qualitative means, a questionnaire-based survey was conducted among Hungarian profit-oriented for-profit organisations in 2018 with the involvement of 498 respondents. The aim of the research presented here is to show that the ICT infrastructure in the life of a business organisation is not simply the result of an internal decision, but is also influenced by external factors. Furthermore, the article shows that, on the one hand, a well-functioning ICT infrastructure is perceived by top management as an operational, tactical and strategic benefits that can motivate innovation, and on the other hand, it provides the technological background for innovation. A research model has been set up and validated by descriptive and inferential statistical procedures to process the data from the questionnaire responses. The result is a model that explains under which boundary conditions a supportive role of ICT infrastructure can be expected to stimulate further innovation in business organisations.

Keywords: digital transformation; enterprise architecture; Industry 4.0; Internet of Things; small- and medium enterprises; supply chain

1 Introduction

The sudden, recent – in the past decade – shift and development of business-oriented information and communications technology (ICT) solutions have fundamentally changed the value creation activities of for-profit organisations. These technological advancements (including, but not limited to: Internet of Things, Artificial Intelligence, smart robots, augmented reality, Big Data, Blockchain, etc.) are collectively referred to as Industry 4.0 technologies [1].

The extent and speed of this transformation is so great that the for-profit organisations are facing a technological paradigm shift [2, 3].

Although the impact of the regular use of Industry 4.0 technologies is noticeable on the for-profit organisations, industrial and national economy levels [4], the present research shall focus on the level of enterprises: the impact of Industry 4.0 on for-profit organisations – based on Porter's Value Chain [5] – has an effect both primary and secondary activities. Industry 4.0 solutions support business competitiveness in several ways: some of them are quantitative, while others are qualitative. The qualitative dimension can be understood as, on the one hand, the replacement of human labor reduces wage costs and, on the other hand, a lower error rate reduces material costs of production. The quantitative dimension means that value-creating processes can react more quickly to changes in the market and customer needs, thus achieving higher customer satisfaction [6]. A noticeable similar development can be seen also in the field of support processes. Through the example of controlling activities, the cited article [6] demonstrates that as a support activity, the analysis of a larger quantity and broader body of historical and current data allow for a more accurate and better data quality. The accessibility of the advanced analysis is more suitable for supporting the management in achieving the long-term, strategic goals [7].

On the sectoral level, it is worth making a distinction between two phenomena: firstly, the production of numerous – previously non-technology-intensive – industries can be revolutionized by Industry 4.0. The best example of this is agriculture [8, 9] – which is faced with significant challenges all across the world due to global warming – or logistics, where the challenge is precisely to reduce carbon dioxide emissions, one of the causes of global warming, through increased efficiency. Apart from revolutionizing production processes, it can also have significant impact on previously non-technology-intensive sectors since Industry 4.0 solutions enable previously unfeasible production innovations as seen in the development of smart garments in the different industries [8, 10]. By analogy, even in the case of industries that were previously considered technology-intensive, there is a noticeable tendency of Industry 4.0 solutions realizing previously "unimaginable" innovations [2, 8].

The spread of Industry 4.0 represents a significant advancement within organizations as well as in terms of international relations as it functions as a catalyst through the vertical and horizontal supply chain integration of various for-profit organisations, standardizing data flow and integrating various production systems across organizations [11]. This is of great significance in terms of industrial relations, for example, in the case of the agricultural and food industry, where the same product is taken through the supply chains of companies belonging to various industries (thus realizing the domino-effect) and the product intended for end use must comply with strict legal requirements [12]. At the same time, however, although some Hungarian SMEs are not familiar with the term Industry 4.0, they still use some of its elements [13] and the majority of SMEs recognise the advantages of digitalization in terms of financial performance, operation and strategic performance. The use of Industry 4.0 elements amongst Hungarian SMEs were in more studies examined, showed that small and mid-size enterprises mostly employ Industry 4.0 elements in the fields of customer relations, management and administration, as well as logistics [14, 15].

As pointed out above, the definition of Industry 4.0 includes a number of recently developed technological innovations. Although some publications treat these technologies as equals [3], the IoT-technology must be considered as the most fundamental Industry 4.0 technology. This is simply because IoT-systems enable data collection through their sensors, which means this is the point where the real, physical world is converted into data, which is then forwarded to another device or server through a data transmission system and then executed in a partly or fully automated manner through a decision-making process based on Big Data-analysis and artificial intelligence. Regardless of whether the sensors provide structured (e.g. production data) or non-structured data [6, 8, 11], the cited publication shows that Industry 4.0 is inevitable based on the continuous, high-accuracy provision of data.

The research presented in this publication is motivated by the need to build a model based on data from Hungary that analyses what can motivate the notoriously – and as we have seen in the demographic characterisation – capital-poor Hungarian SMEs to invest in their ICT infrastructure and become open to innovation in Industry 4.0 solutions. In the second chapter the literature background of the research is presented. In the third chapter the questionnaire survey will be described on which the research presented here is based. In the fourth chapter, the theoretical model of the research and the related questions of the questionnaire will be presented, as well as the statistical analysis of the responses to the questionnaires. In the last chapter before the final one, the results of the statistical analysis are evaluated and finally conclusions are drawn.

