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FELELŐS KIADÓ:
A Budapesti Corvinus Egyetem rektora

ISSN: 0133-0179

NYOMDAI KIVITELEZÉS:
CC Printing Kft. • ccprinting.hu

ELŐFIZETÉS:

Előfizetésben terjeszti a Magyar Posta Rt.
Hírlap Üzletág. Előfizethető közvetlen a
kézbesítőknél, az ország bármely postáján,
Budapesten a Hírlap Ügyfélszolgálati
Irodákban és a Központi Hírlap Centrumnál
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LI. ÉVF., NOVEMBER 2020. 11. szám

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PREREQUISITES FOR A BENEFICIAL KNOWLEDGE TRANSFER BETWEEN MANUFACTURING PLANTS

A TERMELŐÜZEMEK KÖZÖTTI SIKERES TUDÁSTRANSZFER ELŐFELTÉTELEI

The paper aims at exploring the prerequisites for a beneficial knowledge transfer between manufacturing plants of multinational companies (MNCs), by taking the characteristics of the knowledge sending and knowledge receiving plant into consideration. This research seeks to understand how efforts undertaken by manufacturing plants, and how collaborative tools and coordination mechanisms influence a successful knowledge transfer. The study includes thirteen case studies conducted in manufacturing plants from four different European countries (i.e., Switzerland, Romania, Albania, and Macedonia). Given the exploratory nature of this study, the authors used a qualitative research approach. The main method of data collection involved multiple semi-structured interviews at manufacturing plants, uniformly applied in each country in order to observe general patterns across different cases. Their results show that the personal interaction between knowledge sending and receiving plants is more important for a successful knowledge transfer than information systems or prior related knowledge.

Keywords: **knowledge transfer, manufacturing network, knowledge sending, knowledge receiving, multinational companies**

A jelen tanulmány célja megvizsgálni a sikeres és hatékony tudástranszfer előfeltételeit a multinacionális termelővállalatok különböző telephelyei között, figyelembe véve a tudásküldő és tudásfogadó telephelyek tulajdonságait. A szerzők kutatásukban azt vizsgálják, hogy a telephelyek által megtett erőfeszítések, az általuk alkalmazott kollaborációs eszközök és koordinációs mechanizmusok miként járulnak hozzá a sikeres tudástranszferhez. A tanulmány tizenhárom esettanulmányt tartalmaz, amelyeket négy európai országban készítettek (Svájc, Románia, Albánia és Macedónia). Tekintettel a kutatás feltáró jellegére kvalitatív kutatási módszert alkalmaztak a szerzők. Az adatgyűjtés fő módja a félig-strukturált interjúk módszertanára épült, amelyeket az említett négy országban egységesen hajtottak végre annak érdekében, hogy párhuzamot tudjanak vonni a különböző esetek között. Eredményeik azt mutatják, hogy a személyes interakció a tudásküldő és tudásfogadó telephelyek között sokkal fontosabb egy sikeres tudástranszfer tekintetében, mint az alkalmazott információs rendszerek vagy az előzetes tárgyi tudás.

Kulcsszavak: **tudástranszfer, termelési hálózatok, tudásküldés, tudásfogadás, multinacionális vállalatok**

Funding/Finanszírozás:
The authors would like to thank the Swiss National Science Foundation (SCOPES Joint Research Project IZ73Z0_152505) and UEFISCDI Romania (Executive Agency for Higher Education, Research, Development and Innovation Funding, PN-III-P1-1.1-TE-2016-0502 project) for the financial support provided for the research project discussed in this paper.

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This article was received: 23. 09. 2020, revised: 21. 10. 2020, accepted: 22. 10. 2020.
A cikk beérkezett: 2020. 09. 23-án, javítva: 2020. 10. 21-én, elfogadva: 2020. 10. 22-én.

Knowledge sharing enables a firm to develop itself further and to become a learning organisation (Shi & Gregory, 1998). Since many firms do not consist of one manufacturing plant only but are actually dispersed networks of plants scattered around the globe, knowledge sharing and its challenges have gained even more attention over the last couple of years (Dunning, 2006).

In this process, critique arose that studies analysing knowledge flow in manufacturing networks stay at the aggregated network level (Foss et al., 2010). Some authors argue that it is not possible to fully understand the flow of knowledge based on organisational-level analysis alone (Argote & Ingram, 2000; Foss et al., 2010; Gupta et al., 2007). They claim that the plant level, and especially the underlying processes and relationships, need to be analysed as well. It is assumed that they mediate the variables at network level (Abell et al., 2008; Foss et al., 2010).

The objective to analyse both the network and the plant level is also supported by the mixed results concerning knowledge transfer benefits. Studies analysing the achieved benefits by internal knowledge transfer demonstrate positive (Ding et al., 2013), negative (Ambos et al., 2006), mixed (Szász et al., 2016) and curvilinear effects (Erden et al., 2014). To explain these differences, some authors suggest that the benefit of knowledge transfer depends on context similarities, adaptation cost, the cost of knowledge transfer, or the competences of the knowledge receiver. In addition, mechanisms, prerequisites, and motivation to engage in knowledge transfer also need to be considered (Tran et al., 2010).

Given the lack of research in this field, our research is primarily exploratory in its nature, and aims at exploring the prerequisites for a beneficial knowledge transfer between manufacturing plants within MNCs at network and plant levels. On the plant level we aim to analyse knowledge transfer activities by taking the characteristics of the knowledge sending and the knowledge receiving plant simultaneously into consideration (RQ1). On the network level, we take into consideration the coordination mechanisms that influence knowledge transfer activities between plants belonging to the same network (RQ2). Thus, in order to gain deeper understanding in when knowledge transfer is beneficial within a manufacturing network, the study at hand follows to answer two research questions:

RQ1: "What are prerequisites of a beneficial knowledge transfer at the sending and receiving plant?"

a) *"How do efforts undertaken by the knowledge sending and receiving plant influence knowledge transfer success?"*
b) *"How do collaborative tools influence a successful knowledge transfer?"*
c) *"How do similarities between the knowledge sending and receiving plant influence knowledge transfer benefits?"*

RQ2: "How do coordination mechanisms influence a successful knowledge transfer?"

We argue that the research questions are relevant from both theoretical and practical perspectives: it aims to contribute to filling a theoretical gap by enhancing our understanding of the conditions of beneficial knowledge transfer within MNCs, and from a practical perspective it aims to offer useful guidance for plant managers to facilitate successful knowledge transfer projects. The paper therefore builds on an exploratory research, and is structured as follows. We start with the literature review, followed by the description of the case research methodology used. In the last two parts we present our results and findings followed by the conclusions and discussions in the light of our research questions.

Literature review

Knowledge transfer, knowledge sharing and knowledge flow

As our paper is built around the concepts of knowledge transfer, knowledge flow and knowledge sharing, it is important to clarify their meaning. According to Baksa and Báder (2020) knowledge sharing is the efficiency-oriented behaviour of employees, that implies two individuals sharing their experience and knowledge of their fields of expertise (Hankonen & Ravaja, 2017). Through knowledge sharing, individuals can share valuable skills and craftsmanship, resulting new knowledge, which can benefit the learning capacity of the whole plant (Ergün & Avcı, 2018).

On the other hand, knowledge transfer and knowledge flow are rather defined as a process of communication (Minbaeva, 2007) on a manufacturing network level (Tsai, 2002). Knowledge sharing between plants can lead to performance benefits to the knowledge-receiving plant, resulting a better overall performance of the manufacturing network (Szász et al., 2019). Poor knowledge transfer can lead to uncertainty in the manufacturing network, but also be a major waste of corporate resources (Pauleen & Holden, 2010).

Knowledge flow is mentioned as one of the two types of the information flow by Vereecke and De Meyer (2006). The administrative information flow consists of information on inventory, production plans, forecasts, purchasing requirements etc. Knowledge flow is mainly tacit, which is rarely written and relies more on the experience of the individuals involved in the process. According to other researchers, knowledge flow is one of the main reasons multinational companies can exist and are able to dissolve cultural (Pauleen & Holden, 2010) and national boundaries (Dunning, 1993).

Knowledge flows in manufacturing networks

Literature recognises the internal knowledge transfer as a valuable source of competitive advantage in a manufacturing network (Argote & Ingram, 2000). Researchers claim the importance to analyse knowledge flow within manufacturing networks on both the network and plant level (e.g., Foss et al., 2010; Gupta et al., 2007). Subsequently, the literature research is organised along this line.

Knowledge flow within the manufacturing network describes the transferring process between the knowledge-sending and knowledge-receiving plant (Tseng, 2015; Gupta & Govindarajan, 2000; Minbaeva, 2007). Three different flows of knowledge exist: (1) forward, from headquarters to a plant, (2) reverse, from a plant to headquarters, and (3) lateral, between peer plants (Ambos et al., 2006).

Since we are interested in the knowledge transfer between peer plants, we concentrate in this paper on the lateral knowledge flow. In lateral knowledge flows the knowledge-sending plant needs to be willing to transfer knowledge and needs to have transferring capabilities in order for the knowledge transfer to be successful (Wang et al., 2004; Szulanski, 1996; Mahnke et al., 2005; Szász et al., 2019). The knowledge-receiving plant, on the other hand, needs to have absorptive capacities to be able to internalise the provided knowledge (Tsai & Ghoshal, 1998; Foss & Pedersen, 2002). The knowledge-receiving plant furthermore needs motivation to accept and use the provided knowledge, otherwise, the recipient may reject the implementation or feign acceptance of the provided knowledge (Hayes & Clark, 1985). According to Demeter and Losonci (2016) there are several reasons why such a knowledge transfer can become less effective, such as:

- lack of motivation at both plants, especially at the knowledge-receiving, but also at the knowledge-sending plant,
- low level of similarity between the technological and/or geographical attributes of the sending and receiving plants (Rosenkopf & Almeida, 2003),
- competitive relationship between peer plants (Dyer & Nobeoka, 2000),
- causal obscurity, when we do not know how the transferred knowledge affected the performance of the knowledge-receiving plant,
- low absorptive capacity of the knowledge-receiving plant, due to lack of experience and previous knowledge (Cohen & Levinthal, 1990).

Manufacturing network coordination, and especially mechanisms to coordinate the flow of knowledge within one network have been recognised as essential to combine the dispersed knowledge in the network (Ferdows, 2006; Rudberg & West, 2008; Vereecke et al., 2006). Even though many coordination mechanisms have been discussed in literature, the answer is still lacking which of these mechanisms serve as prerequisites to coordinate the knowledge flow within a network. The main coordination mechanisms are: the degree of standardisation (Maritan et al., 2004; Rudberg & West, 2008; Scherrer-Rathje & Deflorin, 2017), centralisation (Feldmann & Olhager, 2011; Netland & Aspelund, 2014; Scherrer-Rathje & Deflorin, 2017) and autonomy, split into strategic and operational decision making autonomy (Golini et al., 2016; Kawai & Strange, 2014). Standardisation is the degree of similarity of products, processes, or systems throughout the network (Maritan et al., 2004). Centralisation and autonomy are linked, as decentralisation of decision making is the main indicator of a site's autonomy (Maritan et al., 2004).

Based on the presented literature, for the paper at hand, we take the dimensions of standardisation, centralisation and autonomy into consideration when analysing prerequisites of a beneficial knowledge transfer at network level (RQ2).

Knowledge flow on plant level

Knowledge flow within the manufacturing network describes the transfer process between the knowledge-sending and knowledge-receiving plant (Gupta & Govindarajan, 2000; Minbaeva, 2007; Tseng, 2015). To analyse the knowledge transfer on plant level, we follow the suggestion of Szulanski (2000) and take the basic elements of knowledge transfer into consideration: the source, the recipient and the channel.

(1) The source of knowledge, in our case the knowledge-sending plant, needs to be willing and needs to have transferring capabilities in order for the knowledge transfer to be successful (Mahnke et al., 2005; Szulanski, 1996; Wang et al., 2004; Szász et al., 2019).

(2) The recipient, in our case the knowledge-receiving plant, needs to have absorptive capacities to be able to internalise the provided knowledge (Foss & Pedersen, 2002; Tsai & Ghoshal, 1998). Absorptive capacity depends on the pre-existing stock of knowledge. Literature discusses causal ambiguity to be an essential prerequisite to internalise provided knowledge (Gupta & Govindarajan, 2000; Phelps et al., 2012; Szulanski, 2000).

(3) The channel links the knowledge sending and receiving plant with each other. These channels can be formal or informal. Formal channels are those that are coordinated centrally, whereas informal channels are self-established friendships or other social ties within the manufacturing network (Adenfelt & Lagerström, 2008; Bell & Zaheer, 2007; Foss et al., 2010; Song, 2014). Thus, most of these informal channels are based on the personal interactions between employees of the knowledge sending and receiving plants.

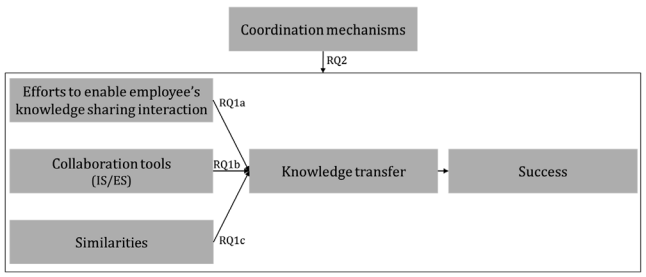
Next to the personal interactions, formal channels also exist in the sense of information and communication systems. These systems can be used to share knowledge among members of the manufacturing network (Bigliardi et al., 2010). In this sense, they also build on the interaction between employees working at sending and receiving plants.

Finally, literature discusses that knowledge transfer can be enabled through similarities. These can be strategic or knowledge similarities (Darr & Kurtzberg, 2000; Scherrer & Deflorin, 2017). Both can help to overcome the possible lack of the pre-existing stock of knowledge of the knowledge receiving plant in the sense that also, for example, similar strategic orientation can enable the knowledge receiving plant to understand the provided knowledge. Strategy can be operationalised through competitive priorities such as cost, quality, flexibility, delivery or innovation (Schoenherr & Narasimhan, 2012; Szász & Demeter, 2014).

To measure the result of the knowledge transfer, we consider two categories. The first consists of knowledge outputs such as an increase in product, process, or technology knowledge (Argote & Ingram, 2000; Darr & Kurtzberg, 2000; Kang et al., 2010). The second consists of operational performance measures, such as cost, quality, flexibility, delivery or innovation (Hayes & Wheelwright, 1984; Rosenzweig & Easton, 2010; Schoenherr & Narasimhan, 2012; Szász & Demeter, 2014).

Figure 1.

