Industry 4.0 Narratives through the Eyes of SMEs in V4 Countries, Serbia and Bulgaria

Andrea Tick

Óbuda University, Bécsi út 96/b, 1034 Budapest, Hungary
tick.andrea@uni-obuda.hu

Abstract: In the third decade of the 21st Century, thanks to the technological developments and digitization, the spread of Industry 4.0 (I4.0) in production and manufacturing as well as in trade and service industry is unquestionable. The spread is inevitable not just among large, capital-strong companies but I4.0. is also penetrating into the life of SMEs. The present research was conducted among SMEs in V4 countries, Serbia and Bulgaria, and while it analyses which I4.0 technologies predict SMEs' familiarity with Industry 4.0, it also finds similarities with the spread of the relevant terms in the narratives in three corpora. The quantitative research uses regression models to analyze the spread of narratives and the behavior of SMEs and finds that four I4.0 technologies significantly contribute to the familiarity with I4.0 among SMEs in the participating countries, implying that raising awareness and training on special I4.0 technologies need to be strengthened among SMEs. Moreover, the research found that the familiarity of I4.0 terms among SMEs and the spread of these terms in the three corpora are partly in alignment, therefore as narratives boost the spread of the term I4.0 so SMEs get more aware and familiar with certain I4.0 technologies.

Keywords: Industry 4.0; Cloud computing; Big Data Analysis; IoT; 3D printing; Robotics; Ngram Viewer; SME; V4 countries

1 Introduction

The 21st Century has been continuously digitalized, which gradually helped companies to introduce new and innovative technologies, change business and production processes as well as exploit the benefits of Industry 4.0 (I4.0). The adoption of digital technologies represents one of the most significant international business developments of the past few years. I4.0 technologies were first introduced in capital-strong large companies but, with time, SMEs continuously get familiar with these technologies, slowly introducing and integrating them in their business operations despite the fact that such investments are capital intensive [1, 2]. Beyond the technological changes I4.0 brings socio-economic changes (impact on labor market, changes in social structure) as well. However, without the awareness of and familiarity with these technologies SMEs

are not in the position to make responsible decisions in case of such introductions and deployments.

Companies at the same time are continuously interested in using new technologies to adapt to the ongoingly changing business conditions, especially in the times of a pandemic when contactless digitalization helps SMEs to maintain their business operation [1, 3] and long-term competitiveness. The fourth industrial revolution poses a huge challenge for manufacturing companies [4], which affects the companies' technological systems, operational processes as well as their management systems [2]. On the other hand, companies including SMEs are also influenced by the spreading of I4.0 technologies and strive to be proactive in technology usage since it ensures their innovative profile, supports cost effectiveness and improves performance. They must use I4.0 technologies to catalyze the adoption of relevant I4.0 innovations to remain competitive in the global value chain [3]. The pandemic reinforced the importance of the deployment of digital technologies, including I4.0 technologies, and therefore the knowledge of I4.0 technologies makes the digital transformation easier for SMEs [1]. I4.0 has contributed to an increase in efficiency in supply chain management [5], but on the other hand, it might lead to a partial replacement of human labor [6] or might increase cybersecurity issues [7]. Cugno et al. [1] investigates what role I4.0 technologies play in the recovery of SME manufacturing activity to pre-COVID-19 levels and point out that such analyses might support managers to identify the optimal and most appropriate I4.0 technology to implement. According to [8, p. 254] digitalization and I4.0 might give "a key stimulus for innovation in various areas of business" and it can become the driving force in industries. SMEs need to be aware of the digital transformation used in I4.0 and should be able to proact and react properly.

The present research investigates how aware and familiar SMEs are with I4.0 and its elements and draws a parallel with the spread of these terms — that is the usage and occurrence of these terms — in the American, British and German corpora. The research reveals that familiarity with certain I4.0 technologies ensures SMEs to be aware of I4.0 and explores whether these are the same technologies that occur in relation with I4.0 in the narratives. The paper focuses on SMEs in the V4 countries, Serbia and Bulgaria, since these countries share similar economic environmental conditions and are clustered in the same group by digitalization maturity [9]. The research is quantitative in its nature and concludes that out of the eight I4.0 technologies surveyed four technologies significantly contribute to the acquaintance of I4.0 among SMEs, the occurrence of three of them strongly correlate and strongly boost the spread of I4.0 in the corpora while Cloud Computing services, Supply Chain Management and Virtual Reality behave differently among SMEs and in the narratives. The research concludes that SMEs' awareness needs to be raised about I4.0 technologies, promotion and training need to focus on the technologies that SMEs do not associate with I4.0.

The paper is organized as follows: after the definition of the terms, it presents the research model, the research questions, the research methodology and data collection methods. Following, it gives the demographic profile and the responses of the SMEs. Then the behavior of SMEs and the spread of the narratives are analyzed, and the two results are compared. Finally, the paper draws conclusions on the hypothesis and research questions, gives recommendations, discusses the limitations and future possibilities of the research.

2 Industry 4.0

The concept of Industry 4.0 (I4.0), defined by the German Industry–Science Research Alliance [10], has exponentially spread in the narratives (Figure 3) since it was defined in 2011. However, definitions vary across industry and academic research [11]. It can be stated that I4.0 is present at all levels in the management hierarchy, from the production of smart products through process management to the strategic decision level at top management.