2 Literature Review

Measuring the impact of Industry 4.0 technological solutions integrated into the value creation processes of companies on profit-oriented organizations is hindered by the fact that one must take stock of a number of – vastly different – technologies when striving for an exhaustive overview [16]. When examining the relevant qualitative studies [17, 18] it becomes apparent that indeed, there are great differences in the spread of these technologies. Nevertheless, the analyses of scientific literature place greater emphasis on two technological solutions: cloud technology and IoT-technology [19].

In relation to IoT-technology solutions, it is important to stress that these solutions are capable of the followings: They are capable of collecting data through sensors and making operational decisions when appropriate. The collected data can be forwarded data by connecting to a data network (LAN). This can take place in a centralized and/or decentralized manner known as M2M communication. And these solutions are capable of executing external decisions or decisions that were previously made autonomously in the form of control [20].

There have been a number of studies on the subject of digital transformation that address the difficulties of introducing Industry 4.0 technologies [16, 21]. Agostini-Nosella [22] studied the various Industry 3.0 technologies that can serve as a basis for Industry 4.0 solutions. By analogy, the study presented in my publication is based on the idea that the results of Industry 4.0 are technologically based on the IT solutions of Industry 3.0 [23, 24], connected to a somewhat integrated corporate governance system. The use of ICT infrastructure solutions tied to the Industry 3.0 "generation" is of great significance not merely because it is based on or supplements its solutions [10], but also because the driving force behind the implementation of Industry 4.0 solutions is that the management of for-profit organisations are capable of sensing and appreciating how ICT-solutions help companies stay afloat in the market competition [25]. The "source" of these challenges can lie within the economic operator (e.g. cost-efficiency) or can originate from outside the organization – for example, when the economic operator in question is an integral part of a larger, integrated supply chain. Amongst the various success factors of company IT systems, a number of authors mention the preparedness and attitude of market partners towards the implementation and integration of ICT solutions [26]. Of these, special mention must be made of the publication of Acar et al. [27], which used quantitative means to demonstrate the connection between the use of ERP, the integrating role of the supply chain and company efficiency. In his study, he followed a similar course [28] of measuring the company efficiency of respondents through "self-assessment" and did not rely on any financial-accounting data to measure the impact of ERP systems. An evaluation based on such a "self-report" can only be successful if workers using the information system share relevant information and experiences. This is also understood in the dimension of sharing knowledge and experience gained from the use of the information system, but also in the dimension of ensuring the flow of information within the company, so that top management can get a picture of the real benefits of using a particular ICT solution and the innovation potential that is to be exploited. The research by Mura et al. [29] shows precisely that this attitude is clearly evident in around 60% of companies, and is a problem in less than a fifth (19%) of companies.

The main aim of this research is to verify that successful ICT-innovation has certain external factors (such as the integration into a supply chain) and internal factors (e.g. the pursuit of efficiency) while it is also necessary for the decision-makers of for-profit organisations to sense the advantages of the ICT-infrastructure [30]. This research is built on the assumption that the management of business organisations can make a sophisticated distinction between the exact nature of the benefits derived from ICT infrastructure. The main aim of this study to examine how typically "Industry 3.0" solutions of Hungarian SMEs set the stage in terms of technology and business for the regular use of Industry 4.0 solutions.

3 General Overview of the Survey

The results stated in the present publication were collected through a questionnaire-based survey conducted in two waves (from spring 2019 to autumn 2019). The questionnaire included a total of 78 questions and the purpose of the survey was to examine the ICT infrastructure and information security relations of the respondent for-profit organisations in the light of senior management satisfaction. The survey was conducted with non-anonymous means, which allowed for establishing connections between the responses and the data published in the respondent is financial reports. The questionnaire was structured in a way that allowed a senior manager to complete it in 12-15 minutes, accordingly placing emphasis on economic and IT-related questions.

Based on the financial reports submitted by respondents in 2018 pursuant to Hungarian accountancy rules, in my study the distribution of for-profit organisations involved in the survey were examined based on their balance sheet total and staff numbers. (Three of the respondents are only engaged in IFRS reporting, therefore, their information was not listed in the official databases could be used for the survey.) The classification of respondents based on balance sheet total and staff numbers are presented in Table 1 below:

Table 1

Distribution of respondents by balance sheet total and staff numbers (source: own ed.)

Staff	**Balance sheet total (in HUF)**					
	less than 1 million	**1–10 million**	**10-35 million**	**25-100 million**	**more than 100 million**	**Total**
> 10	90	4	0	0	0	94
11–50	211	41	0	0	0	252
50–250	30	87	5	3	1	126
250	1	10	10	2	0	23
Total	332	142	15	5	1	495

Left-sided asymmetry is clearly observable along both dimensions and presumably the survey results were greatly influenced by the significant overrepresentation of for-profit organisations with a low balance sheet total.

The respondents were not classified by industry as there was no available database to reliably classify the various businesses in one or more industries. The spot-check like analysis has led me to the conclusion that based merely on the scope of operations listed in the company register (TEÁOR number, unified sectoral classification system of economic activities), The respondents cannot be classified reliably in one or more industries. Nevertheless, for-profit organisations that are presumably required due to compliance with the regulatory environment to obligatorily use IT devices were not approached to complete the survey. The goal was to only have managers complete the survey who are the heads of for-profit organisations where the use of ICT devices is based solely on personal discretion.