Conceptual Framework



Source: own editing

To sum up, Figure 1 shows the conceptual framework of the research paper at hand. While the source and the recipient need to have the described preconditions like the willingness to share knowledge and absorptive capacity to take the knowledge in, the channel can have different characteristics. Since we propose that these characteristics influence the knowledge transfer activities, we group the elements of the channels into (1) effort that a company puts into the interaction between knowledge sending and receiving plants, (2) the provided collaboration tools (information systems, enterprise systems), as well as (3) the similarities between the plants. The (4) coordination mechanisms (i.e. standardisation, centralisation and autonomy) frame the interplay between the plants within the manufacturing network.

Methodology

Being a primarily exploratory research, we have chosen the multiple case study method (Yin, 1988), which gives the possibility to both discover diverse knowledge roles of the multiple plants involved and their different underlying capabilities, but also to observe general knowledge transfer similarities across different cases.

The unit of analysis is the manufacturing plant within the multinational company. To gain an understanding of lateral knowledge transfer we examined 13 manufacturing plants located in Switzerland, Romania, Macedonia and Albania. We used middle-range theory development (Merton, 1968), by linking theory and empirical work. We derived dimensions from theory and refined them through case study research. Eisenhardt and Graebner (2007) recommend the case study approach for research interests such as ours, since the topic is not well documented and relatively unknown. The qualitative research approach (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Voss et al., 2002) provided us with deeper insights into the selected case plants and allowed us to generate new insights. The plant level was selected as the unit of analysis to gain information in the needed level of detail. Moreover, based

Table 1.

Plant's' knowledge transfer activities

		Group 1 Net senders			**Group 2** Balanced actors		**Group 3** Active receivers			**Group 4** Net receivers				
	Plant	S2	S3	S1	M2	A3	M3	R1	R3	A1	M1	A2	A4	R2
	Age [years]	152	74	25	18	6	50	4	8	12	3	9	8	3
Knowledge	Send	+++	++	++	+++	++	++	++	++	+			+	+
	Receive	+	++	+	+++	++	++	+++	+++	+++	+++	+++	+++	+++
Innovation	Send	+++	+++	+	+++	++	+	+	+	+	+		+	
	Receive	+	+	+	+++	++	+++	+++	+++	+++	++		+++	+++
Training	Trainer	+++	+++	+++	+	+	+	++	+	+	+	+		+
	Trainee	+	+	+	++	++	+++	+++	+++	++	++	+++	++	+++

Legend: + = low amount; ++ = medium amount; +++ = high amount

Source: own editing

on Voss et al. (2002) who consider that case studies should contain between 3 and 30 cases, and Eisenhardt (1989) who reduce this interval to 4-10 cases, an approximately equal number of cases (three to four) was targeted in each of the four participating countries, i.e. Switzerland, Romania, Albania, and Macedonia, resulting in a total number of 13 case studies. More specifically, we conducted case study analysis at 3 manufacturing plants from Switzerland (S1, S2, S3), 3 from Romania (R1, R2, R3), 4 from Albania (A1, A2, A3, A4) and 3 from Macedonia (M1, M2, M3). These plants operate in various industries like automotive, electronics, food, constructions, rail, steel, cement, and industrial equipment offering a good variety in terms of country and industry to ensure a higher validity of cross-case analysis.

Case plants were selected based on the joint fulfilment of the following criteria (Szász et al., 2019): (a) they belong to a multinational company (MNC) with at least four

Table 2.

Cross-case analysis of case data related to successful projects

	Company	S1	S2	S3	R1	R2	R3	A1	A2	A3	A4	M1	M2	M3
Efforts to enable employee's knowledge sharing interaction														
Formal	Job Rotation		x	x	x		x			x	x			x
	Cross-functional interfaces				x		x		x					
	Center of Competence					x								
	Help desk				x									
	Global meetings (Centrally coordinated)								x				x	
	Centrally coordinated visits of other plants	x	x		x		x	x		x	x	x		x
	Centrally coordinated trainings		x								x	x		
	Standardised documentation	x				x		x					x	
Informal	Ad-hoc support between plants (Social ties)		x	x			x		x	x				
Collaboration tools	Information Sharing / Web	x	x	x	x	x	x		x	x	x	x	x	x
	Collaboration platform	x	x		x	x			x			x	x	
	Document Management System				x	x	x		x	x	x	x	x	
	Intranet / News	x	x		x	x	x	x	x		x		x	
	Decision support System		x		x	x	x		x				x	x
	Data warehousing, data mining, & OLAP		x		x	x	x		x	x	x	x	x	x
	Conferencing tools (eg., video conferencing)	x	x	x	x	x	x	x	x	x	x	x	x	x
	Communication tools (e.g., email, wikis, file sharing, etc.	x	x	x	x	x	x	x	x	x	x	x	x	
	Artificial intelligence tools/Expert Systems		x			x							x	
	Simulation tools		x	x	x	x	x						x	
Similarities														
Knowledge	Product		x	x		x	x	x	x	x	x	x	x	x
	Process	x	x	x	x	x	x	x	x	x	x	x	x	x
	Technology	x	x	x	x	x	x	x	x	x	x		x	x
	Management				x				x		x		x	x
	Service							x	x	x	x		x	x
Prior related	Product		x					x			x			
knowledge	Process		x		x								x	
	Technology			x										
	Management													
	Service													
Coordination mechanisms														
Standardisation	High		x		x	x	x	x	x	x	x	x		x
	Medium	x		x									x	
	Low													
Centralisation	High	x				x	x	x	x	x	x	x		
	Medium		x		x								x	x
	Low			x										
Strategic decision	Headquarters	x	x	x	x	x	x	x	x	x	x	x	x	x
autonomy	Plant													
Operational	Headquarters						x	x			x			
decision autonomy	Plant	x	x	x	x	x			x	x		x	x	x
Success														
Knoweldge output	Product related knowledge increase													
	Technology related knowledge increase	x				x								
	Process related increase		x	x	x		x		x		x	x		x
Competitive	Cost		x				x							x
Priorities increase	Quality			x	x		x	x	x			x		
	Delivery speed	x				x	x							
	Flexibility	x	x			x	x							
	Innovation					x								
	Service (pre-sales)													
		Knowldge sending plants			Knowledge receiving plants									

Source: own editing

manufacturing plants, (b) their MNC is a leading company in its field, with the headquarters (HQ) in a developed country, and operations in at least three countries, (c) the plant to be interviewed is not an isolated player (Vereecke et al., 2006), i.e. it is actively engaged in knowledge sending and/or receiving to/from other units from within the MNC. Companies with no clear knowledge roles for the analysed plant or companies that were not transparent enough regarding their knowledge transfer activities and underlying were excluded from this study.

Within the qualitative research approach, we used semi-structured interview as the main method of data collection, with an interview protocol uniformly applied in each country. Each manufacturing plant was interviewed at least once, but in some cases follow-up interviews were conducted to clarify specific knowledge transfer aspects. Interviews were targeted at the highest managerial level who oversee the knowledge transfer projects, but also actively participate in facilitating knowledge transfer activities. Researchers have participated in multiple interviews in mixed teams from different countries to enable a uniform understanding of the data collected. Field data were collected from December 2015 until March 2017.

In order to analyse our research questions, we first asked the interviewees general questions about the plants (environmental conditions, strategies and involvement in knowledge transfer activities, embeddedness in network). Second, they were asked to evaluate their embeddedness in the knowledge transfer activities within their networks, more exactly to evaluate in general how much (1) *information* and (2) *innovation* they send and receive and (3) how much *training* they offer to employees from other plants and how much training they received from other plant staff in comparison to other plants in the network. These dimensions were adapted from the work of Vereecke et al. (2006). The first dimension covers the amount of information transferred, which needs to be distinguished from pure data based exchange and refers to more explicit data concerning day-to-day activities related to products, processes, technology, management or services (i.e. meaningful information related to manufacturing). In addition, the second dimension aims at capturing innovation, which is related to a more tacit type of knowledge. Transferring innovation from one plant to another means that there are no routines established and most often, its implementation is based on a combination of knowledge and information. Third, trainings were also assessed as a frequent form of complex knowledge transfer within the manufacturing network of MNCs.

Next, in order to derive differences between beneficial and less beneficial knowledge transfer, we asked interviewees to identify a successful and a less successful knowledge transfer project and to explain what content explicitly has been transferred between plants. Altogether we examined 25 examples of knowledge transfer projects, as one of the 13 plants refused to identify an unsuccessful project. By having multiple knowledge transfer projects, we aimed at getting a better understanding of the specific content transferred within these processes. We were also interested in the factors that made the interviewees consider a knowledge transfer project beneficial or not which were mainly related to the process (e.g. time and resources needed to transfer knowledge) or the outcome (e.g. new process technology introduction) of knowledge transfer processes.

We then discussed the different prerequisites for knowledge transfer based on factors derived from literature. In addition, to gain in-depth insights, we encouraged the interviewees to discuss additional relevant factors. It has to be noted that each knowledge transfer project was investigated from a unilateral perspective, but we aimed to include both sender and receiver plants in our sample to gain a better understanding of both roles within manufacturing networks.

All interviews lasted between two and three hours, were taped and afterwards transcribed. The contents of all interviews were summarised into a manuscript containing the details of each knowledge transfer discussed. Afterwards, the research team conducted a cross-case analysis to compare and to gain a proper understanding of knowledge transfer processes at each manufacturing plant. Besides the interview data, company documentations, archive data, manuals, we used industry publications and personal observations in order to formulate conclusions (Szász et al., 2019).

Data analysis and findings

Following the analysis of interview data, complemented by archival data and personal observation, we categorized the 13 plants in four groups in terms of their involvement in knowledge sending and knowledge receiving activities (Table 1):

- Group 1 (Net senders) consists of those plants that send a lot of knowledge to other plants, but receive only minimal knowledge from others.
- Group 2 (Balanced actors) and Group 3 (Active receivers) are intermediate groups. The plants in group 2 send and receive knowledge approximately to an equal extent. Plants in group 3 are also involved in both sending and receiving knowledge, but they receive somewhat more and send somewhat less than plants belonging to Group 2.
- Group 4 (Net receivers) consists of those plants that are mainly knowledge receivers, and engage only rarely in knowledge sending activities, and if they do so, they send only low amount of knowledge.

Table 1 further shows that the older plants in the sample are those who act as knowledge senders. The younger the plants are, the more they are leaning towards the net receiving group (Group 4). The intermediate groups are not fully consistent related to amount of knowledge transferred and the age. Plant R1 belongs to the active receivers group despite being one of the youngest plants in the sample. Plant M3 is also part of the intermediate group, but with 50 years in age, it is older than the youngest plant in the net sender group (S1). Consequently, we can

only partly support the existing results from literature discussing plant age and the participation in knowledge transfer activities as correlating factors.

During the interviews, the interviewees were asked to identify successful and less successful knowledge transfer projects in order to derive differences between beneficial and less beneficial knowledge transfer. Table 2 shows the cross-case results of case data related to successful projects. All units investigated, no matter if they are knowledge sending or knowledge receiving plants, engage in formal (job rotation, centrally coordinated visits of other plants, trainings, standardised documentation) and informal (ad-hoc support between plants) efforts to facilitate knowledge exchange. Furthermore, all plants have various types of collaboration tools in place (such as information sharing tools, web, intranet, video conferencing, email, file sharing, and even more complex systems which can facilitate knowledge transfer activities). When it comes to similarities, all knowledge exchanging plants have similar process knowledge and most of them also have similar product, process and/or technology knowledge. The level of standardisation and centralisation is overwhelmingly high, with the majority of strategic and operational decisions making activities at headquarters. Overall, if the knowledge transfer projects were successful, the plants reported either a knowledge output in a process or a technology related knowledge increase.

In order to differentiate between beneficial and less beneficial knowledge transfer, we asked the interviewees to identify successful and less successful knowledge transfer projects and to explain what content explicitly has been transferred between plants. From this resulted 25 examples of knowledge transfer projects, one of the plants refusing to comment on unsuccessful projects. Table 3 and Table 4 highlight some examples of prerequisites leading

Table 3.

Examples of successful knowledge transfer projects

Company	Role	Project description	Supporting factors
S1	Knowledge sender	Duplication of production line at sister plant. Knowledge sending plant provided technological and process knowledge and supported employees at sister plant in implementing and ramping-up production.	*Effort* - Monthly video conferences coordinated by central - Every six month visit of employees from knowledge sending plant at knowledge receiving plant - High effort in establishing personal ties between employees of knowledge sending and receiving plant *Collaboration tools* - All necessary documentation stored in information sharing software *Similarities* - Establishment of similar production line as at sending plant - No prior related knowledge in place *Coordination mechanism* - High level of standardisation in documentation *Success* - Technological knowledge output
R3	Knowledge receiver	Implementing of TPM system. Other plant provided knowledge of how to implement TPM and how to follow the rules. TPM was implemented and running after 1,5 years at interviewed plant. To compare: average implementation time within company is 3 years.	*Effort* - Centrally coordinated visits of other plants that had TPM already implemented - One employee from knowledge sending plant served as a consultant for receiver plant - Consultant made frequent visits at knowledge receiving plant *Collaboration tools* - All necessary documentation stored in information sharing software *Similarities* - Similar processes at knowledge sending and receiving plant - No prior related knowledge in place *Coordination mechanisms* - High level of standardisation - High level of centralisation; Autonomy at HQ *Success* - Process knowledge output
M3	Knowledge receiver	New process knowledge transferred from sister plant to M3. In it, the sister plant enabled M3 in how to implement and use a process extensions to the existing production process.	*Effort* - Ad-hoc visits to other plants to see how they conducted process step of interest for selection purpose - One employee from knowledge sending plant served as a consultant for receiver plant - Job rotation with knowledge sending plant was key - Network of peers contacted for ad-hoc questions (social ties) *Collaboration tools* - Information in database - Video conferencing tools used to interact with knowledge sending plant *Similarities* - Similar technology knowledge at sending and receiving plant - No prior related knowledge *Coordination mechanisms* - High level of standardisation - Medium level of centralisation with strategic autonomy at HQ and operational autonomy at plant *Success* - Process related knowledge output

Source: own editing

Table 4.

Examples of unsuccessful knowledge transfer projects

Company	Role	Project description	Hindering factors
S2	Knowledge sender	Product transfer from S2 to low cost plant.	*Effort* - HQ forced employees of S2 to provide their process knowledge - Employees of S2 were not motivated to give their knowledge to other plant - Process was rushed, not enough management attention *Collaboration tools* - All necessary documentation stored in information sharing software, but bad data quality *Similarities* - Similar product, process and technology knowledge - Prior related knowledge related to product, process and technology *Coordination mechanisms* - High level of standardisation - Medium level of centralisation with strategic autonomy at HQ and operational autonomy at plant *Success* - No success
A3	Knowledge receiver	Providing information about accidents so that the same accident does not happen in one of the other plants as well. However, not all accidents could be avoided.	*Effort* - Formal documentation of accident and how it came to it - no personal experience exchange *Collaboration tools* - Database for report *Similarities* - Similar product, process and technology knowledge - No prior related knowledge *Coordination mechanisms* - High level of standardisation - High level of centralisation with strategic autonomy at HQ and operational autonomy at plant *Success* - No success
M2	Knowledge receiver	Reproduction of a product that was produced at an other plant only based on company documentation of that specific product. At the end, the final product did not perform well under different humidity conditions.	*Effort* - No personal contact, experience exchange would have hindered project failure *Collaboration tools* - Product documentation in company database *Similarities* - Same product, process and technology knowledge - Prior process related knowledge *Coordination mechanism* - Medium level of standardisation - Medium level of centralisation with strategic autonomy at HQ and operational autonomy at plant *Success* - No success

Source: own editing

to a knowledge transfer success (Table 3) and some, where the knowledge transfer was unsuccessful (Table 4).