I4.0 is based on two pillars, one being digitization while the other incorporates the exponential technologies. Digitization ('binary conversion') and digitalization or even digital transformation are defined and used differently in recent literature [12]. In Clerk's definition, digitalisation is centred on digital information [13]. However, the term digitalization can be understood from both a technical and a business perspective [14]. In business terms digitalization defines newly created business models and processes [15], while in technical sense it refers to the digitization of processes, contents and objects that were previously physical or analogue (Csedő et al., 2019). „In corporate terms digitalisation means turning interactions, communications, business functions and business models into (more) digital ones which often boils down to a mix of digital and physical as in omnichannel customer service, integrated marketing or smart manufacturing with a mix of autonomous, semi-autonomous and manual operations" [16]. This paper uses digitization in its technical sense and considers specific exponential technologies in I4.0.

2.1 Industry 4.0 Technologies

In order to raise awareness of and familiarity with I4.0 among SMEs the knowledge about exponential technologies needs to be raised. According to [17] the sudden proliferation of Internet of Things (IoT) and Big Data caused a mass of disorganized knowledge; however, these technologies are key drivers of business re-engineering. I4.0 entails "the increasing digitization of the entire *supply chain,* which makes it possible to connect actors, objects and systems based on real-time data exchange" [2, p. 120]. Communication technologies and digitization during the 4th industrial revolution first triggered machine-to-human (M2H) then machine-to-machine

(M2M) communication, and the exponential development of *artificial intelligence* (AI) with Web 3.0 and 4.0 opened a new avenue to automated production, *robotization* and resulted in the emerge of sensors and *Internet of Things (IoT)*. In order to gather, collect and process data *Cloud computing* created the background for *big data analysis* and provides extensive storing and computing capacities and capabilities [18]. M2H and M2M contribute to Cyber-Physical systems that are capable of creating a digital representation of the physical world, and, as such, the interconnection and communication integrating artificial intelligence allows for *Virtual Reality (VR), Augmented Reality (AR)* to be implemented for business processes not just in digital devices [19]. According to Rüßmann et al. [20] nine pillars can be identified in I4.0, namely Autonomous robots, Simulations, Horizontal and vertical system integration, IoT, Cybersecurity, The Cloud, Additive Manufacturing, Augmented Reality and Big Data Analytics. The present survey was not aiming to deal with cybersecurity, however, included Artificial Intelligence and Virtual Reality to integrate two essential elements for digital twin and business analytics possibilities. The research used the following pillars: Cloud computing, Big Data Analysis, 3D printing and Robotics, IoT, AI, VR, AR and Supply Chain Management (SCM).

These terms, referred to as narratives here, can follow various patterns, from the pattern of a pandemic through a hype curve to a product life cycle, i.e., they go viral or popular, have their own birth, virulent period, decline and death. Immediately as a new technological innovation is introduced and is accepted to a great extent, a new narrative emerges and becomes viral while the older one declines and gets forgotten [21].

The originality of this study lies in enriching the literature on the topic of I4.0 awareness among SMEs and its relation to the spread of I4.0 technologies in the narratives. To this end it provides an understanding how the awareness of I4.0 and its technologies can be raised, and which technologies can be expected as familiar technology among SMEs, and to what extent SME owners and managers are aware and familiar with the terms. Furthermore, the study contributes to the literature in including SMEs from the V4 countries, Serbia and Bulgaria. It uses data from two different sources to test the relationship between the spreading of and familiarity with I4.0 and its technologies.

3 Research Methods and Data

The aim of the research is to explore how familiarity with I4.0 can be increased among SMEs in the V4 countries, Serbia and Bulgaria, and whether it can be increased by raising the familiarity with certain I4.0 technologies. It strives to give a good prediction for familiarity, and it explores to what extent I4.0 technologies influence the spread of I4.0 narratives. Furthermore, it compares whether SMEs'

awareness of I4.0 follows the trends in the narratives. Finally, the research aims to find which Industry 4.0 technologies should be more promoted among SMEs in order to familiarize these small– and medium–sized companies with I4.0 thus helping SME managers both to digitalize more and boost business performance and efficiency and to invest in I4.0 technologies to recover from COVID-19.

The research model is based on I4.0 and its selected pillars, and is presented in Figure 1, the familiarity with Industry 4.0 technologies determines and predicts the familiarity with I4.0 among SMEs in the V4 countries, Serbia and Bulgaria.

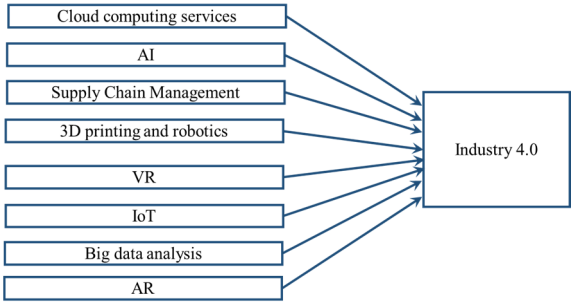

Figure 1
The proposed research model (developed by author)

As no similar analysis could be found in the literature the research contributes to the field of interest by proposing and formulating three research questions, namely:

RQ1: Do SMEs in the V4 countries, Serbia and Bulgaria associate I4.0 technologies, namely Cloud computing, Big Data Analysis, 3D printing and Robotics, IoT, AI, VR, AR and SCM with Industry 4.0 and can the familiarity with these technologies predict the familiarity with I4.0 at SMEs?

RQ2: Do the terms I4.0 and I4.0 technologies spread similarly and are the occurrences highly correlated in the selected corpora? Does the spread of I4.0 technologies in the narratives significantly influence the spread of the term Industry 4.0?

RQ3: Do the SMEs in the V4 countries, Serbia and Bulgaria follow the trend of the spreading of the terms in the selected corpora regarding the familiarity with I4.0 and its technologies? Do they identify the same terms as I4.0 technologies as the narratives suggest?