4 Research Model and Analysis of the Results

In the sub-survey of the survey outlined in the previous chapter which is presented in the current publication, the respondents of the questionnaire are analyzed based on a simplified model of the transition from Industry 3.0 to Industry 4.0, while also examining the extent to which the senior management of the for-profit organisations are capable to sensing the advantages of the ICT infrastructure services. If this is true, then they are able to make accurate decisions in order to choose the right IT solution to achieve the competitive advantage they want to achieve. In this case, the company's management is able to perceive in time when and how to integrate Industry 4.0 solutions into the life of the company. The survey model is summarized in Figure 1 below:

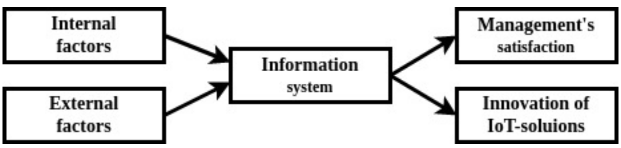

Figure 1
Theoretical model of the survey (source: own ed.)

Only the questions of the questionnaire will be processed for the verification of the model, and accounting data shall not be used for this sub-research.

4.1 Relevant Questions of the Questionnaire

In the following, the questions of the questionnaire and the manner of their processing will be presented. Hereinafter, the various questions shall be represented by their number and with variables representing the question (indicated in parentheses at the end of the question).

In the research presented in this publication, three groups of questions from the questionnaire were processed. Two out of the three groups of questions had to be answered in the same way. Question group 'A3' was used to assess the position of the company in the supply chain and to determine the character of the perceived competition in the market. On this onset, this set of questions asked about economic relations. Question group 'C1' asked about the company's use of classic IT infrastructure elements typical of the Industry 3.0 era and senior management satisfaction with the benefits of the ICT infrastructure. Questions belonging to these two groups had to be answered on a five-point Likert scale. This scale was in line with conventional Hungarian evaluations (1: the worst; 5: the best) and therefore the responses to the questions are on an ordinal scale. For the sake of standardized evaluation, for normalization, the transcoding was carried out as follows: answer number one was transcoded as 0, answer number two as 0.25, answer number three as 0.5, answer number four as 0.75 and answer number five as 1.

Question group 'D1' assessed the stage of adoption of IoT-based solutions. The respondents gave replies to the group of questions on a Likert scale of one too five. The five possible responses are as follows: “Do not use”, “Planned”, “Under implementation”, “Partly introduced” and “Introduced”. The possible responses greatly resemble the categories of Klisenko–Serral [31], although the research results were not available at the time the questionnaire was designed. The responses delineate a developmental trajectory. Therefore, the responses to the questions are on an ordinal scale. During transcoding, the responses were assigned values of 0, 0.25, 0.5, 0.75 and 1.

Each question is listed following the logic of Figure 1.

4.1.1 External Factors

External factors include the following questions:

A3/1. Our company is under considerable pressure to innovate (pinn).

A3/3. Procurements are made out electronically in an automated form (eprch).

A3/4. Sales are made out electronically in an automated form (esll).

Questions 3 and 4 are clearly questions that measure e-commerce activity. This becomes relevant because with the increasing intensity of e-commerce, it can be assumed that data exchange is increasingly automatic and that supply chain activity and related data exchange is increasingly auto-automated. The questionnaire was an attempt to distinguish between B2B and B2C activities. However, the variable representing this question showed no significant correlation to any other variables representing other questions, therefore, it was no longer a part of the analysis.

The innovative character of market competition has been considered an external factor because innovation pressures can be assumed to differentiate the products/services of each actor in the competitive market, so that significant operation influencing information is flowing from the market.

4.1.2 Internal Factors

Internal factors include the following questions:

A3/2. Our company is under considerable price competition pressure (pprc).

A3/6. The implementation/development of IT system(s) have had an impact on the company's structure and/or business processes (icteff).

Question 2 is included as an internal factor because in the case of price competition, it is assumed that there is a segment of the market where buyers are price sensitive, so that the path to market success is partly or entirely through lower prices. A lower price is achieved through lower costs, which implies significant internal efficiencies. The question 6 clearly asks about the impact of IT-Alligment, i.e. whether the respondent has gone through a process of harmonisation between the operation of the company and the operation of the ICT infrastructure.

4.1.3 Information System

The information system part consists of two questions. One question asks about the business processes that are the basis of the information systems, and the other examines the presence of integrated systems. An integrated system can be expected to support all or at least most of the business activities:

A3/5. Low (1) or high (5) degree of automation in production/services (arate).

C2/1. Using standalone software (1) or integrated (5) systems (intsys)?

4.1.4 Management's Satisfaction

The questions of the group C2 basically measure the satisfaction of the condition of the ICT-infrastructure and its operation. As the various questions of the questionnaire covered numerous fields, there are questions on the subjective experiences related to the operation of the ICT-infrastructure from five different approaches. Throughout the survey, respondents were asked about the efficiency-improving effect of the ICT-infrastructure on operative work (C2/2 and C2/4); its market position-strengthening effect (C3/3 and C2/5) as well as the ICT-infrastructure's strategic impact. The questions of the group C2 were the follows:

C2/1.We sense the benefits of the ICT-systems in efficient work (beffw).