The comparison between Table 3, showing examples of successful projects, and Table 4, showing examples of unsuccessful projects, displays that the successful projects were characterised by a high level of effort in personal contact (monthly video conferences, frequent employee visits from knowledge sending plants at knowledge receiving plants, personal ties between the knowledge sending and knowledges receiving plants, job rotations between sending and receiving plants, consultancy activities, frequent visits of key knowledge sending personnel at the knowledge receiving plants, ad-hoc visits to other plants). As the manager of S3 commented: "*Knowledge transfer is a people's business*" or as the plant manager of M3 summed up: "*Systems are not enough. Network is the key factor …. The network of people*."

Even though in all successful projects, information about the emphasised projects were in the company databases, they were only useful if the data quality was appropriate. And even then, the information alone was not useful if there were no employees from the knowledge sending plant explaining the content of the documents and data repositories to their peers at the knowledge receiving plants.

Prior-related knowledge showed to be of no necessity for a successful knowledge transfer. In all three examples provided in Table 3, no prior-related knowledge was in place. In comparison to this, two out of three examples of the unsuccessful projects had prior-related knowledge based on the emphasised project in place.

With regard to the coordination mechanisms, the companies showed similar characteristics, no matter if the project was successful or not. All companies have a medium to high level of standardisation and a medium to high level of centralisation with strategic decision autonomy always at headquarters and operational autonomy partly at headquarters and partly at the plant level.

Discussion and conclusion

The subsequent paragraphs briefly summarise our findings in light of the research questions of this paper.

First, related to RQ1.a, our study revealed that both knowledge sending and knowledge receiving plants

engage in formal and informal efforts to facilitate knowledge exchange. The knowledge transfer is more successful in case of similar process knowledge or similar product/technology knowledge base. Moreover, all companies have a medium to high level of standardisation and a medium to high level of centralisation with strategic decision autonomy always at headquarters and operational autonomy partly at headquarters and partly at the plant level. We align with Scherrer and Deflorin (2017), who consider that these aspects (strategic similarities and product/product family/technology similarities) are prerequisites for a knowledge transfer to be beneficial.

Second, related to RQ1.b, despite the often-discussed fact that the information systems are necessary for a successful knowledge transfer, our data mirror a different perspective. Only if a personal interaction between the knowledge sending and receiving plant is established, the knowledge transfer has been considered as beneficial. In line with this, several authors have criticised the general assumption that information systems can support the knowledge transfer within organisations. Authors claim that if there is no overlap between the knowledge sender and receiver in their underlying knowledge base, knowledge transfer based on information systems alone does not work (Alavi & Leidner, 2001). As stated above, our data do not reveal the importance of prior knowledge stock. Instead, our conclusion is more in line with the statement of Roberts (2000), saying that information systems will never be able to entirely replace face-to-face interactions (RQ1.a) between knowledge sender and receiver.

Third, in relation to RQ1.c, we conclude based on our data that the pre-existing stock of knowledge, claimed to be necessary to have the ability to absorb provided knowledge, does not hold true in all of our cases. With this, our data do not support the necessity of causal ambiguity for a beneficial knowledge transfer (Gupta & Govindarajan, 2000; Szulanski, 2000). Instead, the personal contact seems to be able to overcome non-existing prior knowledge stocks, which is an important implication for newly established plants with less knowledge or plants located in countries with lower levels of pre-existing knowledge base.

Fourth, related to RQ2, we conclude that at least a medium level of standardisation needs to be in place to enable the possibility of knowledge transfer, but the coordination mechanisms alone seem not to be responsible for a successful knowledge transfer.

To sum up, managers seeking beneficial knowledge transfers within manufacturing networks should take the importance of personal interactions during the knowledge exchange process into account. It is worth to invest in personal exchange activities, such as mutual plant visits, joint projects, informal meetings, joint training programs and team-buildings, to bind social ties even prior to knowledge exchange activities, as these social ties support a higher frequency of interactions and a higher willingness to participate in knowledge exchange activities, and ultimately can secure the success of transferring knowledge between peer plants belonging to the internal network of the same MNC.

Overall, our study contributes to operations and knowledge management literature by exploring the role of some plant-level and network-level factors in successful knowledge transfers, but it is also limited in its generalizability given that case study research was conducted. Nevertheless, the variance between the cases in terms of country, industry and age offers a good basis to formulate propositions for further research attempts. Further research on a larger scale should verify our results and quantify the importance of personal factors compared to structural factors in successful knowledge transfers. Future research should also involve additional factors, such as disseminative capability, absorptive capability dimensions, to investigate whether there is an interaction between these factors and the ones involved in our study that can further improve successful knowledge transfers. Another highly relevant future research issue is related to the COVID-19 pandemic as it influences the way employees work at companies and poses an important limit to personal interactions which was deemed as the most influential prerequisite of successful knowledge transfer. How changing work habits will influence knowledge transfer projects remains, thus, an issue for further investigation.

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INDUSTRY 4.0 THROUGH THE LENSES OF TECHNOLOGY, STRATEGY, AND ORGANIZATION: A COMPILATION OF CASE STUDY EVIDENCE

IPAR 4.0 A TECHNOLÓGIA, STRATÉGIA ÉS SZERVEZET SZEMSZÖGÉBŐL: ESETTANULMÁNY-ALAPÚ EREDMÉNYEK

In the last few years, the management literature has become noisy with Industry 4.0 (I4.0). Although several concepts and typologies intend to make the phenomenon more understandable, these endeavours generally focus on technological aspects or specific issues. Therefore, integrated approaches of the I4.0 transformation on the business side and a comprehensive investigation of this phenomenon on the academic side are still needed. This paper synthetizes the lessons of 15 case studies from five sectors (automotive, FMCG, logistics services, retail, and business services) and places them in a triadic framework of technology, strategy, and organization. The case studies are based on interviews, internal documents and public information. This paper reveals that the analysed companies focus on I4.0 technologies that are substantially related to the development of core activities. Companies in a highly competitive global environment (e.g., automotive industry and business services) are more prepared and progress faster with I4.0 technology implementation.

Keywords: **Industry 4.0, strategy, organization, Industry 4.0 technologies, digital transformation**

Az elmúlt években a menedzsmentirodalom az Ipar 4.0-tól (I4.0) vált hangossá. Bár számos koncepció és kategorizálás létezik, amelyek igyekeznek érthetővé tenni a jelenséget, ezek gyakran a technológiai szempontokra vagy néhány konkrét megoldásra fókuszálnak. A cikk a digitális transzformáció üzleti szempontú, komplex és integrált megközelítését adja a technológia-stratégia-szervezet keretrendszer alkalmazásával. A kutatás öt ágazat (autóipar, FMCG, logisztikai szolgáltatások, kiskereskedelem és üzleti szolgáltatások) 15 vállalatának tapasztalatait szintetizálja. A részletgazdag esettanulmányok interjúkon, valamint céges és publikus dokumentumokon alapulnak. A kutatás eredményei szerint a vizsgált cégek aktívan foglalkoznak az I4.0 technológiákkal, legfőképpen az elsődleges értékteremtő folyamatok fejlesztése kapcsán. A globálisan kiélezett versenyhelyzetben lévő vállalatok (járműipar, üzleti szolgáltató központok) felkészültebben indulnak és gyorsabban is haladnak az I4.0-val.

Kulcsszavak: **Ipar 4.0, stratégia, szervezet, Ipar 4.0 technológiák, digitális transzformáció**

Funding/Finanszírozás:
This research was supported by the project "Aspects on the development of intelligent, sustainable and inclusive society: social, technological, innovation networks in employment and digital economy" (EFOP-3.6.2-16-2017-00007). The project has been supported by the EU, co-financed by the European Social Fund and the budget of Hungary.

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This article was received: 21. 09. 2020, revised: 20. 10. 2020, accepted: 21. 10. 2020.
A cikk beérkezett: 2020. 09. 21-én, javítva: 2020. 10. 20-án, elfogadva: 2020. 10. 21-én.

The phenomenon of the Fourth Industrial Revolution permeates everything. It has completely subverted several service sectors (e.g., retail, banking, and music) and cannot be neglected in either processing industries or whole supply chains. Digitalization in this paper is used as a synonym for I4.0, and even though the difference between the two is well-known (Demeter & Losonci, 2020), it is accepted here as a common practice among both researchers and practitioners.

Despite the tremendous impact of I4.0, the analysis of it is still in its infancy. One obvious reason is that many different perspectives (e.g., business, design, maturity, and implementation) (Demeter & Losonci, 2020) and several ad hoc categories are used for examining new emerging technologies. Furthermore, the more-trivial representatives of 4.0 technologies, such as 3D printing and big data analytics, are usually discussed in academic studies as specific and separate issues, where the most frequent unit of analysis is the project. Although it supports an understanding of the narrow phenomenon, project-focused approach offers much less insight into company level efforts using I4.0. Moreover, managers can be confused when reading two extreme examples, namely, studies on the best companies (see World Economic Forum, 2019) and studies regarding the evidence and expectations of less-experienced companies (Dalenogare, Benitez, Ayala, & Frank, 2018). Therefore, this "granular" approach and ambiguous research context create strong barriers, among others, and practically hinder the development of proper recommendations to companies managing I4.0 transformation issues.

To address these shortcomings, our business-oriented paper aims to draw a complex and integrated view of companies' I4.0 transformation. To grasp the phenomenon in this manner, we applied a technology-strategy-organization framework.

The structure of the article is as follows. To propose a common understanding, our paper first briefly classifies the I4.0 technologies and then examines the main features of the I4.0 transformation at the business unit level, including the internal factors of contingency (Soliman, 2014) (strategy and organization) and technology. Following the literature review, the case study methodology and data collection protocol are described. A total of 15 case reports were used to identify business unit practices. Business units were selected from different positions in different supply chains. Relying on this cross-case analysis, the results section provides insights into the differences in the transformation patterns. Highlights and future research directions are detailed in the conclusion.

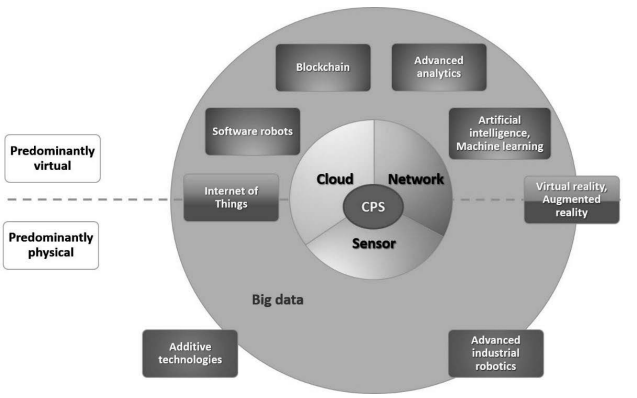
Literature review

Technologies

Although I4.0 technologies are rooted in the Third Industrial Revolution, they extend far beyond this period. Ubiquitous computing, a specific attribute of the Fourth Industrial Revolution, was the prerequisite for I4.0 technology development. The research emphasized three elements that provide the foundations of I4.0 technologies: sensors, networks, and the cloud (Figure 1). *Sensors* are the parts of a machine or product that sense its operation and environment (Lee, Kao, & Yang, 2014). A sensor can be an RFID tag, a scale, a camera that can monitor a product, or a process, and it records and transmits data. *The network* ensures communication connectivity between devices via the Internet (wired or wireless). Networked and sensor-based production systems allow real-time communications and interactions in which the product can be clearly identified and traced during production and use (Prause, 2015). The *Cloud* is a tool for storing, manipulating and sharing large amounts of data generated by the previously described elements (Ghobakhloo, 2018). These three technologies form the cyber-physical system (CPS), where physical devices and the virtual world are connected. According to Monostori (2014), the CPS is composed of collaborative computing units that are connected to the physical world (objects and devices) and its processes and can share data continuously in a network. According to Brettel (2014), the CPS can establish a communication link between people, machines, and products. In Brettel's view, the CPS is capable of an end-to-end integration of business processes and services.

Figure 1.

The interdependence of I4.0 technologies



Source: own compilation

I4.0 technologies are based on these outlined fundamentals. The research distinguishes between technologies that are dominantly virtual (advanced analytics, software robots, blockchain, machine learning and artificial intelligence), those that are dominantly physical (additive production and advanced robotics) and two that are balanced combinations of virtual and physical elements (IoT and virtual/augmented reality). This is very similar to the approach by Culot, Nassimbeni, Orzes, & Sartor (2020), who categorized technologies on a scale from hardware to software.

In the *blockchain*, all agreements, processes, tasks, and payments have a digital code and imprint that are clearly identifiable, authentic, and stored in the same format at each shared location. This allows individuals,

organizations, machines and algorithms to freely conduct transactions and interact with each other (Hammond, 2017; Iansiti & Lakhani, 2017).

Artificial intelligence (AI) is the ability of a computer to think, perform tasks, interact, and act as a human in areas that humans are capable of (Dirican, 2015). *Machine learning*, a branch of AI, computer systems that can automatically improve with experience, has been used in many aspects of business where large amounts of data are generated, including after-sales services, diagnostic functions of complex systems and control of logistics chains and intelligent automation software (Jordan & Mitchell, 2015).

At the interface of predominantly physical and virtual spaces, solutions are based on a combination and use of both spaces, such as the *Internet of Things* (IoT) in networking and data sharing, and *augmented and virtual reality* (AR/VR) in repair and maintenance. The IoT is a summary description of solutions that allow objects equipped with sensors to network, communicate, and share data (Hermann, Pentek, & Otto, 2016). Further, the IoT embraces older machine-to-machine (M2M) technologies as well as the typical industrial machines that communicate directly using various communication channels. According to Azuma (1997), augmented reality is the integration of virtually rendered objects into the environment in real-time. From Azuma's perspective, virtual reality is another version of augmented reality.

Advanced industrial robotics (AIR) is a branch of robot development that enables machines to perform intelligent tasks with sensors and dynamic programming with greater flexibility and precision than conventional robots (Eurofound, 2018; Lorenz et al., 2015).

Robotic process automation (RPA) is a software robot (bot) that automates rules-based, repetitive, labour-intensive tasks to replace the human workforce, e.g., in an office environment (Lacity, Willcocks, & Craig, 2015). Installed on a computer, RPA is a software solution that uses IT systems through user interfaces in the same way that a human does (Asatiani & Penttinen, 2016).