3.1 Research Method and Data Collection among SMEs

The research used self-administered questionnaires, anonymity was ensured, and responding SMEs gave their consent to the survey. Responses were collected during the pandemic between September and November 2021. The quantitative analysis was conducted by the statistical program SPSS V25, Rapid Miner and MS Excel.

Descriptive analysis, Chi2 tests, correlations, regression procedures, and data mining modeling were used to explore which I4.0 technologies are determining the model. Binary logistics regression was applied to predict the probability of the familiarity with I4.0 given certain predictor variables (I4.0 technologies) [22].

3.2 Research Method and Data Collection for Spreading of the Terms Related to I4.0

The Google Ngram Viewer was used to collect data on the spread of narratives from 1950 to 2019 (the latest date available). Ngram Viewer provides a good visual representation of the frequency of terms in various corpora ranging from English (British and American separately) through French, German, Italian, Spanish, etc. to even providing Chinese corpus. It is an online search engine that charts the relative frequencies of any set of search words and phrases, using a yearly count of n-grams found in millions of books, printed between 1950 and 2019, in the Google Books corpus. The corpus enables the quantitative analysis of cultural, linguistic as well as economic or business trends [23, 24]. The source is limited to the pool of Google Books but depicts well the popularity, development and proliferation of these phrases.

Quantitative analyses were conducted in MS Excel, correlation and regression analyses were carried out to see the relationships and influences of the terms on I4.0 and its spreading in the corpora. Finally, the results of the two analyses are compared and conclusions are drawn about the behavior of SMEs compared to the spread of narratives in the corpora.

4 Familiarity with I4.0 and its Elements in the Narratives

4.1 Spread of Industry 4.0 Terms

As soon as the technological innovations are announced they appear in the narratives and, as Schiller [21] states, they go viral and follow the spread of viruses. The life of technological innovations at the same time follows the shape of the Gartner's Hype cycle [25] as well — Technology Trigger, Peak of Inflated Expectations, Trough of Disillusionment, Scope of Enlightenment and Plateau of Productivity — and as the technologies get older and more mature they are approaching the plateau of production, they are more widely used in industry and are more widespread in publications. According to Gartner Research [25] and Kenn, et al. [26] Engineering and Business Maturity and the Hype Cycle of technologies converge and run align in the phase of the plateau of production.

The Google Ngram Viewer is one of databases that allow researchers to see the spread of narratives. The usage of the terms — I4.0, Cloud computing, Big Data Analysis, 3D printing and robotics, IoT, AI, VR, AR and SCM — was analyzed between 1950 and 2019 (the latest date available). As Figure 2 displays, the usage and spread of the listed terms show similar trends in the American, English and German Corpora.

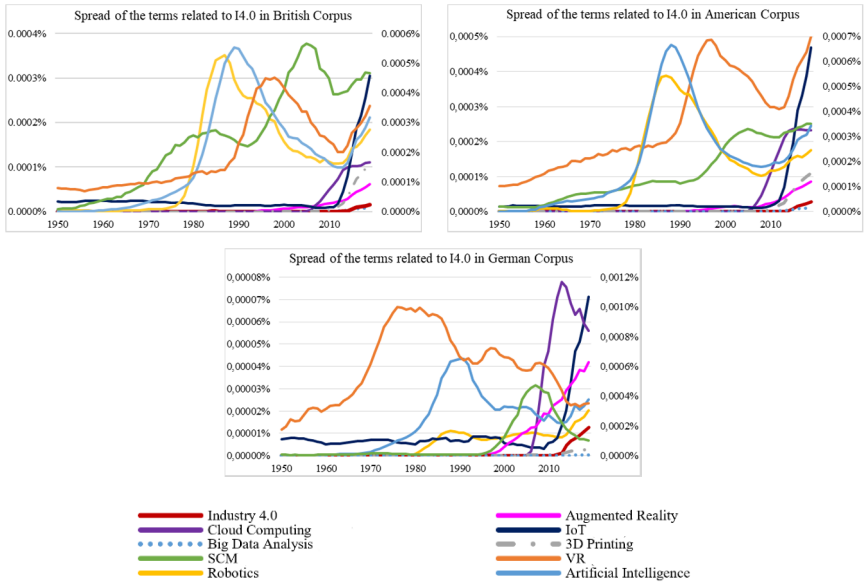

Figure 2
Spread of the terms related to Industry 4.0 in the British, American and German corpora (developed by author)

Applying the terminology of the Hype cycle, I4.0 is in the phase of the exponential and rapid growth together with IoT, 3D printing, Big Data Analysis, implying them being in the phase of Technology Trigger. Since no slowdown can be noticed in the spreading, these terms probably have not reached their peak of Inflated Expectation phase yet. Robotics has already reached the plateau of production in the British and American corpora while it is in its second Technology Trigger phase in the German Corpus. After the peak era in the 90s' AI is also in the plateau of production with a second awakening in the British corpus. The spread of VR shows similar trends in the American and British corpora with a 5-year time shift, while it is in the phase of Trough of Disillusionment in the German Corpus.

Slowdown in the American and British corpora and downturn in the German corpus imply that Cloud Computing has already reached its Peak of Inflated Expectation. AR has been also exponentially growing in the corpora, with a short phase of Disillusionment in the American corpus in the first decade in the century, but since

then the term has been virulent and infectious in all three corpora not having reached its peak yet. The term SCM behave differently in all three corpora. While it is still virulent in the American corpus (phase of Technology Trigger), it has its second epidemic wave (Scope of Enlightenment) in the British corpus, and it is not virulent at all in the German corpus (Trough of Disillusionment).