C2/2. We sense the benefits of the ICT-systems in customer satisfaction (bcuss).

C2/3. We sense the benefits of the ICT-systems in automation of processes (bpaut).

C2/4. We sense the benefits of the ICT-systems in reacting to challanges (benrea).

C2/5. We sense the benefits of the ICT-systems in growth (bcuss).

5 Results and Findings

The results of the research are analysed in two steps: first, a descriptive statistical analysis of the responses is carried out (and this is complemented by an examination of the relationship between some of the variables), and then the model shown in Figure 1 is validated using regression models.

5.1 Descriptives

Supplementing the descriptive statistic review of the responses to the questions of the group A3, the Pearson's A skewness coefficient is summarized in the following table:

Table 2

Summary of the responses to the relevant questions of the Group A3 (source: own ed.)

Qn.	1	2	3	4	5	Avg.	Mode	Median	A-value
A3/1	74	94	146	111	73	3.03	3	3	0.02
A3/2	20	22	77	150	229	4.10	5	4	-1.85
A3/3	155	148	111	56	28	2.31	1	2	1.10
A3/4	331	84	49	22	12	1.59	1	1	0.60
A3/5	92	106	186	85	29	2.70	3	3	-0.26
A3/6	32	61	123	177	105	3.53	4	4	-0.42

The descriptive statistic data show that comparatively, the responses show widely ranging positional and mean values with a distribution of different degrees and directions. These factors gained relevance in the case of two pairs of questions, those concerning the extent of the digitalization of the supply chain (questions A3/3 and A3/4) as well as those referring to price competition and the market pressure to innovate (A3/1 and A3/2). The cross tabulates of the two questions referring to market competition took shape in Table 3.

The data show that unfortunately, price competition has a more intensive impact on the respondents, whilst price competition and innovation competition are non-exclusive as 30,72% of the respondents (n=153) were identified in significant price and innovation competition. Only 28.71% of the respondents (n=143) are on the main diagonal of Table 3.

Table 3

The impact of market and innovation competition on respondents (source: own ed.)

A3/2 (price competition)	**A3/1 (innovation pressure)**					
	1	**2**	**3**	**4**	**5**	**Total**
1	15	1	3	0	1	20
2	4	8	2	7	1	22
3	14	13	28	10	12	77
4	20	31	44	39	16	150
5	21	41	69	55	43	229
Total	74	94	146	111	73	498

This also implies that the vast majority of respondents (71.29%) are dominated by either price or quality-based competition that pushes innovation. This is also confirmed by the χ^2-test performed (χ^2=83,31, p<0,001). However, this allocation was not suitable for cluster analysis as there was no allocation with individual clusters that had roughly the same number of respondents. The examination of supply chain digitalization yielded similar results (Table 4):

Table 4

Supply chain digitalization amongst respondents (source: own ed.)

A3/4 (electronic sales)	**A3/3 (electronic procurement)**					
	1	**2**	**3**	**4**	**5**	**Total**
1	142	93	54	27	15	331
2	7	42	25	7	3	84
3	5	6	23	11	4	49
4	0	6	6	7	3	22
5	1	1	3	4	3	12
Total	155	148	111	56	28	498

Yet again, there are significant differences in terms of the number of respondents belonging to possible clusters and the relative predominance of electronic procurement over electronic sales is also considered unfortunate. When examining the absolute numbers, there are a significant number (n=281, i.e. 57%) of respondents who do not belong to some digital supply chain, or only to a minimum extent. The extent to the respondents' digital supply chain structures were analysed. Only 43.17% of respondents (n=215) are on the main graph in Table 4 (χ^2=119,21, p<0,001). Reviewing the distribution of the data in Table 4, we can see that electronic sales are more significant. Considering the demographic data, this can be interpreted as the fact that these are typically small and medium sized enterprises, which do not have a supplier base in which an integrated relationship could be established.

The descriptive statistics for question group C2 were as follows (Table 5):

Table 5
Summary of the responses to the relevant questions of the group C2 (source: own ed.)

Question	**1**	**2**	**3**	**4**	**5**	**Avg**	**Mode**	**Median**	**A-value**
C2/1	76	55	133	131	103	3.26	3	3	0.20
C2/2	35	34	104	173	152	3.75	4	4	-0.22
C2/3	45	69	138	132	114	3.40	3	3	0.33
C2/4	47	69	113	149	120	3.45	4	4	0.44
C2/5	43	76	127	153	99	3.38	4	4	-0.51
C2/6	52	83	137	143	83	3.24	4	3	-0.62

The review of satisfaction-related responses is worthy of descriptive statistic analysis. One of the essential features is that there is both noticeable right and left-sided asymmetry and there are significant differences in regard to positional and mean values. This is of great significance as this verifies that although multiple questions refer to the same area, these variations show that the questions examine different conditions. As the cross-tabulation of satisfaction-related questions would require 10 cross-tabulates, a correlation matrix in the Table 6 for further examination has been employed:

Table 6
The correlation matrix of satisfaction-related questions (source: own ed.)