Additive technology, or 3D printing, significantly accelerates and simplifies the production of a prototype and the release of the first version of a product (Dalenogare et al., 2018). It increases customer satisfaction through an accelerated process and offers design freedom, supply chain simplification, rapid prototype production and small series availability (Ghobakhloo, 2018).

Storing a huge amount of data generated in these systems is a tremendous task for companies, and these data must be structured, refined, and analysed with various algorithms and software. While *advanced analytics* generates relevant and structured information from available data (Wang, Wan, Li, & Zhang, 2016), social media analytics help clarify buying habits and patterns, and helps companies develop offers that consumers are more likely to accept (Ghobakhloo, 2018). Business intelligence (and analytics) summarizes techniques, technologies, systems, practices, and applications that can be used to gather and analyse critical business information (Chen, Chiang, & Storey, 2012).

All the technologies shown in Figure 1 have some relation to data; i.e., they either generate, use or analyse them. While there are many other categorizations of technologies, Figure 1 shows the important relationships between them, it is not a mere list. Furthermore, as indicated in this figure, horizontal and vertical integration, which is frequently listed as an I4.0 technology, is clearly not a technology but is the result of using the aforementioned technologies.

Strategy and Organization

Studies of the digital transformation of organizations usually focus on various I4.0 technologies and the business and technological issues they solve because, without these innovations, there could be no discussion about the transformation of organizations or industries. However, fewer articles address the role of strategy, structure, organizational culture, project management, and other organizational characteristics regarding the successful adoption of these new technologies. The research has gathered and structured the key strategical (see Table 3) and organizational factors (see Table 4) that either foster or hinder the environment for I4.0 technology-driven projects.

I4.0 means linking different digital technologies into one integrated phenomenon, and the integration of these technologies greatly depends on a clearly defined digital strategy. Kane et al. (2016) argued that creating a clear and coherent digital strategy is vital for the digital maturity of organizations because it enables the use technologies not for solving individual problems with individual technologies but for promoting business transformation with integrated I4.0 technologies. However, less-mature organizations do not have a clear or intended strategy to drive transformation. The factors of a digital strategy can be divided into intracompany and competitive level categories. While some factors explain how a digital strategy forms the internal organization, competitive level factors explain how a strategy changes the company in the external competitive environment.

Considering the extent to which a strategy is articulated, Mintzberg (1977) and Andrews (1987) differentiated the explicit strategy and the implicit strategy. The more formulated and explicated the strategy is, the easier to implement it, because the participants are aware of it; however, the higher the bureaucracy with it, as well. Under some circumstances, different explicit and implicit strategies exist in parallel; for example, a centralized strategy is formulated by headquarters, but another business unit or department-level strategy also has formulated a strategy within the organization. Furthermore, based on the autonomy of the organization, the decentralized strategy can also be explicit and determinative. Herbert (2017) argued that establishing real digital transformation requires that three different areas of the organization be address: the business model, customer experiences and internal processes. Daubner et al. (2017) created a more

exhaustive categorization for digital transformation with the digital transformation of products/services and divided the internal processes into core and support roles. The digital strategy can positively or negatively influence the relative position of the company in the corporate hierarchy, or the company position can remain unchanged. Renjen (2019) highlighted the significance of the financial conditions of I4.0 projects. Some implementations are financed by a dedicated corporate project fund, and others are financed through a local decentralized budget, external sources, or a combination of sources. The financing mechanism is dependent on the innovation culture, whereas earnings support is underpinned by accurate planning.

Regarding the *competitive level of the strategy*, Gilbert (1994) argued that some changes are dramatic in their scope and impact and clearly fall within the radical category; however, other changes are more incremental and slower. The changes may have the same strategic value, and the outcomes may be the same but are reached more slowly. The digital strategy may focus on change in the competitive edge of the organization by cost-decreasing or customer value-increasing approaches. A cost-decreasing strategy involves the adoption of new technologies that increase efficiency efficient, whereas a value-increasing strategy does not necessarily reduce costs but creates new value through the implementation of new technologies. In some cases, external conditions prompt a change, and in some situations, a mixed approach is the optimal option for the organization. According to Szász, Demeter, Rácz, & Losonci (2020), I4.0 supports both cost-decreasing and value-increasing approaches.

Gilbert (1994) stated that innovative strategies that favour the development and introduction of innovation, require radical, inventive and quick planning and involve higher costs and risks of failure, while also offering greater rewards and improvement. Hence, these strategies are referred to as proactive. On the other hand, a strategy that is incremental, imitative, and relatively late is called reactive. A preactive strategy does not create but rather predicts the future. I4.0 technological change is seen as the driving force of the organization. If an organization has a plan, then it can take advantage of current change. A passive or inactive strategy focuses on preserving the advantages of the present into the future. Moreover, a digital strategy can alter, either positively or negatively, the external position of the organization in the value chain or in the market

Various organizational factors can influence the success of technological implementations. These factors can be structured to link *management issues, ways of working and characteristics of human resources*. Davis-Peccoud et al. (2018) argued that the commitment of management can be assessed by the extent to which dedicated leaders and organizational units responsible for digitalization are established. Shared managers and shared groups/departments have other responsibilities in the organization that can hinder the comprehensive exploitation of new technologies. Accordingly, some organizations build formal organizational units, such as centres of excellence/exercise (CoEs), and foster more-informal groups, such as communities of practice (CoPs), to stimulate new sources of knowledge and perform internal experiments, but others obtain them from outside the organization or use internal and external sources. Agostini & Filippini (2019), Renjen (2019) and Kane et al. (2016) focus attention on the fundamental role of the innovation culture in digital transformation. Organizations with a strong innovation culture (characterized by a shared innovation mindset, risk-taking, collaborative work style, individual incentives, and major standard processes to foster innovation, seem to be more successful with respect to technological adoption and the exploitation of benefits. A weak innovation culture is characterized by individual initiatives, a risk-averse attitude, an independent work style, manager contract/business unit level incentives, and, primarily, ad hoc processes to stimulate innovation. Agostini & Filippini (2019) stated that the success of a technological project depends on the attributes of human resources. The more educated**,** skilled and younger the workforce employed in the organization, the likelihood of deploying I4.0 technologies successfully increases. Keszey & Tóth (2020) reached similar conclusions. Finally, company size and geographical coverage of an organization (global/local) can also influence the spread of I4.0. According to international survey results (Szász et al., 2020), larger companies invest more in I4.0 technologies, but multinational companies do not have advantages over local firms. Nevertheless, in their literature review, the authors listed many studies that reached different conclusions.

Some aspects of I4.0 projects are independent of organizational and strategic factors. While an organization may embrace, for example, a cost-decreasing strategy, an I4.0 project may aim to increase customer value. Furthermore, I4.0 projects can have other characteristics with respect, for example, the role of technology and its interactions with human resources (e.g., replacing humans with technology, providing humans with technological support, or extending human capabilities, e.g., the exoskeleton), the level of human resistance against technology, the internal or external direction of project initiatives (e.g., clients, suppliers, etc., from both a top-down and bottom-up approach), or the financial preparation of a project for approval (i.e., argument based or calculation based). However, due to space limitations we do not deal with project-level issues in this paper.

Based on the different issues discussed in the literature review thus far, it is evident that achieving a digital transformation is a complex task for companies. Therefore, providing detailed case study results may reveal the paths that companies and/or sectors follow and may also support researchers as they strive to understand the relationships between various factors. Providing this support is the objective of our paper.

Methodology, data collection and data analysis

There are many reasons to choose the case study research approach. First, as presented previously, the available fragmented experiences regarding I4.0 and the prescriptive and expectations-based nature of many I4.0-related works currently do not foster a complex picture of the lived experiences or the true policies of companies and plants. Furthermore, since it is a relatively new phenomenon, the more flexible data collection process of the case method provides advantages that enabled us to gain more valid data by addressing the managers in charge.

We followed the convenience sampling approach searching for units that are more mature in and/or open towards I4.0 initiatives. The sampling process included only one specific factor: we aimed to study both a) subsidiaries of international corporations and b) locally owned units or units with local HQs. Initially, we believed that the opportunities are considerably different for these two groups. We also expected that the diversity of ownership, industry and size would reflect the potential for different approaches.

The data were collected on 15 case units representing 14 different corporations from five sectors of the economy representing supply chains: 1) automotive manufacturing and 2) food producing companies, 3) logistics service providers, 4) retail companies, and 5) business service centres (BSCs) (Table 1). The data collection process was formalized by a 20-page data collection guide that suggested a structure for the case description. The main highlights of the guide were industry- and corporate-level 4.0 experiences and a detailed summary of unit-level I4.0-related changes. It also integrated the introduction of the two most important projects. The data collection guide defined the most relevant aspects of the inquiry, and the supplement suggested a protocol for semi-structured interviews, which were conducted and subsequently transcribed. The case description combined data from these interviews, public data, and descriptions of experiences obtained from visits. For several units, the (long-range) research cooperation ensured the data. Each case description was sent to the unit's representative to validate the content and to make improvements, if necessary. Data collection and processing were supported by doctoral and undergraduate university students under the supervision of the researchers.

Table 1.

Main characteristics of the cases (sectors separated by grey-white cell colour)

Sector	Case plant	Main industrial activity	No. of employees of the		HQ is in	Main focus of technological and digital developments
			case plant	corporation		
Auto-motive	**M-Conn**	automotive connectors	1,500+	100,000+	Western Europe	e-lean solutions, predictive maintenance, dashboard on shop floor
	H-Elect	automotive electronics	1,500+	10,000	Hungary	automation, better organization based on integrated data collection system
	H-Plast	customer goods and automotive	1,400+	10,000	Hungary	improve core and support technologies and machines; provide better organization and tighter control
	M-Elect	automotive electronics	1,800+	200,000+	Western Europe	establish simulation-based new production lines with advanced robotics
Logistics	**H-Log**	transportation, logistics services	1,000+	1,000+	Hungary	improve efficiency of service, support human workforce
	M-Log	transportation, logistics services	250*	7000+	Turkey	improve efficiency of service, support human workforce
Retail	**Sport**	sports retail	1,500*	40,000+	Western Europe	improve back-end processes and support human workforce, enhance customer experience
	Fashion	fast fashion retail	100*	11,000	Western Europe	improve back-end processes and support human workforce
Food	**Milkprod**	food industry	100	700	Hungary	improve core technology, assure food safety and quality
	Milkproc	food industry	450	1,000	Western Europe	provide automation and robotization, improve core technology, assure food safety and quality
	Pasta	food industry	100	100	Hungary	provide automation of the core technology and robotization in support processes
BSC	**US**	business services	2,000+	40,000+	US	support and replace human workforce
	TechB	business services	1,000+	100,000+	US	support and replace human workforce
	Alpha	business services	1,500+	100,000+	US	support and replace human workforce
	IT	business services	4,500+	200,000+	Germany	support and replace human workforce

* in Hungary

Source: own compilation

While the units were open to show their I4.0 efforts, many requested anonymity. As the data were not distorted, contingency-related problems were also studied.

The study included 47 interviews with 52 people from diverse positions between the mid-2018 and the mid-2019. More than one interviewee participated in some of the interviews, which is the reason that the number of interviewees exceeds the number of interviews. Details about the interviewees' positions and the dates of the interviews are summarized in Table 2. The interviews lasted between 40 and 90 minutes, and when feasible, two researchers conducted the semi-structured interviews. If the interviewee asked about the research project, the researchers sent them the data collection guide or the interview protocol in advance by e-mail.

While we had an initial understanding of the technology, organization, and strategy (covered by the data collection guide), after the completion of the case description, we refined this preliminary framework. On the one hand, the literature helped us crystallize the specific dimensions of these categories (e.g., more specific dimensions of strategy development and deployment and integration of lean and I4.0 efforts). On the other hand, the experiences of the units revealed important, previously neglected aspects of the transformation process (e.g., the importance of budget and the availability of financial sources). We arrived at the final framework in an iterative way by combining the cycles of senior researchers' preparations and presentations and workshops with discussions that involved 8-12 participants. Building on the case description and the final framework, a two- to three-page within-case analysis was written about each unit. The next section explains the cross-case comparison.

Results

Technologies

Case companies in all sectors focus on the predominantly digital technologies, such as sensors, the Cloud, IoT, and big data (see Table 3). However, the least-used technologies, that is, blockchains and AR/VR are also predominantly digital. The negligible use of the latter two technologies may be the results of their low maturity.

In addition to the common digital base, significant sectoral differences were revealed. In sectors with physical products (produced, transported, or sold), companies highlight sensors, which enable the transformation of physical activities into digital data. However, only these companies invest in advanced robotics (for manufacturing or transport) and additive manufacturing, which is used in

Table 2.

Case data collection summary (sectors separated by grey-white cell colour)

Sector	Cases	Position of interviewees	# inter-viewees	# inter-views	Date
Auto	M-Conn	Head of digital/lean department; senior lean engineer; IT business analyst and developer; member of digital/lean department	4	3	July 2018
	H-Elect	CEO; director of sales, engineering and purchasing; chief technical expert	3	3	May, Nov 2018
	H-Plast	CEO; head of engineering; production manager (former lean expert); facility manager	4	4	June 2018
	M-Elect	Head of digital department; head of lean group; expert	3	3	Mar-May 2019
Log	H-Log	Chief digitalization officer; IT project manager; head of innovation and projects; project manager	4	4	Sep 2018
	M-Log	Country manager; digitalization team leader	2	2	Nov 2018
Ret	Sport	Chief customer experience officer; fitness department manager; fitness department digital ambassador; two employees	5	5	Aug-Sep 2018
	Fashion	Country manager; HR business partner; HR trainer; area manager; assistant store manager; brand manager	6	6	Sep-Nov 2018
Food	Milkprod	Farm manager	1	1	Feb 2019
	Milkproc	Plant manager	1	1	Apr 2019
	Pasta	Plant manager	1	1	Aug 2018
BSC	US	CEO and automation lead	2	2	Nov 2018
	TechB	Managing director; HR services (external); procurement; Q2C (sales support); chief information officer; indirect tax; accounts payable; HR transformation (internal)	8	5	Oct-Nov 2018
	Alpha	Site executive; head of automation; service quality analytics expert	3	3	Jan 2019
	IT	Security lead; expert architect; IoT portfolio unit lead; managing director; business unit lead	5	4	Dec 2018
		Sum of interviewees and interviews	52	47	

Source: own compilation

the creation of an automotive after-sales market. Software robots, such as chatbots and RPA, constitute another set of sector-specific technologies that are used in each BSC, but nowhere else. Although chatbots can be efficiently applied to customer services in other sectors, Machine learning is used most frequently in the BSC sector. Logistics firms can also use it efficiently for routing, warehousing, or truck loading optimization. These sector-specific technology sets may reflect different I4.0 directions even in the mid-term.