The correlation of the occurrences of the terms was also analyzed to support the research questions. Based on the Pearson's *r* correlation coefficients (Table 1), the spread of the term I4.0 is in strong correlation with the spread of the I4.0 technologies, such as AR, Cloud Computing, IoT, Big Data Analysis, 3D printing in the narratives, however, the spread of the terms AI, Robotics, SCM and VR moderately or weakly contribute to the spread — and familiarity — of I4.0 in all three corpora.

Table 1
Correlation of I4.0 elements with I4.0 in the American, British and German corpora

Industry 4.0 / Corpus	**American**	**British**	**German**
Augmented Reality (AR)	**0.850**	**0.874**	**0.831**
Cloud Computing	**0.727**	**0.766**	**0.693**
IoT	**0.986**	**0.991**	**0.989**
Big Data Analysis	**0.937**	**0.962**	**0.994**
3D Printing	**0.960**	**0.983**	**0.974**
Robotics	0.061	0.135	0.602
Artificial Intelligence (AI)	0.118	0.147	0.153
SCM	0.430	0.330	0.088
Virtual Reality (VR)	0.377	0.245	-0.301
Multiple R^2	*99.43%*	*99.69%*	*99.73%*

Moreover, VR is in negative correlation with I4.0 in the German corpora (r_D=–0.301) implying that VR is less associated with I4.0. The term AI is progressing toward the plateau of production; however, having integrated semantic analytics and machine learning it started its second wave around the 2010s', but is presumably not directly linked to I4.0 [27]. Robotics is also in weak correlation with I4.0 in the American and British corpora (r_{USA}=0.061, r_{Br}=0.135) while it contributes strongly to the familiarity of I4.0 in the German corpus (r_D=0.602). The spread of the term is different in the three corpora, while it behaves similarly in the British and American corpora, it shows a continuous growing pattern with a rapid increase from around 2015 in the German corpus. This might explain the strong correlation there. I4.0 technologies contribute with different strength to the spread of the term I4.0, which supposes that the weaker the correlation, the technology is less associated with I4.0. SCM is in weak correlation with I4.0 in the German corpus (r_D=0.088) and relatively weakly supports I4.0 in the American and British (r_{USA}=0.43, r_{Br}=0.33) corpora. The German corpus gives strong correlation for each element except AI and SCM. VR is negatively correlated with I4.0 in the German corpus, although the correlation is relatively weak in all three corpora.

Considering only I4.0 in all three corpora between 2000 and 2019, the spread is exponential, the steepest being in the American corpus (Figure 3).

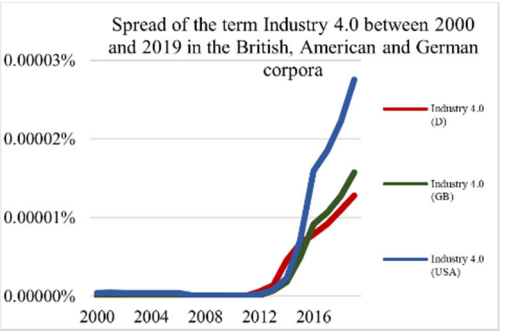

Figure 3

Spread of the terms 'Industry 4.0' in the British, American and German corpora (developed by author)

The significance of the elements was also tested in the regression analysis. Different technologies proved to be significant in the different corpora (Table 2).

Table 2

I4.0 technology significances in regression to I4.0 as dependent variable

I4.0 elements	**Significance level in regression model (p values)**		
	American	*British*	*German*
Augmented Reality	0.1596	0.7872	0.2508
Cloud Computing	**0.0060**	**0.0107**	**0.0144**
IoT	0.0987	0.0928	**0.0000**
Big Data Analysis	**0.0000**	**0.0000**	**0.0000**
3D Printing	**0.0000**	**0.0001**	0.6972
Robotics	0.9569	**0.0200**	**0.0510**
Artificial Intelligence	0.9332	0.4324	0.1219
Virtual Reality	0.0830	**0.0470**	0.9589
SCM	0.2952	0.5800	0.6459

Dependent variable: Industry 4.0

As Table 2 shows the usage of the term Cloud Computing and Big Data analysis contribute significantly to the spread of I4.0 in all three corpora, while the spread of the term 3D Printing significantly boosts the spread of I4.0 in the American and British corpora. Robotics and VR are significant in the British corpus. In each case the p value is less than 5% (Table 2). Surprisingly, the spread of IoT boosts the spread of I4.0 solely in the German Corpus at p=0.05, and Robotics is significant only at p=0.10 in the German corpus while IoT is significant at p=0.10 in the American and British corpora. Should the spread of viruses be considered, the significant elements in the German corpus are presumed to be more influential in the familiarity with Industry 4.0 among SMEs in V4 countries, Serbia and Bulgaria.

Consequently, based on the spread of narratives, the correlation and regression between I4.0 and I4.0 technologies, it is hypothesized that:

H1$_1$: The familiarity with Cloud Computing, Big Data Analysis, 3D printing, Robotics, IoT and VR contribute positively to the familiarity with I4.0 among SMEs in the V4 countries, Serbia and Bulgaria, they associate these technologies with I4.0 and the familiarity with I4.0 among SMEs can be predicted with high probability.

H1$_2$: AR, AI and SCM are not considered elements of I4.0 among SMEs in the V4 countries, Serbia and Bulgaria. SMEs do not associate these technologies with I4.0.