	C2/2	C2/3	C2/4	C2/5	C2/6
C2/2	1.00	0.77***	0.76***	0.67***	0.64***
C2/3		1.00	0.75***	0.77***	0.72***
C2/4			1.00	0.77***	0.76***
C2/5				1.00	0.81***
C2/6					1.00

In the correlation table above, the significance level for the correlation of all pairs of variables is $p<0.001$ (***). The correlation matrix data confirms the descriptive statistics data, i.e. the responses to the questions are significantly interrelated, yet the scale of difference is enough to ensure they serve as the subject of sophisticated analysis. (This means that the respondents did not evaluate the same phenomenon in their responses given to the various questions.)

The descriptive statistics for question group D1 were as follows:

Table 7
Summary of the responses to the relevant questions of the group A3 of questions (source: own ed.)

Qn.	**0.00**	**0.25**	**0.5**	**0.75**	**1.00**	**Avg.**	**Mode**	**Median**	**A-value**
D1/1	191	77	30	168	32	2.54	1	2	1.07
D1/2	262	56	25	119	36	2.22	1	1	0.83
D1/3	208	81	30	103	76	2.51	1	2	0.97
D1/4	298	50	28	96	26	2.00	1	1	0.73

A number of phenomena are to be emphasized in the statistical analysis. One of these is that the responses to the four examined questions show a distribution with similar "characteristics" (with right-skewed multimodal empirical distribution), yet there are still significant variations and differences in regard to positional and mean values. Of these, the two questions must be highlighted on IoT infrastructure of which the crosstabulate is as follows (Table 8):

Table 8

The use of IoT technologies amongst respondents (source: own ed.)

D1/2. we are capable of the remote control of production devices (IoT).	D1/1. we are capable of automated data collection (IoT)					
	0	**0.25**	**0.5**	**0.75**	**1**	**Total**
0	161	30	5	59	7	262
0.25	7	25	10	12	2	56
0.5	2	4	8	10	1	25
0.75	12	14	6	75	12	119
1	9	4	1	12	10	36
Total	191	77	30	168	32	498

In relation to the table, it must be noted that only 279 of the 498 respondents (56%) are in the "major diagonal", i.e. automated data collection and control have similar importance in their production. This could be due to the use of autonomous vehicles and devices [1, 32], yet it is definitely noteworthy that there are 119 responses indicating the two extremes, i.e. when a company solely uses IoT solutions for either data collection or control.

The fact that all the responses for the three groups of questions form an ordinal scale means that the connection between the sub-questions of the three questions can be analyzed with inferential statistics.

4.2 Model Creation Results

Throughout the model creation process it became clear that there are two questions that may play a central role in the model (Figure 1: "Information System" element). These are question A3/5 on the automation of business processes and question C2/1 on the application of integration systems. This approach is in line with the [33, 34], pointing out the indispensable role of business processes (amongst others) in terms of the function of the ICT-infrastructure, the execution of which is realized by certain elements of the ICT-infrastructures of for-profit organisations. [1, 3, 4] When examining the relevant lines of tables 1 and 4, it is noticeable that they show an empirical distribution with different kurtosis, yet identical size – close to zero. These two elements correspond to the central element of pre-Industry 4.0 generation information systems [6]. (Naturally, the stochastic relation between these two factors has been examined, yet the explanatory power of the established regression model was so low – R^2=0.044 – that the strength of the connection between the two can be negligible.) The external and internal factors of the model will be grouped around these two external elements. In regard to the exploration of the factors explaining the two central elements, the model creation was concluded with the following results:

$$\text{arate} = 0.2482^{***} + 0.2269^{*}\text{pinn}^{***} + 0.0963^{*}\text{eprch}^{*} + 0.2100^{*}\text{esll}^{***} \quad (1)$$

where the global testing confirmed the significance of the model (F3, 494 = 28.35, p < 2.2e-16; adjusted R^2 = 0.1417, significance of variables: ***: p < 0.001; *: p < 0.05.)

$$\text{intsys} = 0.2654^{***} + 0.0974^{*}\text{pprc}^{\circ} + 0.3553^{*}\text{icteff}^{***} \quad (2)$$

where the global testing confirmed the significance of the model ($F_{2, 495}$ = 29.24, p < 0,001; adjusted R^2 = 0.1057, significance of variables: ***: p < 0.001; °: p < 0.1.)

Throughout the model creation process, in relation to both outcome variables, It was examined, whether they are significantly related to any of the possible explanatory variables. In the case of equations (1) and (2), only significant explanatory variables were displayed. Equations (1) and (2) are summarized in the following Figure 2:

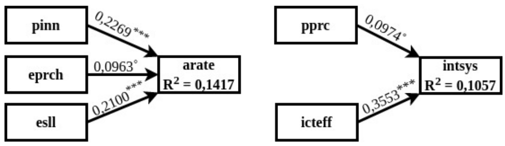

Figure 2
Equations (1) and (2) in a unified model (source: own ed.)

Since the relationship between the information system and management satisfaction would be described by five regression models (Figure 3), the actual models will be forgo described and will instead present a summary of the results similarly to Figure 2 (8 additional regression equations would have to be described, which would not yield any additional information beyond the summary figure, yet their description would presumably hinder the clarity of the overview, therefore these regression models will not be discussed.):

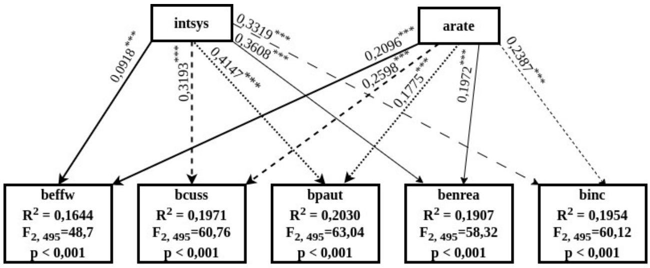

Figure 3

Sophisticated recognition of the ICT-infrastructure's benefits by the management (source: own ed.)