Finally, within-sector differences are also relevant and explained by technology maturity level, innovativeness, and specific contextual factors. Firms' different technology maturity levels may be the result of industrial "standards" amplified by their respective, current supply chain position. All these factors might lead to differences in the level to which a specific technology is adopted, which is not evident from the table data. For example, M-Conn, a TIER 2 firm in the automotive sector has a machine connectivity (IoT) of approximately 60%, while another parts supplier, a TIER 3 manufacturing company is limited to only M2M solutions. While the innovativeness of a firm's culture reflects its openness to low maturity I4.0 technologies, the context also determines, to some extent, their usage. For example, despite its maturity in IoT, M-Conn does not invest in robots due to product complexity and variety.

Based on Table 3, there are no major differences in the number of technologies used by companies, with the numbers varying between 2 and 7 and a median value of 5, which means that companies usually invest in several technologies simultaneously. This practice is understandable given that big data analytics in manufacturing settings requires sensors, the cloud, connected devices (IoT), and big data.

Table 3.

Technologies used in case companies (sectors separated by grey-white cell colour)

Sector	Cases	Technologies											
		Sensor	Cloud	IoT	Big data	Big data analytics	Blockchain	Software robots	AI	AR/ VR	Addit. mfg.	Ind. robots	Σ
Auto	M-Conn	x	x	x	x	x					x		6
	H-Elect	x	x	x								x	4
	H-Plast	x	x	x	x	x							5
	M-Elect	x	x	x							x	x	5
Log	H-Log	x	x	x	x	x			x			x	7
	M-Log	x		x									2
Ret	Sport	x	x	x	x	x							5
	Fashion	x	x		x	x							4
Food	Milkprod	x			x	x						x	4
	Milkproc	x	x	x	x	x						x	6
	Pasta	x	x	x	x							x	5
BSC	US		x		x	x		x					4
	TechB		x		x	x	x	x	x				6
	Alpha		x		x	x		x	x	x			6
	IT		x	x	x	x		x	x				6
All	# Appl	11	13	10	12	11	1	4	4	1	2	6	

Source: own compilation

Strategy

While several aspects are considered, the picture remains quite vague (Table 4).

Strategy visibility. Even if one-half of the case companies have an explicit corporate or company level digital strategy to deploy, many others have only an implicit digital strategy or no strategy at all. There does not seem to be any sectoral or general pattern with respect to this issue.

Level of centralization. The lack of a pattern also holds for this variable. There is not a single sector for which each company follows the same policy. However, at some companies there is a balance between centralized decisions and local initiations. For example, at *M-Conn* there is a local budget devoted to small digitalization projects, but for major actions they require approval and financial support from their headquarters. At *M-Elect* the headquarters provides direction, but the sites must make the decisions regarding the deployment of the strategies. At others, there is little room left for local actions. At *Fashion,* for example, the shops have no voice in the decisions; they must follow central orders. In contrast, there are companies where everything is decentralized with the sole requirement that each reaches its profit targets.

Level of transformation. The majority of companies in this study (13 of 15) usually make efforts to transform their core processes, although there are examples of companies making business model changes and engaging in product/ service development. For example, at *Sport*, a kiosk has been added where customers can place orders directly in the shop for products not available at the moment; at *IT*, an advanced Cloud-based solution was developed with computing and data analysis capabilities, which can be used both in-house and by clients. At *Milkprod*, the production process is completely digitalized and capable

Table 4.

Strategic issues at case companies (sectors separated by grey-white cell colour)

Sector	Cases	Corporate level				Competitive level		
		Visibility[a]	Centralization[b]	Transform[c]	Internal position[d]	Pace of change[e]	Innova-tiveness[f]	External position[g]
Auto	M-Conn	Exp. corp	Balanced	3	Improved	Increm.	Proactive	No change
	H-Elect	Implicit	No	3	n.r.	Increm.	Reactive	No change
	H-Plast	Implicit	No	3	n.r.	Increm.	Reactive	No change
	M-Elect	Exp. corp	Balanced	3,4	Improved	Increm.	Reactive	No change
Log	H-Log	Explicit	Centralized	3,4	n.r.	Increm.	Proactive	No change
	M-Log	Exp. corp	Balanced	3,5	Improved	Increm.	Reactive	No change
Ret	Sport	Exp. corp	Balanced	2,3,4,5	No change	Increm.	Proactive	No change
	Fashion	Exp. corp	Centralized	3,4,5	No change	Increm.	Proactive	No change
Food	Milkprod	Not exist	Centralized	1,3,4	n.r.	Radical	(Pre)active	No change
	Milkproc	Not exist	Balanced	3	No change	Increm.	(Pre)active	No change
	Pasta	Explicit	Decentr.	3,4	n.r.	Radical	Proactive	Improved
BSC	US	Not exist	Centralized	3	Improved	Increm.	Reactive	No change
	TechB	Implicit	Decentr.	1	Improved	Radical	Proactive	No change
	Alpha	Implicit	Decentr	1,3,5	Improved	Increm.	Proactive	Improved
	IT	Exp. corp	Balanced	2,4	Improved	Increm.	Proactive	Improved

Source: own compilation

a) Visibility/articulation variables: explicit and deployed from corporate level, explicit, implicit, does not exist

b) Level of centralization: centralized, decentralized, both, no

c) Level of transformation: 1) business model, 2) product/service, 3) core processes, 4) support proc., 5) customer proc.

d) Internal relative position change: improved, declined, unchanged, not relevant (n.r.)

e) Pace of change: radical, incremental

f) Innovativeness: proactive, (pre)active, reactive, passive

g) External position change: improved, declined, unchanged

of providing detailed data for internal and external purposes about the health status of the cows, the quality and quantity of their milk, food safety, etc.

Internal (within corporation) and external (on market) positions. Internal position is relevant only for multinational companies where subsidiaries can upgrade themselves in the internal value chain. While companies usually experience improved positions within their corporation to earn more and/or offer higher value-adding activities within their network, this improvement is much less visible at the competitive level. Only the managers at *Pasta,* which has a large-scale, completely new digital plant, think that they can improve their position by expanding to new markets.

Pace of change and innovativeness. There seems to be a relationship between the existence of strategy and innovativeness, indicating that proactive innovation requires some strategy, while companies with no explicit digital strategy are reactive. However, there are exceptions in both directions. For example, although *M-Log* has an explicit corporate strategy, it is still reactive, while milk-producing and processing companies do not have any strategy and are (pre)active. We can also see examples of radical changes, e.g., the new digital plant at *Pasta* and the digitalized milk production process at *Milkprod*. Furthermore, at *TechB,* as the digital strategy is deeply rooted in the corporate culture, the developments change the business model via automation, robotics, and machine learning. Nevertheless, there are cases where the changes are still slow, and progress is made at a stepwise incremental pace.

Organization

There are extensively heterogenous solutions at the organizational level (Table 5).

Responsibility and digital (government) unit. At some companies, the people responsible for digitalization are either in top managerial positions (C-level) or, at the very least, dedicated to digitalization. However, some managers (shared managers) have to handle tasks in addition to I4.0. Only one company had no management level representation in its digitalization field. Even though I4.0 is represented at all but one company by a manager in a high position, not every manager has a dedicated or shared unit supporting his/her work. For example, we did not find this type of unit in the retail or the food sectors as the retail sector is too centralized to allow for local experiments, and food sector players are too small to operate this type of unit efficiently.

Innovation processes. The innovation processes are usually standardized regardless of the project purpose. For example, at *M-Conn* standard digitalization projects differ from lean projects. Digitalization projects are more complex and involve more people and more roles for participants.

Companies with less frequent experimentation are not at a level capable of standardizing digital-based innovation (e.g., *M-Log* and *Pasta*).

Ways of working. The sample is quite diverse in this aspect. Considering the analysed project, we noted that, at some companies, ideas are obtained from customers, and thus, they are pushed to innovate. In these companies, the culture of innovation is not exceptionally strong, but they are, nevertheless, willing to keep pace with their customers. Other companies have a strong innovation culture, thus moving towards I4.0 is easier as the people are ready to make changes and learn new things. Some companies from the automotive and BSC sectors have lean culture, which helps make continuous improvements and combine their lean culture with digitalization.

Employees. Digitalization does not depend on employee characteristics. Some companies exhibit good progress with trained workers, (i.e., they have engineers, but the ratio is quite small and skilled workers, e.g., BSC organizations). Similarly, no difference is found for age. For example, *H-Log* with older employees seems to be more committed to digitalization and ahead in the digital journey than *M-Log* with a younger generation, a result that may be due to the stronger innovation culture of the former.

Table 5.

Organizational characteristics of case companies (sectors separated by grey-white cell colour)

Sector	Cases	Organization factors						
		Management			Ways of working		Employees	
		Responsibility[a]	Governmental unit[b]	Innovation processes[c]	Source of knowledge[d]	Innovation culture[e]	Education level[f]	Age[g]
Auto	M-Conn	Dedicated	Dedicated	Standard	Both	Strong (lean)	Balanced	Balanced
	H-Elect	Shared	Shared	Standard	External	n.i.	Trained	n.i.
	H-Plast	Shared	Shared	Standard	External	n.i.	Trained	n.i.
	M-Elect	Dedicated	Dedicated	Standard	Both	Strong (lean)	Trained	n.i.
Log	H-Log	C-level	Dedicated	Standard	Internal	Strong	Balanced	Older
	M-Log	Dedicated	Dedicated	Ad hoc	External	Weak	Balanced	Younger
Ret	Sport	C-level	Not exist	Balanced	Both	Strong	Balanced	Balanced
	Fashion	Shared	Not exist	Standard	Both	n.i.	Balanced	Younger
Food	Milkprod	Shared	Not exist	Balanced	Both	Strong	Balanced	Balanced
	Milkproc	Shared	Not exist	Balanced	Both	n.i.	Balanced	Balanced
	Pasta	Shared	Not exist	Ad hoc	n.i.	Weak	Trained	Balanced
BSC	US	Dedicated	Shared	Ad hoc	Internal	Strong (lean)	Balanced	Balanced
	TechB	Not exist	Shared	Balanced	Both	Strong	Skilled	Younger
	Alpha	C-level	Dedicated	Balanced	Internal	Strong	Skilled	Younger
	IT	Shared	Shared	Balanced	Both	Strong	Skilled	Younger

Source: own compilation

a) Responsibility: C-level executive, dedicated manager, shared manager, does not exist

b) Governmental unit: dedicated department, shared department, does not exist

c) Innovation processes: major standard processes, mainly ad hoc processes, both

d) Source of knowledge: internal, external, both, not identified (n.i.)

e) Innovation culture: strong, weak, lean, not identified (n.i.)

f) Educational level: mainly educated, skilled; mainly trained, balanced

g) Age: mainly y generation or younger, mainly older than y gen, balanced, not identified (n.i.)

Discussion

The research synthesizes the daily I4.0 experiences of 15 different supply chain actors from five sectors in the technology-strategy-organization (TSO) triad. Each leg of the triad framework represents a distinct, however converging approach of the I4.0 journey. Our study is among the first (another is Demeter, Losonci, Szász, & Rácz, 2020) that applies the three perspectives of TSO to the examination of firms' digital transformation. Applying this theoretical framework to a wide variety of corporate experiences provides opportunities to explore specific trajectories and patterns. We believe that this study's complex approach complements the loud discourse and wide-spread narratives of one-sided interests (e.g., specific technology, project level, or indicator-focus).

Technology

While the power of I4.0 is the consequence of the combined availability of many technologies, and synergy is possible, the modular design implies that these technologies can be used independently. Given the maturity of individual technologies (Demeter et al., 2020), it is not realistic in today's environment for a company to combine these technologies into one cyber-physical system. Even in the

cases of companies with higher technological levels, only *mature technologies* are implemented; these companies consciously avoid novel, less mature technologies or reach only pilot status with them (e.g., in big data analytics). Off-the-shelf, boxed products are not yet available.

The empirical analysis of different sectors provides further insights into technology usage. The findings emphasize that there has been a commonly used set of core technologies (e.g., IoT, big data and analytics, cloud, and sensors) (see Frank et al., 2019) from the very first steps of digital transformation. Furthermore, this cross-sectoral research has revealed that in addition to this common set of technologies, different sectors also require and use different applications. A major difference between companies with *physical products* (e.g., automotive components) and those offering services is that the former have an additional layer from which to collect data; that is, they must build sensors into machines to make the production status digitally available. This may be one of the reasons BSCs are in the forefront with respect to the use of the cutting-edge digital technologies that are currently still neglected by manufacturing plants.

Strategy

In contrast to often optimistic expectations (Dalenogare et al., 2018), self-assessment based findings (i.e., López-Gómez, McFarlane, O'Sullivan, & Velu, 2018), and summaries of highly successful digital transformations (World Economic Forum, 2019), our research found that, in most cases, technology upgrades are required to maintain a company's competitiveness. In other words, by neglecting digital-based innovation, companies will lose customers and markets. It should be added, however, that competitiveness might depend on the types of innovations companies create (process, product/service or business model). We found very few examples of business model or product/service innovations, which may explain why these companies are unable to gain a competitive advantage. Making improvements only to processes does not attract new customers (Herbert, 2017); these improvements are only the start of a digital transformation. Nevertheless, they can create some internal advantages within the corporation by obtaining more business from other business units. Reactive companies seem to be pushed into their digitalization journeys as many of them have external opportunities they wish to pursue, and thus, they start the digitalization process because of their partners' expectations.

Furthermore, the research demonstrated that among the strategic characteristics, technologies can be used for a wide range of purposes: business model, product, and process changes. Therefore, digitalization can potentially affect the majority of companies. Companies operating with less-advanced technology select from the pool of I4.0 technologies based on their current innovation orientation. In many of our case companies, this orientation equates to the development of operations and support technologies. Nevertheless, some of our case plants made leap-frog type progress due to their core technology development.

Organization

While we talk about a major wave of digitalization in the environmental context, the most important question is whether the attitudes of companies change with this context. The diversity of *organizational solutions* suggests that an openness towards innovation is "present" before digitalization. In other words, our results suggest that a culture of innovation determines the level of adaptation (the whole business or only manufacturing processes) to the changes; that is, culture affects adaptation not vice versa (adaptation affects culture). A lean culture with continuous improvement efforts reflects an innovation culture and seems to play a key role in supporting and boosting digitalization.

However, there is still an unresolved problem with respect to procedures. While new machines, which are sometimes complete manufacturing systems, acquired today often include sensors for data collection and control, as well as machine connectivity opportunities, *business management decisions* do not usually incorporate the big data from these sources, even though they are currently available.