Namely, the SMEs that are familiar with the above technologies are more probable to be familiar with the term I4.0 and use it in their daily business operations. The following section presents the SME responses and the results of the research based on the survey among SMEs in the V4 countries, Serbia and Bulgaria.

5 Familiarity with I4.0 and its Elements among SMEs

5.1 Demographic Profile of SMEs

A total number of 635 responses were collected from the V4 countries, Serbia and Bulgaria. After filtering large companies 535 valid SME responses were analyzed. In the research Hungary represents 20.56% of the SMEs, Slovakia gives 17.01% while the other countries take around 15% of the responses. The country distribution is not significantly different, they are equally represented in the sample (Chi2=6.492, p=0.261).

Table 3 presents the demographic profile of the responding business professionals and SMEs.

Table 3
SME Demographic Profile

Personal characteristics	**n=535**	**Distribution of respondents (%)**	**Business characteristics**	**n=535**	**Distribution of respondents (%)**
Age			***SME size (number of employees)***		
18-30	117	21.87	Micro	243	45.42
31-45	193	36.07	Small	139	25.98
46-60	180	33.64	Medium-sized	153	28.60
> 61	45	8.41			
Gender			***The dominating sector of the company***		
Male	326	60.93	Production	161	30.09

Female	204	38.13	Services	95	17.76
No wish to answer	5	0.93	Trade	279	52.15
Position			***Company age (years)***		
The owner	192	35.96	Up to 2 years	50	9.35
Senior manager	90	16.85	3-5	52	9.72
Manager	108	20.22	6-10	104	19.44
Employee	144	26.97	11-20	132	24.67
			>21	197	36.82

One fifth of the respondents are under 30 while over two thirds of the respondents are aged between 31 and 60. Sixty percent of the respondents are male (60.93%) and 38.13% of them are female in the sample. In terms of their position, almost an equal number of owners and managers responded, 35.96% and 37.07%, respectively, while 26.97% of the respondents were employees. In terms of business characteristics, the largest proportion is that of micro enterprises (45.42%), Small enterprises give a quarter of the sample (25.98%) and medium-sized enterprises made up 28.6% of the sample. More than 60% of the enterprises surveyed are more than 11 years old while 9.35% and 9.72% are less than 2 years old or are between 3 and 5 years. The remaining 20% are between 6 and 10 years old. More than half of the enterprises in the sample are belong to the Trade sector, one third to the Production sector and 17.76% to the Services sector.

Based on the distributions, micro enterprises (Chi2=35.723, p=0.000), more mature enterprises (Chi2=140.262, p=0.000) and businesses in the services sector (Chi2=97.450, p=0.000) are more represented in the sample. At the same time, owners and managers are also overrepresented (Chi2=9.843, p=0.007), which fits the analysis well since the introduction of I4.0 technologies and I4.0 depends on the management of an enterprise to a great extent.

5.2 Country Comparison on Familiarity with I4.0

Figure 4 shows that SMEs in the participating countries are differently familiar with I4.0. In total, 52.9% of SMEs are not familiar with the term I4.0, less than half (47.1%) of them know the term.

Over two thirds of the SMEs in the Czech Republic are familiar with I4.0, 61% in Slovakia, while half of the Serbian SMEs know the term. Hungary is the fourth with 40% [28], and less than 40% of SMEs in Poland and Bulgaria are familiar with I4.0.

There is a significant difference between the countries in terms of familiarity with I4.0 (Chi2 = 30.346, p=0.000, while Cramer's V=0.24, p=0.000). As Table 4 shows, SMEs in the Czech Republic are significantly more familiar with the term I4.0 than in Hungary (B), Poland (D) and Bulgaria (F), while Slovakian SMEs do not differ significantly from the Hungarian (B), Serbian (E) and the Czech SMEs (A).

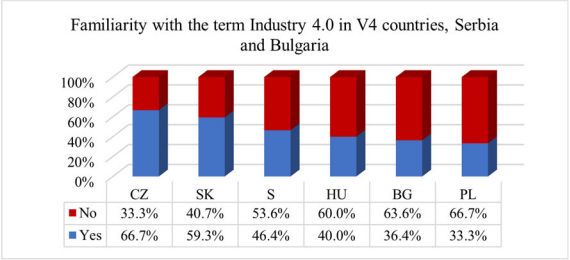

Figure 4
Familiarity with I4.0 in V4 countries, Serbia and Bulgaria (developed by author)

Table 4
Significant differences of I4.0 familiarity between SMEs by country

Are you familiar with the term INDUSTRY 4.0 (%)							
Country	**CZ (A)**	**H (B)**	**SK (C)**	**PL (D)**	**S (E)**	**BG (F)**	**Total**
Yes	66.7 B D F	40	59.3 D F	33.3	46.4	36.4	47.1
No	33.3	60 A	40.7	66.7 A C	53.6	63.6 A C	52.9
Total	100	100	100	100	100	100	100

Results are based on two-sided tests. For each significant pair, the key of the category with the smaller column proportion appears in the category with the larger column proportion. Significance level for upper case letters (A, B, C): 0.05

5.3 I4.0 Technologies to Determine Familiarity with I4.0 among SMEs

The familiarity with I4.0 technologies was also surveyed on a Likert scale ranging from 1—'never heard about it' to 5–'have heard and use it in everyday business operations'. Further response options were 2—'have heard but never used', 3– have heard and do plan to use it' and 4—'have heard and use it occasionally'. With these statements the research strives to explore why SMEs in these countries show a low-level of familiarity with I4.0 on average and seeks to find a cause-and-effect relationship between the familiarity of I4.0 and its pillars. Table 5 presents that SMEs are familiar with cloud computing services (Mean≈3), half of the SMEs have heard about it and plan to use it in their business processes (Median=3) but based on the Median and Mode values the majority of SMEs have heard about the term but have never used it.