The analysis will proceed in Figure 4 in the same fashion as in the case of the analysis of the relationship between the "Information System" representing Industry 3.0 and the basic technologies of Industry 4.0.

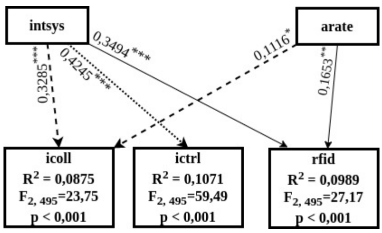

Figure 4

Relationship between the existing ICT-Infrastructure and Industry 4.0 (source: own ed.)

In the case of Figures no. 5, 6 and 7, the significance level is indicated as usual: ***: $p < 0.001$; **: $p < 0.001$; *: $p < 0.05$°·: $p < 0.1$.

Figures no. 5, 6 and 7 show that a significant statistical relationship was established successfully between external and internal factors and the ICT-infrastructure (more specifically, the integrated corporate governance system and business processes), as well as between the ICT-infrastructure and senior management satisfaction and the basic technologies of Industry 4.0. Therefore, the verification of the survey's theoretical model was a success. The qualitative evaluation of the results can take place accordingly.

6 Evaluation of Results

As first step Figure no. 5 will be evaluated, which aims to provide a summary of the entire model. It is important to emphasize that the degree of the automation of business processes and the existence of an integrated corporate governance system are the result of the combined effect of the company's external and internal factors. The question is whether the integrated corporate governance system had a significant explanatory power on the entirety of the company. Consequently, the partial conclusion can be drawn that the introduction of integrated systems is a precondition for the implementation of Industry 4.0 technologies, not just in terms of technology, but also this requires harmonizing the IT and business processes within the economic operator.

Apparently, the role the company plays in a supply chain and the market competition it comes up against also have an identifiable and statistically verifiable effect on the company ICT-infrastructure (the extent of innovation and price competition pressure).

Figure no. 6 provided a summary illustration of the fact that the automation of business processes and the existence of integrated systems are necessary for company managers to sense the advantages of the ICT-infrastructure. Although the regression models of the summary Figure have a similarly explanatory power, the coefficients of the explanatory variables in the five regression models – where the explanatory variables were identical and only the result variables were different –diverge significantly. It follows that in themselves, the two elements contribute in different degrees to the tangible "success" of the ICT-environment. Therefore, the various elements of the ICT-infrastructure can have their full effect in synergy with other (hard and soft) organizational factors. However, throughout the examination of Industry 4.0 solutions, this also suggests that it is worth considering the question of the other supporting factors required for the realization of competition advantages.

The three regression models summarized in Figure no. 7 verify the generational connection between Industry 3.0 and Industry 4.0. In line with previous experiences, the three regression models have a similar explanatory power. Oddly enough, there is no statistically significant relationship between automatic control devices and integrated systems. Two consequences can be drawn from this: firstly, it is not a worthwhile effort to uniformly assess the impact of IoT devices on for-profit organisations in the sense that not all devices capable of automated data collection have the same impact as devices that are capable of functioning remotely. Secondly, when it comes to IoT devices, remotely and/or centrally controlled devices and autonomous production devices and vehicles should be assessed separately in terms of control [6, 8]. Generally speaking, there are two different types of IoT-infrastructures that can and should be distinguished and evaluated separately: the infrastructure of centralized and decentralized IoT-devices should be examined side by side.

Returning to Figure no. 1: throughout the statistical analyses the statistically significant relationship between the senior management satisfaction of the use of the ICT-infrastructure and the implementation of Industry 4.0 devices will be demonstrated, yet this ultimately proved to be unsuccessful. However, the presented interim conclusions are sufficient for drawing up a Technology

Acceptance Model [35] – with the inclusion of further variables representing other questions included in the questionnaire – with the aim of identifying the factors that support or hinder the IT innovations of Hungarian small and mid-size enterprises.

Conclusions

Two conclusions can be drawn from the survey results. Firstly, in themselves, Industry 4.0 solutions cannot ensure any competitive advantages. For this to truly represent a competitive advantage, it is necessary to understand the external surroundings of the company – even if these are not market-driving factors due to the size and/or significance of the company. Thus, the innovation of the ICT-infrastructure must suit the internal environment of the company and must also take the market environment into consideration. As it from the survey results can be seen, the management of for-profit organisations are capable of the sophisticated evaluation of the advantages offered by the ICT-infrastructure, yet this in turn implies that one of the preconditions of successful ICT-investments is that the management of for-profit organisations must be aware of the driving forces behind the market competition and consequently, be able to identify in which field and to what extent they require the added value of ICT-infrastructure services.