Global network aspects

Relying on a TSO framework, we discovered specific aspects related to larger corporations and global networks. In the context of digitalization, *innovation* must *quickly become formalized* in large corporations; otherwise, these corporations cannot coordinate and eliminate parallel efforts. Therefore, large corporations tend to follow a formalized approach of innovation. This formalized approach leads to a *deployment process* at the subsidiary level while also limiting experimentation at the local level. Although the directive of the corporation headquarters is carefully considered, local experts and managers may identify ways to adapt the central direction of the corporation. Accordingly, manufacturing subsidiaries that strive for "differentiation" can seek their own path, e.g., launching a pilot project in the business unit at the local plant, joining domestic I4.0 programs or developing a centre of excellence at the same location, as suggested by Davis-Peccoud et al. (2018). A fortunate coincidence is realized when the central direction fully reflects the needs of the plant, e.g., robot installation when a workforce shortage is a daily issue.

Subsidiaries of global corporations built on standard processes show similarities, especially in the manufacturing and BSC sectors. The consequences for large, global corporations are more similar consequences than those within the overall industry. Although there are differences with respect to the adopted technology, formalized solutions at the strategic and organizational levels as well as clearly defined digital roadmaps are common, thus leading these companies towards faster business transformation, as argued by Kane et al. (2015). The experiences of these subsidiaries also suggest that their solutions cannot be replicated by smaller companies. While smaller companies may use the same technology, the underlying formalized solutions will be different (as in our food sector examples).

Thus, the question arises, how can small companies gain access to these practices? While the economy of scale seems to work with respect to digitalization, is it valid for each technology? These differences were also identified by Horváth & Szabó (2019).

Accordingly, we cannot confirm that global companies necessarily perform better than local firms (e.g., the logistics companies), as found by Szász et al. (2020). What we can say, however, is that the process of digital transformation, including the deployment process and the level and speed of standardization, are definitely different between the two groups of companies.

Conclusion

The objective of our business-oriented paper was to develop a complex and integrated picture of the I4.0 transformation of firms. To achieve this goal, we proposed a triad framework based on TSO and examined 15 case studies from different sectors. Our TSO framework has revealed many relevant variables that promote the understanding of the digital transformation. These relevant variables may describe important differences between companies and explore differing patterns between sectors. The results indicate that companies are following a large variety of approaches and that there is not a single or best approach. Companies can reach similar I4.0 maturity with or without a strategy, with or without a dedicated unit, etc. Our findings have two important implications. First, while larger companies (especially global ones) gravitate towards formal institutions, the first steps may be led by local curiosity. Second, the innovativeness of the firm culture, reflected by using lean management in many cases, is a decisive factor. While I4.0 does not change the current culture, an innovative culture enhances I4.0. Furthermore, while every firm deploys base digital technologies, in the adoption of additional technologies, we saw sector-specific directions. Finally, we determined that manufacturing is biased towards physically dominated technologies and that BSCs are biased towards chatbots, RPA or AI.

There are limitations of our paper. The 15 case studies prevented us from providing deep insights in this short paper but are insufficient to generalize the results. By segmenting the topics and sectors, we can conduct a deeper analysis in the future; however, for this paper, we intentionally chose a more comprehensive, integrated approach. We believe that, after some rigorous tests, this triad and collection of important TSO variables can be the bases for developing a questionnaire that validates and deepens our generalizable understanding and knowledge.

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VIKTORIIA SEMENOVA

TECHNOLOGY ADOPTION THEORIES IN EXAMINING THE UPTAKE OF BLOCKCHAIN TECHNOLOGY IN THE FRAMEWORK OF FUNCTIONALIST AND INTERPRETIVE PARADIGMS

TECHNOLÓGIAADAPTÁCIÓS ELMÉLETEK A BLOKKLÁNC-TECHNOLÓGIA ELTERJEDÉSÉNEK VIZSGÁLATAKOR A FUNKCIONALISTA ÉS INTERPRETATÍV PARADIGMÁK KERETÉBEN

The purpose of this paper is to examine the adoption process of emerging technology on the example of blockchain. The theoretical interpretation of blockchain acceptance and its implications are discussed from the positions of technology adoption theories (diffusion of innovation theory, the technology acceptance model, the unified theory of acceptance and use of technology, the technology – organisation – environment framework) as well as sensemaking theory. These theoretical models help understand the perception among end-users (e.g. supply chain practitioners) and facilitate technology diffusion among enterprises. Due to the novelty of the research field, the analysis revealed that current studies were conducted within the functionalist paradigm; however, studies on blockchain implementation can be equally done in the interpretive paradigm. The results indicate a shortage of empirical research investigations and the need for greater theory elaboration to accelerate the adoption process within organisations.

Keywords: **blockchain technology, functionalism, interpretivism, sensemaking**

A cikk célja a feltörekvő technológiák adoptációs folyamatának vizsgálata a blokklánc példáján keresztül. A blokklánctechnológia elfogadásának kereteit és következményeit a technológiaadaptáció-elméletek, valamint a jelentésadás (sense-making) elmélet alapján tárgyalja. Az előbbiek közül a cikk az innovációterjedés-elmélet, a technológiaelfogadási modell, a technológiaelfogadás és -használat egyesített elmélete, illetve a technológia-szervezet-környezet keretrendszer következtetéseire épít. Ezek az elméleti modellek segítenek megérteni a végfelhasználók (például az ellátási lánc szakemberek) felfogását, és megkönnyítik a technológiai megoldások vállalkozások közötti terjedését. Az elemzés feltárta, hogy a témában végzett eddigi kutatások a funkcionalista paradigmán belül történtek; azonban a blokklánc bevezetésével kapcsolatos vizsgálatok ugyanúgy elvégezhetők az interpretatív paradigmában is. A cikk eredményei az empirikus kutatások hiányára mutatnak rá, illetve felhívják a figyelmet a szervezeteken belüli adoptációs folyamatok felgyorsítását szolgáló elméletalkotó munkák szükségességére.

Kulcsszavak: **blokklánc-technológia, funkcionalizmus, értelmezés, érzékalkotás**

Funding/Finanszírozás:
The author did not receive any grant or institutional support in relation with the preparation of the study.

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This article was received: 17. 09. 2020, revised: 13. 10. 2020, accepted: 13. 10. 2020.
A cikk beérkezett: 2020. 09. 17-én, javítva: 2020. 10. 13-án, elfogadva: 2020. 10. 13-án.

Advances in new technologies have expanded the capacity of firms to disperse their activities geographically. The digital revolution and development of global supply chains have made possible the emergence of novel organisational forms and the upgrade of strategies and practices of business organisations (Baum & Haveman, 2020). These trends require powerful analytical tools to address the challenges

posed by increasingly complex and rapidly changing organisations.

Blockchain technology (BT), along with its emergence, adoption, and exploitation, has generated many kinds of research in different fields ranging from purely technical to business topics. In general, Demeter and Losonci (2020) indicated the increasing interest of academia and professionals towards the adoption of new and innovative technologies as well as digitally enabled new business models. The adoption behaviour in relation to different novel technologies has been widely studied, among them the "Internet of things" (Gao & Bai, 2014), big data (Sun et al., 2018), cloud computing (Alkhater et al., 2018), and bitcoin (Folkinshteyn & Lennon, 2016).

The present study explores the main technology adoption theories and models which explain the benefits of blockchain for organisations and their processes and predict the further adoption process of the technology. The broader use of blockchain for business purposes has already been started by such leading companies as IBM, SAP, Microsoft, and Boeing (Saberi et al., 2018). Bearing the characteristics of a decentralised trustless database, blockchain allows global-scale transactions and process disintermediation and decentralisation amongst various parties (Crosby et al., 2016). The technology can significantly reduce costs and improve operational efficiencies (Kshetri, 2018) as well as weaken the role of middlemen in the network by supporting peer-to-peer transactions (Saberi et al., 2018). Economically, diffusion of blockchain technology can benefit a firm and its supply chain from various business dimensions affecting economic performance (Saberi et al., 2018).

The significance of theories of economics, strategic management, and organisation for blockchain technology management is seen in the extant literature. In order to explain the phenomenon of blockchain and its strategic competitive advantage, such mainstream theories and views as transaction cost economics (Ahluwalia et al., 2020; Schmidt & Wagner, 2019; Treiblmaier, 2018); agency theory (Pan et al., 2020; Treiblmaier, 2018); network theory (Queiroz & Wamba, 2019; Somin et al., 2020; Treiblmaier, 2018); contract theory; the resource-based view (Treiblmaier, 2018); the diffusion of innovation (DOI) theory (Kshetri, 2018); the technology acceptance model (TAM) (Kamble et al., 2019); the unified theory of acceptance and use of technology (UTAUT) (Queiroz & Wamba, 2019; Wong et al., 2020a, 2020b); and the technological, organisational, and environmental framework (TOE) (Clohessy et al., 2019; Wong et al., 2020a) are extensively used by the scholars. Diffusion theory suggests that technology can have various levels of diffusion across diverse industries (Rogers, 1995). The TAM and UTAUT, derived from the original TAM constructs, explain the acceptance of technology based on behavioural intention, whereas the TOE suggests a more comprehensive view on the adoption of technology.

Regarding the multiplicity of theories and views, it is complicated to comprehend their connections. Moreover, the theoretical development is not fully elaborated because this technology is still in its early stage (Frizzo-Barker et al., 2020) and the number of enterprises that are developing and implementing it is constantly increasing each year (Puel et al., 2020). According to Baum and Haveman (2020), organisation theories can significantly assist in understanding new phenomena. So there is a need for more empirical research and greater theory elaboration for this interdisciplinary domain to better understand its potential and the adoption process among the network of enterprises.

Due to a considerable number of technology adoption theories related to the potential of blockchain and the radical changes blockchain can induce, the following research questions are formulated: What major technology adoption theories and models have been applied in relation to blockchain technology? How do they contribute to explaining the adoption process of blockchain? The answer to these questions will be given by providing a review of the technology adoption models being recently applied in relation to blockchain technology implementation in supply chains. Papers conducted in the framework of the positivist/functionalist paradigm are analysed and compared to articles conducted within the interpretive paradigm that can be considered an alternative to them. The purpose of the study is to explore the adoption process of blockchain technology and the main factors influencing the adoption behaviour of supply chain practitioners.

The paper is organised in the following way. The second part outlines the research methodology. Section 3 introduces blockchain technology and provides a summary of the existing literature reviews on blockchain. Section 4 is devoted to multiparadigm inquiry and compares functionalist and interpretive paradigms. Section 5 consists of an analysis of the studies incorporating technology adoption theories and sensemaking theory and considers them under two paradigms. Conclusions, limitations, and further research directions are provided in the last section.

Research methodology

As the technology of blockchain is applicable across various industries and for different applications, there are a number of adoption theories that are used to investigate the implications and acceptance of this new and complex technology. The method of systematic literature review is applied in this study as it generates useful information and identifies practical implementation and conceptual frameworks from available resources (Hart, 1998); additionally, it can result in more objective, transparent, and replicable reviews (Briner & Walshe, 2014). So this paper focuses on analysing the existing literature on various technology adoption theories pertinent to blockchain technology's user perception and application in the context of supply chains. The fact that most of these studies were conducted using a positivist paradigm and are compared to the one interpretive study helps to more thoroughly explain the emerging phenomenon.

The relevant research studies were searched in June 2020 in the two world-leading and competing citation

databases: Web of Science (WoS) and Scopus (Zhu & Liu, 2020). The search terms "*blockchain*" AND "*adoption theory*" AND "*supply chain*" were used within these databases to retrieve available publications. This specific search yielded similar papers in both databases; namely, around 20 articles were identified. Each of the papers retrieved by the search was reviewed for quality and relevance. As advised by Kitchenham and Brereton (2013), the search and data collection process followed a three-stage process – search, select, and validate the literature. Both conceptual and empirical studies were analysed. Some articles were excluded for the following reasons: application of economic or informatic theories which did not correspond to the subject of the paper; articles which explored other fields (e.g., cryptocurrencies, token economics) rather than the supply chain area; and articles without full availability, duplicate papers, or articles published in low-ranked journals and conference proceedings. In the end, 8 high-quality publications were collected, including 7 papers using at least one of the technology adoption theories and prepared within the functionalist paradigm and one article with the application of sensemaking theory and conducted within the interpretive paradigm. The data on these articles were grouped according to the theories applied, the main constructs were analysed, and the results were compiled, as shown in Table 1. The reviewed articles were primarily published in such high-impact Q1 journals as the *International Journal of Information Management, International Journal of Production Research, International Journal of Production Economics,* and the *Journal of Business Logistics*.

Acquaintance with blockchain technology and its literature reviews

Blockchain was first introduced in the bitcoin protocol by using several existing technologies which allow the creation of a peer-to-peer version of electronic cash. BT is a protocol of open, transparent, and secure distributed ledger technology that eliminates the need for a trusted third party (Nakamoto, 2008). The interest in blockchain is due to its attributes that ensure security, anonymity, and data integrity without any third-party organisation controlling the transactions (Yli-Huumo et al., 2016). While some authors (Kane, 2017; Pilkington, 2016) have labelled blockchain as a radical disruptive innovation that has the characteristics of a general-purpose technology (GPT), Iansiti and Lakhani (2017) proposed a more relevant definition of BT, naming it a foundational technology that can create new foundations for social and economic systems. According to Iansiti and Lakhani (2017), blockchain has recently emerged as a critical technological advance. Clohessy et al. (2019) professed a belief in the dual mission of blockchain by stating that it will "put an end to traditional ways of doing things and usher in a new era for business and the world" (pp. 69 – 70). As the introduction of bitcoin in 2008 led to a paradigm shift in how transactions are processed around the world (Nakamoto, 2008), bitcoin's popularity generated broad interest in its underpinning technology. It is said that blockchain technologies will disrupt a multitude of industries and transform existing business processes. For example, blockchain has a high potential to disrupt inefficient models and improve supply chain management (SCM) operations models (Queiroz & Wamba, 2019).

After the publication of Satoshi Nakamoto (2008) on the blockchain mechanism and main application, the technology of blockchain has gained wide public recognition and generated great research interest. The literature on blockchain predominantly has covered the technological aspects since Nakamoto's publication. In this regard, Yli-Huumo et al. (2016) located and mapped all papers on blockchain with its technical perspectives containing security, performance, data integrity, privacy, and scalability. The results indicate that most of the papers mentioned the seven technical challenges and limitations outlined by Swan (2015): throughput; latency; size and bandwidth; security; wasted resources; usability; and versioning, hard forks, and multiple chains (pp. 81 – 83). These challenges and privacy were used to classify and map the existing studies on blockchain, among which more than 80% of the works focused on the bitcoin system, and less than 20% dealt with other blockchain applications like smart contracts, voting, and property licensing (Yli-Huumo et al., 2016). Most of the research studies attempted to address the issues with blockchain's limitations from privacy and security perspectives.