The worst case in these countries is the unfamiliarity with Big Data Analysis, as most SMEs most have not heard of and never used this possibility in I4.0 (Mode=1). Based on the descriptive results the familiarity with the technologies is low, most of the responding SMEs have not heard about the technology, or have heard but never used them.

Table 5
SME Familiarity with the Elements of I4.0

I4.0 elements	n	Mean	Median	Mode	SD	IQR
Cloud computing services	530	2.93	3	2	1.440	2
AI	531	2.51	2	2	1.155	1
Supply Chain Management	530	2.50	2	2	1.152	1
3D printing and robotics	530	2.48	2	2	1.165	1
VR	529	2.46	2	2	1.116	1
IoT	526	2.44	2	2	1.277	2
Big data analysis	531	2.38	2	1	1.231	2
AR	528	2.23	2	2	1.110	2

Supposedly, as hypothesed earlier, an increase in the awareness of the individual technologies could boost familiarity with I4.0 and consequently might lead to a better understanding and higher rate of usage of these technologies, leading to a positive contribution to digitalisation and business recovery after COVID-19.

6 Contribution of Industry 4.0 Technologies to the Familiarity with I4.0 among SMEs

The research conducted among SMEs found that in average over 50% of SMEs are not familiar with the term I4.0, however, in Poland and Slovakia the familiarity is over 59%. According to the aim of the research the familiarity with an awareness of I4.0 and its elements need to be boosted, so it is to be investigated what leads to the familiarity with I4.0 and how it can be changed to the positive. Which elements contribute positively, and which hinders the spreading of I4.0?

All the 535 responses were used for the analysis. The analysis did not differentiate between the countries in order to get a general view in the V4 region, Serbia and Bulgaria. The data were cleaned, meaning that all records with no response for the analyzed questions, and all records with unengaged responses were deleted. The missing values were replaced by the Median due to the Likert scale used for rating. Finally, a total number of 436 responses remained for analysis using correlation, logistic regression with enter and with the stepwise Wald method.

At first, correlation was checked to see whether there is a relationship between the familiarities with the technologies (Table 6). While the I4.0 technologies are relatively weakly correlated with I4.0 ($0.202<r<0.374$), some of them are in strong correlation pairwise (e.g $r=0.709$ in AR−VR relation).

Figure 5 displays the weights of the elements in the model, showing that familiarity with Big Data Analysis, IoT and 3D printing and Robotics would rather determine the SMEs' familiarity with I4.0.

Table 6
Correlation of the elements of I4.0

	I4.0	*Cloud Computing Services*	*Big Data Analysis*	*3D Printing and Robotics*	*IoT*	*VR*	*AR*	*SCM*
Cloud Computing Services	0.202							
Big Data Analysis	0.374	0.53						
3D Printing and Robotics	0.309	0.295	0.409					
IoT	0.345	0.383	0.535	0.453				
VR	0.294	0.311	0.466	0.574	0.509			
AR	0.332	0.386	0.568	0.523	0.603	0.709		
SCM	0.299	0.286	0.438	0.409	0.408	0.453	0.404	
AI	0.235	0.321	0.489	0.505	0.459	0.622	0.595	0.454

Each correlation is significant at the 0.01 level (2-tailed).

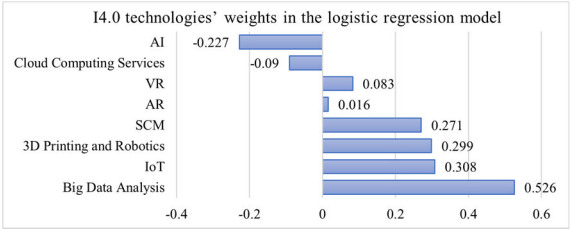

Figure 5
I4.0 elements' weights on the logistic regression model

Suprisingly Cloud Computing services has a negative weight (–0.09), implying that SMEs do not associate Cloud Computing services with I4.0. It is, despite the fact that these are the most widespread among SMEs in these countries; 58.4% of the SMEs in the survey have heard about it, plan to use it or use the technology. AI has the lowest weight in the model (–0.227), while its familiarity is not outstandingly low among SMEs (41.74%). SCM is the second well known term and technology, however, less than half of the participating SMEs, 47.25% of them, have heard about the technology and plan to use it or use it.

Since more than half of the SMEs in the V4 countries, Serbia and Bulgaria marked that they were not familiar with the term I4.0 logistics regression was used to predict the knowledge of which pillars of I4.0 used in the research could contribute to the better familiarity and knowledge of I4.0, i.e. which elements are significant for SMEs to be acquainted with and be promoted more. The sample contained independent observations, and no multicollinearity problem occurred as tolerance values ranged between 0.374 and 0.7, while VIF values ranged between 1.43 and 2.68 for the predictors [29].

With all the elements entered in the model, it classified 68.8% of the responses well, increasing considerably from the 50.7% in the sample (with a precision of 70.3%), while the Wald method resulted in an accuracy of 69% (with a precision of 70.6%), i.e. the stepwise method has slightly improved on the model. Based on the Hosmer and Lemeshow Test both methods resulted in a model that fits the original data well at p=0.01 (Enter method: Chi2=17.491, p=0.025 and Wald method: Chi2=17.851, p=0.022). According to researchers [30] the conventional significance level p=0.01 can be used with large samples (over 300) if alpha is fixed since the probability of Type II error decreases.