As mentioned above, the spread of Industry 4.0 solutions is revolutionizing the production processes of industries that were previously considered to be non-technology intensive. [8, 11] The interim conclusions of my survey presented in this publication indicate – as a warning sign for the future – that the lack of inclusion of a particular technological generation can lead to great subsequent strategic disadvantages as it leads to the absence of the technological environment that can serve as the basis for the appearance of a new generation of technology. However, it remains to be seen what impact the advent of revolutionary changes necessitated by "deferred" evolutionary changes shall have on the economic operator in question.

References

[1] C. Bai, P. Dallasega, G. Orzes and J. Sarkis, "Industry 4.0 technologies assessment: a sustainability perspective," *International Journal of Production Economics*, Vol. 229, Nov. 2020, Art. no. 107776, doi: 10.1016/j.ijpe.2020.107776

[2] J. L. Hopkins, "An investigation into emerging industry 4.0 technologies as drivers of supply chain innovation in Australia," *Computers in Industry*, Vol. 125, Feb. 2021, Art. no. 103323, doi: 10.1016/j.compind.2020.103323

[3] A. Keszthelyi, "Some Special Results of ICT Revolution," in *XVIII. International May Conference on Strategic Management*, in IMCSM Proceedings, Vol. 18, No. 1, May 2022, pp. 479-484

[4] H. Ç. Bal and C. Erkan, "Industry 4.0 and Competitiveness," *Procedia Computer Science,* Vol. 158, pp. 625-631, 2019, doi: 10.1016/j.procs.2019.09.09

[5] M. E. Porter, "The Value Chain and Competitive Advantage," in *Understanding Business: Processes*, D. Barnes, D, Ed., London, United Kingdom: Routledge, 2001, pp. 50-66

[6] S. Aheleroff, X. Xu, Y. Lu, M. Aristizabal, J. P. Velásquez, B. Joa and Y. Valencia, "IoT-enabled smart appliances under industry 4.0: A case study," *Advanced Engineering Informatics*, Vol. 43, Jan. 2020, Art. no. 101043, doi: 10.1016/j.aei.2020.101043

[7] P. Pisar and D. Bilkova, "Controlling as a tool for SME management with an emphasis on innovations in the context of Industry 4.0," *Equilibrium. Quarterly Journal of Economics and Economic Policy*, Vol. 14, No. 4, pp. 763-785, Dec. 2019, doi: 10.24136/eq.2019.035

[8] M. Alexy and T. Haidegger, "Precision Solutions in Livestock Farming– feasibility and applicability of digital data collection," in *2022 IEEE 10th Jubilee International Conference on Computational Cybernetics and Cyber-Medical Systems (ICCC)*, 2022, pp. 233-238, doi: 10.1109/ICCC202255925.2022.9922883

[9] F. Othmane, M. A. Ferrag, L. Shu, L. Maglaras and X. Wang, "Internet of Things for the Future of Smart Agriculture: A Comprehensive Survey of Emerging Technologies," *IEEE/CAA Journal of Automatica Sinica*, Vol. 8, No. 4, pp. 718-752, Apr. 2021, doi: 10.1109/JAS.2021.1003925

[10] D. A. Zakoldaev, A. V. Shukalov, I. O. Zharinov and O. O. Zharinov, "Modernization stages of the Industry 3.0 company and projection route for the Industry 4.0 virtual factory," in *IOP Conference Series: Materials Science and Engineering,* Vol. 537, No. 7, 2019, Art. no. 032005, doi: 10.1088/1757-899X/537/3/032005

[11] M. Dobler and J. Schumacher, "Innovation and emerging ICT in logistics for Europe position paper for the workshop is logistics catching up the pace of emerging technologies?" in *International Conference on Engineering, Technology and Innovation (ICE/ITMC)*, R. Jardim-Gonçalves et al., Eds, 2017, pp. 1509-1516, doi: 10.1109/ICE.2017.8280061

[12] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay and A. Martynenko, "IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry," *IEEE Internet of Things Journal*, Vol. 9, No. 9, pp. 6305-6324, May 2022, doi: 10.1109/JIOT.2020.2998584

[13] J. Kárpáti-Daróczi, A. Tick and R. Saáry, "Implementation of Industry 4.0 among SMEs in Hungary" in: *Az üzleti szervezetek túlélési esélyei napjaink legújabb kihívásainak idején: Vállalkozásfejlesztés a XXI. században*, J. Varga et al., Ed. (eds.), Vol. 2022/1, 2022, pp. 141-160

[14] A. Tick, "Industry 4.0 Narratives through the Eyes of SMEs in V4 Countries, Serbia and Bulgaria," *Acta Polytechnica Hungarica*, Vol. 20, No. 2, pp. 83-104, 2023, doi: 10.12700/APH.20.2.2023.2.5

[15] A. Tick, J. Kárpáti-Daróczi, and R. Saáry, "To familiarise or not to familiarise' - industry 4.0 implementation in SMEs in Hungary," in *Possibilities and barriers for Industry 4.0 implementation in SMEs in V4 countries and Serbia*, Ed., Bor, Serbia: University of Belgrade, Technical Faculty in Bor, Engineering Management Department, 2022, pp. 35-61

[16] T. Masood and P. Sonntag, "Industry 4.0: Adoption challenges and benefits for SMEs," *Computers in Industry*, Vol. 121, Oct. 2020, Art. no. 103261, doi: 10.1016/j.compind.2020.103261