Since 2014, business scholars have started to research blockchain's different aspects and business applications. Several systematic literature reviews (Casino et al., 2019; Frizzo-Barker et al., 2020; Ozdagoglu et al., 2020; Wamba & Queiroz, 2020) have already been performed. Casino et al. (2019) conducted a systematic literature review of blockchain-based applications across multiple fields to discover how specific characteristics of this disruptive technology can revolutionise business-as-usual practices. The authors presented a classification of the blockchain-enabled applications across diverse sectors based on a structured, systematic review and thematic content analysis of the literature. Frizzo-Barker et al. (2020) carried out a PRISMA guided systematic review of the blockchain research in the business literature from 2014 to 2018. According to the results of their research, blockchain remains an early-stage area of research in terms of theoretical foundation, methodology, and empirical work. Instead of technical aspects, Frizzo-Barker et al. (2020) explored the business and organisational implications of this nascent technology. Ozdagoglu et al. (2020) conducted a study to discover the current state of blockchain research by applying a scientometrics methodology, which is used in analysing data extracted from online scientific databases, and the authors provided a holistic view of the blockchain-related literature.

Hughes et al. (2019) noted that blockchain applications have often been discussed in the context of logistics and SCM. In this context, it is relevant to refer to the study of Wamba and Queiroz (2020), in which the researchers

aimed at understanding blockchain applications in operations and supply chain management (OSCM) and the way firms create and capture value with blockchain technologies. Wamba and Queiroz's bibliometric analysis demonstrated that blockchain applications in regard to OSCM still remain in the infant stage, and there is a need to explore the role of blockchain in terms of operations traceability, e-commerce, public services, agriculture, and other areas.

Multiparadigm inquiry: focus on the functionalist and interpretive paradigms

In order to stimulate further research on blockchain and blockchain-based enterprises, a brief multiparadigm review of the related literature is presented in this section. Multiparadigm reviews, along with multiparadigm research and metaparadigm theory building, are three approaches to multiparadigm inquiry which were described by Lewis and Grimes (1999). In multiparadigm reviews, two techniques assist reviewers: paradigm bracketing and bridging (Lewis & Grimes, 1999, p. 673). The first technique implies differentiating between diverse sets of assumptions and adds a critique of alternative views. Burrell and Morgan's typology of sociological paradigms serves as the most relevant framework for paradigm bracketing. The second technique reviews transition zones, attempting to integrate paradigms' theoretical perspectives and combine their similarities. Such transition zones allow researchers to grasp a variety of research strategies within different paradigms and thereby enrich the research outcomes. As noted by Lewis and Kelemen (2002), multiparadigm reviews help researchers to understand the assumptions of various paradigms and be aware of the differences in the obtained results.

Burrell and Morgan (1979) classified existing theories within their typology to show how opposing viewpoints are maintained by different assumptions. Within the Burrell and Morgan matrix, the politically conservative functionalist and interpretive paradigms are contrasted with the conflict-oriented radical structuralist and radical humanist viewpoints. In contrast, the functionalist and radical structuralist paradigms share a more objectivist scientific view, while the interpretive and radical humanist paradigms adopt a more subjectivist position. Due to various characteristics, each of the four paradigms has its own approaches and analytical tool to conduct research.

The current study concentrates on comparing functionalist and interpretive perspectives because they are the dominant ones in organisation and management studies (Burrell & Morgan, 1979). For instance, they were applied in analysing the application of information technologies (IT) for knowledge management (Butler & Murphy, 2007), understanding the implementation of a new computer system in the workplace (Prasad & Prasad, 2000), and explaining the relationship between globalisation and IT (Ardalan, 2011). Functionalist studies tend to approach technology as a determinant of organisational structure (e.g. structural contingency theory) (Donaldson, 2003), while interpretative works treat it as a social object (Barley, 1986) that can alter the relations of production and organisational structure. Doing research within these two paradigms, it is possible to compare the subjectivist stance on a given topic with the more objectivist one. Before proceeding further, the main peculiarities of these two paradigms are briefly described.

The functionalist paradigm often employs refinement of theory. According to Donaldson (2003), functionalist research aims to generate general theories or control phenomena (Chia, 2003). The theory building is primarily implemented in a deductive manner, that is, the first step includes the literature review and the consideration of prior theories. As suggested by Gioia and Pitre (1990), the aims of hypotheses are threefold: the revision/extension/rejection of original theory in a new way, the attempt to close a research gap in the current state of knowledge, or the testing of competing interpretations for structural relationships. The formulation of hypotheses is based on the selected variables; therefore, in accordance with the formulated hypotheses, specific instruments are used to collect the necessary data and the required procedures are designed. The researchers stick to the consistency of variables and hypotheses throughout the whole theory-elaboration processes (Gioia & Pitre, 1990, p. 590).

By contrast, the theory-building process in the framework of the interpretive paradigm is mainly grounded in the inductive reasoning that may reveal structuring processes due to which actors construct social meanings and roles. Based on Cunliffe (2011), exploring narratives is an important characteristic but building theories is not. Gioia and Pitre (1990) emphasised that the researcher should tend to be a part of the studied phenomenon. One of the tasks of the researcher is to gather data that are important to the informants and convey their unique representations. The analysis of data starts simultaneously with the data collection and usually uses coding procedures. Subsequently, analysis, theory generation, and further data collection are interrelated processes (Gioia & Pitre, 1990, p. 588).

Donaldson (2003) and Hatch and Yanow (2003) noted that the two paradigms possess differences in relation to the mode of analysis: interpretive analysis is associative whereas the functionalist paradigm operates in a causal mode. Furthermore, interpretivists consider the importance of culture and context for shaping phenomena, and they explain their findings in terms of emergent images and metaphors, while the functionalist or positivist paradigm adheres to the predefined and universal analytical framework, analysts operating under this paradigm tend to generalise things. As was mentioned, interpretive scholars, unlike positivists, use relatively low levels of deductive and higher levels of inductive reasoning.

As Donaldson (2003) stated, the organisation has to adapt to its environment by fitting its organisational structure into the contingencies, such as the size of organisation or technology. Studies conducted in the framework of the functionalist paradigm are analysed to understand how the organisation exploits or plans to

employ emerging technologies. Here the researchers are acting as functionalists by following a quantitative and positivist approach, and they prefer such scientific research methods as statistics, questionnaires, and structured interviews. In contrast, interpretive researchers construe social reality through a sensemaking process and rely on qualitative data, mainly interviews. That is why, as an alternative view to positivist research, the work of Wang et al. (2019) was chosen as work that is done within the interpretive paradigm with the application of sensemaking theory. According to interpretivism, individuals are those who create society through their interactions. In this context, this sensemaking approach allows us to more deeply understand the perception and knowledge of supply chain (SC) experts about technology (Wang et al., 2019) and predict their future actions and the actions of other practitioners regarding its application.

Analysis of works done under functionalist and interpretive paradigms

Technology adoption theories

First of all, a number of research studies have been conducted to assess the blockchain effect on organisational activities and examine the adoption process of blockchain technologies across various industries (Grover et al., 2019). As a matter of fact, the majority of such studies have been done in the framework of the functionalist paradigm and in relation to SCM and logistics. According to Kshetri (2018), blockchain technology has a relative advantage in SC activities in comparison to the financial industry. The technology can result in SC disintermediation, leading to reductions in transaction costs and time and to a decrease in business waste in the supply chain (Saberi et al., 2018). The most widely applied models are the diffusion of innovation theory (Kshetri, 2018), the technology acceptance model (Kamble et al., 2019; Queiroz & Wamba, 2019), the unified theory of acceptance and use of technology (Queiroz & Wamba, 2019; Wong et al., 2020b), the technology – organisation – environment framework (Clohessy et al., 2019; Wong et al., 2020a), and interorganisational system (IOS) adoption theory (Sternberg et al., 2020). They serve to identify the constructs and factors which impact the decision to adopt technological innovation, in this case, blockchain technology (see Table 1), and to understand the behavioural intentions of adopting BT.

Table 1.

Papers based on application of technology adoption theories & models in relation to blockchain deployment

Author(s) / Year	Journal	Theories applied	Type of study	Sample/data source	Results
Kshetri (2018)	*International Journal of Information Management* (Q1)	DOI theory	Conceptual	11 case studies of blockchain projects; archival	– A relative advantage of BT in supply chain compared to finance industry – Blockchain-based SC products are more appropriate for the tech, auto, and garments industries and the oil trading sector, and the food industry is the most affected by blockchain
Kamble et al. (2019)	*International Journal of Production Research* (Q1)	TAM, TPB, TRI	Empirical	Online survey, 181 SC practitioners from 102 companies in India; archival	The validity of the proposed model based on the integration of TAM, TPB, and TRI: – Perceived usefulness, attitude, and perceived behaviour control – the most critical constructs that explain behavioural intention for BT adoption in SC – Discomfort and insecurity are not perceived as the inhibiting factors in the BT adoption process by SC experts – Low level of blockchain awareness among the SCM respondents
Queiroz & Wamba (2019)	*International Journal of Information Management* (Q1)	Network theory; TAMs with special focus on UTAUT	Empirical	Questionnaire, 344 & 394 SC professionals from India and the US, respectively; archival.	An altered version of the classical UTAUT with the integration of 2 new "constructs" trust of SC stakeholders and blockchain transparency: – Performance expectancy influences behavioral intention – Behavioral intention influences behavioral expectation – Facilitating conditions were supported only in the US, while in developing countries (e.g., India) such conditions repulse the BT adoption – Trust between SC stakeholders does not affect BT adoption in both cases

Wong et al. (2020b)	*International Journal of Production Research* (Q1)	UTAUT + additional constructs of technology readiness, technology affinity, trust	Empirical	Questionnaire, 157 firms in Malaysia were asked regarding BT adoption in SCM; archival.	– Incapability of the UTAUT to predict the adoption of immature technologies, and the key role of environmental readiness in adopting BT – Low familiarity with the technology among respondents, uncertainty in blockchain use at their companies – Insignificance of trust
Clohessy et al. (2019)	In Treiblmaier & Beck	Innovation Theory; TOE considerations	Conceptual	Review of the BT literature (16 final research resources) conducted in 7 databases	– Important technological considerations: perceived benefits, complexity and compatibility – Organisational considerations: organisational readiness, top management support, and organisational size – Environmental considerations: the regulatory environment and market dynamics – Important role of top management support in adopting BT
Wong et al. (2020a)	*International Journal of Information Management* (Q1)	TOE framework	Empirical	Questionnaire, 194 SMEs in Malaysia regarding BT adoption for OSCM	– The top 4 significant considerations: competitive pressure, complexity, cost, and relative advantage – Insignificant considerations: market dynamics, regulatory support and upper management support
Sternberg et al. (2020)	*Journal of Business Logistics* (Q1)	IOS adoption theory	Empirical	Single case study on the ReLog's vine supply chain	– Introduction of a synthesised model for BT interorganisational adoption in SC – Identification of positive (perceived benefits, external pressure, and organisational readiness) and negative IOS factors of adoption (perceived obstacles, external resistance, and organisational immaturity) – Specific phenomena of BT adoption in SC: the trust – investment paradox and the traceability – efficiency, visibility – privacy, and performance – commitment tensions

Source: author's compilation

Diffusion of innovation theory

The diffusion of innovation theory was developed by Rogers, who defined 5 main interrelated attributes for predicting future innovations' rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1995, p. 211).

Kshetri (2018) developed a framework to consider the contribution of blockchain to achieving the main SCM objectives through such mechanisms as validation of individuals' and assets' identities and incorporation of the IoT, which may "make tracking possible and more accurate" (p. 87). In this context, 11 case studies of blockchain projects at various stages of development were discussed: Maersk; Provenance; Alibaba; the largest defence contracting firm Lockheed Martin; San Francisco-based blockchain start-up Chronicled and life sciences supply chain consultancy LinkLab; the Swiss start-up Modum in cooperation with the University of Zurich; the London-based start-up Everledger; Walmart; Gemalto; Intel; and Denver-based start-up Bext360. The selected cases were used to compare BT adoption in a variety of industries such as the food, pharmaceutical, diamond, wine, and coffee industries and cybersecurity-related initiatives. Based on DOI theory and the analysis of cases, Kshetri (2018) revealed that blockchain will primarily transform the SC processes by addressing issues related to communication. The industry which will be significantly impacted by blockchain is the food industry. And the tech, auto, and garment industries as well as the oil-trading sector are the most suitable ones for blockchain-based SC products due to a smaller number of suppliers. So the examples derived from these case studies prove the ability of blockchain to reduce costs, eliminate manual paper-based processes, automate SC processes, and allocate the proper amount of resources (Kshetri, 2018, p. 86). Meanwhile, there are many challenges, for example, the need for a high level of computerisation and the requirements for parties operating in the global SC to comply with diverse institutions, laws, and regulations.

TAM/TPB/TRI

Kamble et al. (2019) tried to understand the user perceptions of blockchain technology through the example of 181 SC practitioners in India by assimilating the constructs of three adoption theories – technology acceptance model, technology readiness index (TRI) – and the theory of planned behaviour (TPB). The TAM is the most widely used model in a diverse set of technologies and users. It

measures the developing attitude towards the behavioural intention and the perceived ease of use and perceived usefulness (Davis, 1989). The TPB is the extended version of the theory of reasoned action (TRA), and it measures the impact of perceived behavioural control and subjective norms on the adoption process (Ajzen, 1991). And the TRI model contains four sub-dimensions: two motivators of the technology – optimism and innovativeness, and two inhibitors – discomfort and insecurity. The technology readiness index measures the perceived risks that inhibit general technology adoption (Parasuraman, 2000). Thus, Kamble et al. (2019) adopted the two TRI's constructs of discomfort and insecurity, which act as the inhibiting factors during blockchain adoption in supply chains. The results of the statistically validating model revealed the insignificant effect of the discomfort and insecurity constructs on the perceived ease of use and usefulness, while the perceived usefulness, attitude, and perceived behavioural control affect the behavioural intention and the subjective norms negligibly impact the behavioural intention. The findings indicated that SC practitioners perceive blockchain adoption to be free of effort and that their activities should concentrate on "making blockchain more user-friendly" and easier to use (Kamble et al., 2019, p. 2026). The authors advised the companies that have successfully implemented blockchain in SCs to share their stories and explain its benefits in comparison to traditional SCs.

UTAUT

The unified theory of acceptance and use of technology was proposed by Venkatesh et al. (2003) to research technology acceptance. The model is an extension of existing models, including the TAM, DOI, TRA, and TPB, whose limitations the UTAUT tries to address. Venkatesh et al. (2003) identified four constructs which are direct determinants of user acceptance and usage behaviour – performance and effort expectancy, social influence, and facilitating conditions – and the model is moderated by gender, age, experience, and voluntariness (p. 447). This influential model has been employed in a number of studies on adopting new technology. Regarding blockchain adoption, the constructs of this framework and other main adoption theories have been tested by multiple authors (Kamble et al., 2019; Queiroz & Wamba, 2019; Wong et al., 2020a, 2020b).