Both the Enter and the Wald methods gave a medium effect size. Nagelkerke's Pseudo R^2 being 0.262 and 0.253, respectively, indicating that the non-significant elements added some explanation why SMEs are familiar or not familiar with the term I4.0. The Chi2 test of Model Coefficient proved to be significant (-2log likelihood decreased significantly, p=0.000) so the use of the I4.0 technologies as independent variables is justified (Table 7).

Table 7
Model Summary and Pseudo R^2

Method	*Step*	*-2 Log likelihood*	*Cox & Snell R Square*	*Nagelkerke R Square*
Enter	1	509,070[a]	0.196	0.262
Wald	4	512,563[b]	0.190	0.253

Table 8 presents how the familiarity with I4.0 technologies used in the survey contribute to the familiarity with I4.0 among the SMEs in the V4 countries, Serbia and Bulgaria.

Table 8
Logistic Regression model (Enter Method) – contribution of I4.0 elements to the familiarity with I4.0

I4.0 elements	***B***	***S.E.***	***Wald***	***df***	***Sig.***	***Exp(B)***
Cloud computing services (x_1)	–0.063	0.090	0.491	1	0.483	0.939
Big Data analysis (x_2)	0.428	0.125	11.716	1	**0.001**	**1.533**
3D printing and Robotics (x_3)	0.261	0.123	4.543	1	**0.033**	**1.298**
IoT (x_4)	0.240	0.111	4.673	1	**0.031**	**1.271**
Virtual Reality (x_5)	0.077	0.161	0.227	1	0.634	**1.080**
Augmented Reality (x_6)	0.152	0.169	0.809	1	0.368	**1.164**
Supply Chain Management (x_7)	0.239	0.115	4.361	1	**0.037**	**1.270**
Artificial Intelligence (x_8)	–0.201	0.136	2.182	1	0.140	0.818
Constant	–2.732	0.385	50.316	1	0.000	0.065

According to the Enter method, when SMEs are familiar with *Big Data analysis, 3D printing and robotics, IoT* and *SCM* they are predicted to be familiar with Industry 4.0 as these elements are significant in the model. However, the other elements, namely *Cloud Computing services, VR, AR,* and *AI* have proved to be insignificant in the model. The Exp(B) value being larger than 1 for the significant

elements, i.e Big Data analysis improves the prediction by 53.3%, 3D Printing and Robotics by 29.8%, IoT by 27.1% and SCM by 27%. Two of the non-significant elements, VR and AR also increase the prediction by 8% and 16.4%, respectively. Surprisingly, two of the non-significant elements (Cloud Computing services (–6.1%) and AI (–18.2%)) seem to contrast with the familiarity with I4.0 among the participating SMEs. These two technologies are not associated with I4.0 among the responding SMEs.

Based on the coefficients, the logistics regression function is the following using all the technologies in the model,

$$\log\left(\frac{p}{1-p}\right) = -2.732 - 0.063x_1 + 0.428x_2 + 0.261x_3 + 0.240x_4 + 0.077x_5 + 0.152x_6 + 0.239x_7 - 0.201x_8 \quad (1)$$

while the probability of SMEs' familiarity with I4.0 is given by the following equation:

$$P(I4.0) = \frac{1}{1+e^{-(-2.732-0.063x_1+0.428x_2+0.261x_3+0.240x_4+0.077x_5+0.152x_6+0.239x_7-0.201x_8)}} \quad (2)$$

The Wald method leaves the four previously significant elements in the model (Table 9), namely *Big Data Analysis, 3D printing* and *Robotics, IoT* and *SCM.*

Table 9

Logistic Regression model (Wald Method) – contribution of I4.0 elements to the familiarity with I4.0

I4.0 elements	*B*	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Big Data analysis (x_1)	**0.401**	0.109	13.447	1	**0.000**	**1.493**
3D printing and Robotics (x_2)	**0.260**	0.111	5.469	1	**0.019**	**1.297**
IoT (x_3)	**0.255**	0.103	6.123	1	**0.013**	**1.291**
Supply Chain Management (x_4)	**0.218**	0.111	3.849	1	**0.050**	**1.244**
Constant	**–2.828**	0.357	62.586	1	0.000	0.059

However, in this model the contribution to the familiarity with I4.0 among SMEs are different, the Exp(B) values show that Big Data analysis improves the prediction by 49.3%, 3D Printing and Robotics by 29.7%, IoT by 29.1% and SCM by 24.4%. This could be explained by the correlations between the significant and non-significant elements of I4.0 (see Table 6).

Based on the coefficient values the logistic regression function is the following using the four significant technologies,

$$\log\left(\frac{p}{1-p}\right) = -2.828 + 0.401x_1 + 0.260x_2 + 0.255x_3 + 0.218x_4 \quad (2)$$

while the probability of SMEs' familiarity with I4.0 is given by the following equation with the four significant technologies:

$$P(I4.0) = \frac{1}{1+e^{-(-2.828+0.401x_1+0.260x_2+0.255x_3+0.218x_4)}} \quad (2)$$

The four non-significant elements in this model were Cloud Computing Services, VR, AI and AR, their elimination resulted in eliminating the strong correlations between the elements in the original correlation matrix.

The following section will compare the results and will discuss the findings. Finally, the hypotheses will be evaluated and the research questions answered.