[17] J. Basl, "Enterprise Information Systems and Technologies in Czech Companies from the Perspective of Trends in Industry 4.0," in *Research and Practical Issues of Enterprise Information Systems. CONFENIS 2016.*, in Lecture Notes in Business Information Processing, Vol 268. Nov. 2016, pp. 156-165, doi: 10.1007/978-3-319-49944-4_12

[18] Zs. R. Szabó and L. Hortoványi, "Digital transformation and Industry 4.0: experiences from Hungary, Serbia, Slovakia and Romania," *Külgazdaság,* Vol. 65, Nos. 5-6, pp. 56-76, Jun. 2021, doi: 10.47630/KULG.2021.65.5-6.56

[19] B. Chen, J. Wan, L. Shu., P. Li, M. Mukherjee and B. Yin, "Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges," IEEE Access, Vol. 6, pp. 6505-6519, 2018, doi: 10.1109/ACCESS.2017.2783682

[20] V. Majstorovic, S. Stojadinovic, B. Lalic and U. Marjanovic, "ERP in Industry 4.0 Context," in *Advances in Production Management Systems. The Path to Digital Transformation and Innovation of Production Management Systems. APMS 2020.* in IFIP Advances in Information and Communication Technology, Vol. 591, 2020, doi: 10.1007/978-3-030-57993-7_33

[21] G. Orzes, E. Rauch, S. Bednar and R. Poklemba, "Industry 4.0 Implementation Barriers in Small and Medium Sized Enterprises: A Focus Group Study," in 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 2018, pp. 1348-1352, doi: 10.1109/IEEM.2018.8607477

[22] L. Agostini and A. Nosella, "The adoption of Industry 4.0 technologies in SMEs: results of an international study," *Management Decision,* Vol. 58, No. 4, pp. 625-643, 2020, doi: 10.1108/MD-09-2018-0973

[23] Z. Jiang, S. Yuan, J. Ma and Q. Wang, "The evolution of production scheduling from Industry 3.0 through Industry 4.0.", *International Journal*

of Production Research, Vol. 60, No. 11, pp. 3534-3554, 2021, doi: 10.1080/00207543.2021.1925772

[24] Y. Yin, K. E. Stecke and D. Li, "The evolution of production systems from Industry 2.0 through Industry 4.0," *International Journal of Production Research*, Vol. 56, No. 1-2, pp. 848-861, 2017, doi: 10.1080/00207543.2017.1403664

[25] T. Taurino and A. Villa, "A method for applying Industry 4.0 in Small Enterprises," *IFAC-PapersOnLine*, Vol. 52, No. 13, pp. 439-444, 2019, doi: 10.1016/j.ifacol.2019.11.099

[26] H. O Awa and O. U. Ojiabo, "A model of adoption determinants of ERP within T-O-E framework," *Information Technology & People,* Vol. 29, No. 4, pp. 901-930, 2016, doi: 10.1108/itp-03-2015-0068

[27] M. F. Acar, S. Zaim, M. Isik and F. Calisir, "Relationships among ERP, supply chain orientation and operational performance," *Benchmarking: An International Journal,* Vol. 24 No. 5, pp. 1291-1308, 2017, doi: 10.1108/bij-11-2015-0116

[28] D. Gefen, A. Ragowsky, "A Multi-Level Approach to Measuring the Benefits of an Erp System in Manufacturing Firms," *Information Systems Management*, Vol. 22, No.1, pp. 18-25, 2005, doi: 10.1201/1078/44912.22.1.20051201/85735.3

[29] L. Mura, T. Zsigmond, and R. Machová, "The effects of emotional intelligence and ethics of SME employees on knowledge sharing in Central-European countries," Oeconomia Copernicana, Vol. 12, No. 4, pp. 907-934, 2021, doi: 10.24136/oc.2021.030

[30] D. Horváth, R. Zs. Szabó, "Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?" *Technological Forecasting and Social Change*, Vol. 146, pp. 119-132, 2019, doi: 10.1016/j.techfore.2019.05.021

[31] O. Klisenko and A. E. Serral, "Towards a Maturity Model for IoT Adoption by B2C Companies," *Applied Sciences,* Vol. 12, No. 3, 2022, Art. no. 982, doi: 10.3390/app12030982

[32] F. Othmane, M. A. Ferrag, L. Shu, L. Maglaras and Wang, X., "Internet of Things for the Future of Smart Agriculture: A Comprehensive Survey of Emerging Technologies," *IEEE/CAA Journal of Automatica Sinica*, Vol. 8, No. 4, pp. 718-752, Apr. 2021, doi: 10.1109/JAS.2021.1003925

[33] P. Michelberger, S. Dombora, "A Possible Tool for Development of Information Security-Siem System," *Ekonomika, Journal for Economic Theory and Practice and Social Issues*, Vol. 62, No. 1, Mar. 2016

[34] P. Michelberger, Zs. Horváth, "Security aspects of process resource planning," *Polish Journal of Management Studies*, Vol. 16, No. 1, pp. 142-153, 2017, doi: 10.17512/pjms.2017.16.1.12

[35] Folkinshteyn, D. and Lennon, M., „Braving Bitcoin: A technology acceptance model (TAM) analysis," *Journal of Information Technology Case and Application Research*, Vol. 18, No. 4, pp. 220-249, Feb. 2016, doi:10.1080/15228053.2016.1275242