Conclusions

The research aim was to explore and predict the familiarity with I4.0 by the I4.0 technologies among SMEs in the V4 countries, Serbia and Bulgaria and compare the findings with the spreading if these narratives in various corpora. The research results show that there are similarities but also discrepancies in the list of I4.0 technologies that contribute positively to and can predict well the familiarity with I4.0 among SMEs and the technologies that spread similarly as I4.0 in the narratives. The results imply that certain I4.0 technologies are not associated with Industry 4.0 among SMEs and do not occur together with Industry 4.0 in the narratives.

Based on the results the first hypothesis, according to which

$H1_1$: The familiarity with Cloud Computing, Big Data Analysis, 3D printing, Robotics, IoT and VR contribute positively to the familiarity with I4.0 among SMEs in the V4 countries, Serbia and Bulgaria, they associate these technologies with I4.0 and the familiarity with I4.0 can be predicted among SMEs with high probability, is partially confirmed. Big Data Analysis, 3D printing and Robotics, IoT and SCM significantly predict the familiarity with I4.0 among SMEs, meaning that the higher the familiarity with these terms the higher the probability of SMEs being familiar with the term I4.0 and use the technology in their daily business operations. Cloud Computing services, VR, AR and AI do not predict significantly the familiarity with I4.0 among SMEs. Cloud Computing services contribute negatively implying that SMEs do not associate the technology with I4.0.

The hypothesis stating that

$H1_2$: AR, AI and SCM are not considered elements of I4.0 among SMEs in the V4 countries, Serbia and Bulgaria. SMEs do not associate these technologies with I4.0,can also be partially accepted,since SCM proved to be a significant predictor in the model while AR and AI are non-significant technologies when used for predicting I4.0 familiarity among SMEs in the V4 countries, Serbia and Bulgaria. Furthermore, AI proved to negatively contribute to the prediction, implying that SMEs do not associate the technology with I4.0. SCM, however, proved to be the fourth significant predictor that improves the familiarity with I4.0 by 27% among the participating SMEs. The results for both hypotheses align with the findings of [1, 8, 31, 32].

The partial acceptance of the above two hypotheses gives answers to the first Research Question, as expect Cloud Computing services and AI, the selected I4.0 technologies contribute positively to the familiarity with I4.0 among the responding

SMEs and four of them significantly predict the familiarity with I4.0. SMEs associate these technologies with Industry 4.0, except Cloud Computing services and AI, despite the fact that Cloud computing is the most frequently used services.

The present research covered the spread of these narratives in three corpora and found that the occurrences of AR, Cloud Computing, IoT, Big Data analysis, and 3D printing are highly correlated with the occurrences of I4.0 in all three corpora, while Robotics, AI, SCM and VR show strong correlation in certain corpora. VR is negatively correlated with I4.0 in the German corpus, implying no association with I4.0. On the other hand, apart from Cloud Computing and Big Data analysis, the other terms do not significantly spread the same way as I4.0 in all three corpora. The spreading and usage of the terms 3D printing and Robotics are similar with that of I4.0 in two corpora, while IoT and VR spread similarly as I4.0 in only one corpus. Consequently, responding Research Question 2, AR, AI and SCM do not significantly influence the spread of the term I4.0 in the narratives.

Finally, Research Question 3 seeks similarities in the spreading of the terms and SMEs' familiarity with I4.0 and its technologies. Based on the results, the research question can be partially answered. AI and AR are not good predictors of I4.0 in either the narratives or among SMEs, they were insignificant in both models (Table 10), implying that SMEs do not associate these technologies with I4.0.

Table 10
Comparison of significance of I4.0 technologies among SMEs and in the narratives

I4.0 technologies	***Significant among SMEs***	***Significant in the narratives***
Big data analysis	+	+
3D printing and robotics	+	+
IoT	+	+*
Supply Chain Management	+	—
Cloud computing services	—	+
VR	—	+**
AI	—	—
AR	—	—

Significance level is $p<0.05$ if not marked otherwise

*Significant in American and British corpora at $p<0.1$, significant in German corpus at $p<0.05$

**Significant in American corpora at $p<0.1$, significant in British corpus at $p<0.05$, not significant in German corpus

Big Data Analysis, 3D printing and Robotics, as well as IoT proved to be significant in both models, the familiarity of these terms predicts well the familiarity with I4.0 among SMEs while they spread similarly in the narratives. SMEs associate these terms with I4.0, i.e. if they are familiar with these terms, they are predicted to be familiar with I4.0. SCM, Cloud Computing and VR behave differently, and while SCM is a positive contributor to the familiarity with I4.0 the term does not occur together with I4.0 in a significant volume. The same applies to Cloud Computing and VR but in a reverse mode, they occur together with I4.0 in the narratives but do not predict the familiarity with I4.0 among the participating SMEs in the V4 countries, Serbia and Bulgaria.

Consequently, if SMEs are to be strengthened to be digitalized and use Industry 4.0 technologies, the technologies that proved to be insignificant should be popularized, promoted and introduced so that SMEs, their owners and managers would learn about these technologies and would introduce them in their business practices to a greater extent. Without familiarity with I4.0 technologies it is hard for SMEs to digitalize and improve on the integration of these technologies. Therefore, the digitalization of the sector and the spreading of I4.0 solutions could be improved and would help SMEs to increase their competitiveness, efficiency and business performance. The results align with the findings in [4, 6] as well.

The research has its limitations, since the sampling method did not allow us to have a fully representative sample, however, the sample size was large enough to make it possible to draw conclusions on the behavior of SMEs. The researchers are planning to gather more data and develop further research models to investigate the digitalization level of SMEs that would further support the use of I4.0 technologies at SMEs in these countries.

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