To understand blockchain adoption behaviour in the SC management domain, Queiroz and Wamba (2019) proposed a model on a modified version of the classical unified theory of acceptance and use of technology with the integration of two new constructs: trust of SC stakeholders and blockchain transparency. The authors combined the extant literature on supply management and blockchain and, mainly, on network theory and the TAM, with particular attention on UTAUT and UTAUT2 (Venkatesh et al., 2003, 2012), and conducted cross-cultural research on adoption behaviours between India- and US-based professionals. Firstly, network theory aids in explaining the complexity of interfirm relationships and cooperation as well as the impact of external variables on technology adoption. Within SCM, blockchain can transform the relationships among network members, optimise transaction costs, and improve efficiency. The UTAUT allows a better understanding of employees' motivations for adopting blockchain (Queiroz & Wamba, 2019, p. 73). The results show that there are differences in blockchain adoption behaviour among SC professionals in India and the US, but both Indian and American respondents are reluctant to exchange data with their SC members.

In order to predict blockchain adoption intention in the SCM, Wong et al. (2020b) extended the UTAUT model by omitting the construct social influence (SI) and including the additional exogenous constructs of technology readiness, technology affinity, and trust as well as adopting regulatory support as the moderating variable instead of the UTAUT model's primary moderators. After statistically testing the proposed model based on data collected from 157 firms in Malaysia, the authors revealed the incapacity of the UTAUT to predict the adoption of immature technologies and the insignificance of trust but found the direct impact of such constructs as the facilitating conditions, technology readiness, and technology affinity on blockchain adoption in SCM. Therefore, following the meaning of these three determinants, the behavioural intention of the firm mainly depends on the right infrastructure and resources and the main personnel's propensity and interest in exploring new technologies as well as on external stakeholders' support in terms of regulatory authorities and safe practices (Wong et al., 2020b, p. 2114). The authors advocated the need for integration of inter- and intra- organisational parties to adopt BT in SCM. The authors suggested that those companies planning to adopt blockchain technologies should increase the level of this technology's awareness and develop the required expertise, trust, and environment towards successful implementation.

The TOE framework

Clohessy et al. (2019) earlier revealed important technological, organisational, and environmental blockchain adoption considerations that can serve as a foundation for advancing research on the blockchain adoption in organisations. By applying innovation theory and the TOE framework, Clohessy et al. (2019) conducted a comprehensive review of the blockchain-related literature and identified the top three organisational considerations – organisational readiness, top management support, and organisational size – which were used as mediating concepts in the research. From the technological and environmental perspectives, several key considerations such as perceived benefits, complexity, and compatibility as well as the market dynamics and the regulatory environment were specified. One of the main findings was the important role of top management support in incrementally adopting this technology.

Due to disregard of the organisational and environmental factors by the UTAUT and the TAM, Wong et al. (2020a) adopted the technology, organisation, and

environment framework to analyse the effects of relative advantage, complexity, upper management support, cost, market dynamics, competitive pressure, and regulatory support on blockchain adoption for OSCM among Malaysian small- and medium-sized enterprises. Based on the innovation adoption theory, the TOE framework was developed by Tornatzky et al. (1990) to consider the technological, environmental, and organisational factors that influence the decision to adopt technological innovations. Unlike the traditional models such as TAM, UTAUT, and DOI, Wong et al. (2020a) referred to the TOE framework by stressing the combination of human and non-human factors into a single framework, thereby offering a more holistic view of technology adoption among small and medium-sized enterprises. SMEs comprise a group of economic actors that lack resources for technological investments; meanwhile, they must also adhere to the same requirements for optimising the business process and effectively managing their resources. This is when blockchain may come into play to support SMEs' sustainability, owing to the technology's features of transparency, immutability, and security. According to the findings, constructs of the research model such as competitive pressure, complexity, cost, and relative advantage have significant effects on behavioural intention, whereas market dynamics, upper management, and regulatory support are found to be insignificant predictors. Wong et al. (2020a) concluded that blockchain technology has the potential to solve many problems of enterprises, for example, via improving SC traceability. However, its adoption requires a gradual process through collaboration between various internal functional divisions and external members because of blockchain's complexity, uncertainty, and security concerns, as well as the higher costs inherent in implementing this technology.

The IOS adoption theory

Furthermore, Sternberg et al. (2020) also emphasised that blockchain technologies entail a network effect in supply chains. This means that the value of one organisation adopting blockchain is limited, as the technology yields benefits only when multiple members in a network – stakeholders and value chain partners – adopt this technology. In this research, blockchain was considered an interorganisational system; therefore, the adoption of blockchain in SCs was studied from the perspective of the IOS adoption theory proposed by Iacovou et al. (1995). The reasons for selecting and developing this IOS adoption model were due to its main determining factors such as perceived benefits, organisational readiness, and external pressure that are the positive IOS factors of adoption as well as its ability to address the negative IOS factors of adoption – perceived obstacles, external resistance, and organisational immaturity. Based on the single-case study on ReLog's vine supply chain, Sternberg et al. (2020) proposed an interorganisational adoption model and identified four specific phenomena of blockchain adoption between organisations in SCs: the trust – investment paradox and the traceability – efficiency, visibility – privacy, and performance – commitment tensions occurring between positive and negative IOS factors of adoption (p. 13). In conclusion, the authors highlighted the necessity to consider both the benefits and challenges that the adoption of blockchain causes in SCM. And from the human-centric view, they emphasised privacy concerns, especially among SC employees, as one of the greatest blockchain-related issues.

Comparison of studies on BT adoption conducted under interpretivist and positivist paradigms

The potential of blockchain to alter SCM and logistics is one of the fields which was studied from the lenses of different theories, including mainly transaction cost theory and principal-agent theory, but also other technology adoption theories (Ahluwalia et al., 2020; Kamble et al., 2019; Queiroz & Wamba, 2019; Schmidt & Wagner, 2019; Treiblmaier, 2018; Wong et al., 2020a, 2020b) within the positivist paradigm. For instance, the study of Kamble et al. (2019) is a clear example of research conducted in the framework of the functionalist paradigm. The authors aimed to analyse the factors which affect the acceptance of blockchain in SCs. For this purpose, a unified research model integrating the different constructs of three adoption theories – TAM, TPB, and TRI and the related hypotheses – was tested by applying such quantitative techniques as confirmatory factor analysis and structural equation modelling (see Table 2). The target audience consisted of SC practitioners whose perception was studied to understand the adoption process of blockchain technology in the area of the SC. To examine the relationships among the proposed parameters, an online survey was conducted with the participation of 181 SC professionals representing 102 (manufacturing, technology, or logistics) companies from 4 major cities of India (Kamble et al., 2019).

This quite large sample size and the applied standardised measures, as well as the statistically validated model, corresponded to the requirements of research within the positivist paradigm. The findings revealed that the TRI constructs (insecurity and discomfort) had an insignificant effect on affecting the behavioural intentions of the SC practitioners, while the constructs of TAM and TPB – perceived usefulness, attitude, and perceived behaviour control – were the most critical ones in explaining behavioural intention for blockchain adoption in SCs. In general, perceived usefulness helped build the attitude towards blockchain adoption, which the SC practitioners perceived effortlessly. These practitioners were familiar with this technology; however, they lacked practical knowledge and experience regarding its further implementation that made them consider both the advantages and issues pertinent to introducing BT into SC.

In contrast, the interpretive paradigm is also well-suited to research a new and underinvestigated area. An alternative approach to examine the implications of blockchain in transforming the contemporary SC within the interpretive paradigm was provided by Wang

et al. (2019). The authors applied a well-established sensemaking theory (Weick, 1990; Weick et al., 2005) in organisation and management studies to analyse how SC practitioners developed assumptions and knowledge about the technology of blockchain which later shaped their actions. The aim of Wang et al. (2019) was to interpret the future impact of blockchain technology on the SC domain by focusing on individual sensemaking of SC experts, that is, the way these practitioners make sense of the nascent technology. The data collection technique applied in this research was semi-structured interviews, which are common for qualitative research and the interpretive paradigm. The data were gathered from 14 interviews, a small sample size that nevertheless is considered acceptable for conducting research under the interpretive paradigm. This example illustrates how the researchers interpreted the reality (blockchain adoption) from the perspectives of participants (14 subject matter experts) through a sensemaking process rather than a hypothesis testing process. Wang et al. (2019) were interested in local understandings of specific uses in a certain field. Based on the individual sensemaking and the practitioners' interpretations, the individual cognitive maps were constructed for every interviewee. After collecting and comparing all codes, they were grouped into such categories as benefits, applications, and challenges' frames, and the collective cognitive mapping was created as a data analysis technique. The narrative analysis was the second method of data analysis, which was an iterative process of moving back and forth between the collected data, the literature on blockchain, and Wang et al.'s emerging framework of sensemaking (Wang et al., 2019, pp. 226 – 228). The research demonstrated that the SC practitioners tended to first understand the usage of technology and then gradually implemented small-scale applications of blockchain rather than make radical changes.

Thus, both research studies, carried out either in the positivist or interpretive paradigms and in the same time period, have considerable explanatory power in relation

Table 2.

Comparison of the adoption of blockchain technology in the context of supply chains within positivist and interpretive paradigms

Characteristics of articles	PARADIGMS	
	Interpretive	**Functionalist**
Authors/Year/ Title	Wang et al. (2019): Making Sense of Blockchain Technology: How will it transform supply chains?	Kamble et al. (2019): Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context.
Journal (country/ rank)	*International Journal of Production Economics* (The Netherlands / Q1)	*International Journal of Production Research* (The UK / Q1)
Theoretical framework	sensemaking theory	TAM, TPB, TRI
Research type	– qualitative, explorative approach	– quantitative research
Aim	– explore how emerging BT technology may transform SC – examination of individual sensemaking of SC practitioners	– understand the blockchain adoption process in SCs – analyse the factors which affect the acceptance of BT in SCs
Data collection method	– semi-structured interviews	– online survey (to examine the relationship between constructs; 33 parameters proposed in the research model)
Sample size	– 14 SC experts: senior executives/managers from the UK, Germany, Switzerland, Indonesia, Romania, and Portugal who had in-depth domain knowledge in SCM with a sufficient understanding of IT	– 181 SC professionals representing 102 companies (manufacturing, technology, and logistics) from 4 major cities of India (Mumbai, New Delhi, Bangalore, and Chennai)
Data analysis	– narrative analysis – cognitive mapping: individual maps – a collective strategic map – iterative process of moving back and forth	– model and hypotheses testing with confirmatory factor analysis – use of AMOS 21 to conduct structural equation modelling
Contribution	– extension of sensemaking theory: contribution to the emerging field of behavioural operations research by applying sensemaking theory to gain insights into how SC actors make sense of the emerging technology – preparation of industries' practitioners to adopting BT, which is disruptive technology for some of the domains – further insight for the stream of technology adoption studies	– identification of the critical constructs for successful adoption of BT in SCs and the development of the SC practitioner's behavioural intentions on adopting BT – the study advances the literature of technology adoption and tests a unified model integrating the theories of TRI, TAM, and TPB

Source: Table created by the author based on Kamble et al. (2019) and Wang et al. (2019).

to blockchain technology adoption, and they aimed at preparing SC practitioners to implement this technology (Table 2). This indicates that the same phenomenon can be studied in the framework of different theoretical perspectives and paradigms. The analysed studies have mixed assumptions that can reinforce each other; however, this would need additional discussion.

Conclusion and future research directions

The academic works here were discussed through the lenses of technology adoption theories and sensemaking theory as an alternative option. Regarding the area of supply chain management, the studies analysed behavioural intention and behavioural expectation in adopting the technology of BT as well as the factors that influence the decision to incorporate this technological innovation.

The widely used theories regarding blockchain are the DOI, the TAM, the UTAUT, the TOE framework, and the IOS adoption theory that were frequently employed in examining the supply chain area. The analysis of academic papers reveals that some authors tended to integrate several theories and then propose and test the modified research models. For instance, Clohessy et al. (2019) combined innovation theory and the TOE framework, while Queiroz & Wamba (2019) integrated the constructs of the UTAUT and network theory to outline the complexity of intercompany relationships. Some researchers found that supply chain practitioners saw the adoption of blockchain as a process that requires little effort (Kamble et al., 2019), while others warned about the need to consider both benefits and challenges related to blockchain adoption (Sternberg et al., 2020). However, there was a consensus that this complicated technology should gradually be implemented (Kamble et al., 2019; Wang et al., 2019; Wong et al. 2020a). For the successful acceptance of technology in SCM, the right infrastructure and resources, awareness and knowledge among employees (Wong et al., 2020b), and the support of top management and external network members (Wong et al., 2020a, 2020b) are required.

Following the position of Vegh and Primecz (2019), I tried to avoid being driven by the paradigm taxonomy, and instead the study was primarily guided by two research questions. The purpose of the article was to review the results of existing studies on BT acceptance and compare them with academic works carried out within the functionalist and interpretive paradigms. The findings showed that the majority of studies in the field of blockchain technology management had been done within the functionalist paradigm. Research studies completed in the framework of these two paradigms were the most appropriate for analysing the new opportunities created by blockchain and users' perception to it. Due to the multiparadigm reviews, a multiplicity of data collection and data analysis techniques as well as a cross-fertilisation of ideas might enrich the elaboration of the relatively new research field on blockchain technology incorporation.

The research outcomes support the argument of Vegh and Primecz (2019) that organisation studies should be based on predefined research questions and not on paradigm assumptions, as there is no need for such works to be grounded in the paradigm debates. This review of technology adoption theories may help organisations develop their strategies for new technology introduction and understand the attitude of their personnel to the technology.

Thus, because this research contains a review of blockchain from the lens of technology adoption theories and sensemaking theory, it is recommended that future research continue the analysis from the perspectives of other organisation theories and concepts and derive classifications of them. Given the infancy of blockchain technology, most studies have explored prior attitudes towards BT adoption, which is why further research can be devoted to studying the post-adoption process throughout multiple industries.

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JUDIT NAGY – ORSOLYA DIÓFÁSI-KOVÁCS

HOW CAN ADVANCED INFORMATION AND COMMUNICATION TECHNOLOGY SUPPORT CORPORATE ENVIRONMENTAL PERFORMANCE?

HOGYAN TUDJA A FEJLETT INFORMÁCIÓS ÉS KOMMUNIKÁCIÓS TECHNOLÓGIA TÁMOGATNI A VÁLLALATOK KÖRNYEZETI TELJESÍTMÉNYÉT?

In this paper the authors investigate the relationship of advanced information and communication technology (ICT) use and the environmental performance on the company level. Their presumption is that companies with advanced ICT can have better environmental performance as well. The level of ICT development is assessed by Pham's model, while environmental performance is interpreted along with the model of Schultze and Trommer. The authors tested the models and the relationship of ICT and environmental performance by statistical analysis, using the database of Hungarian Competitiveness Research Centre. Regarding the results, there is a positive connection between high-level ICT use and environmental performance in many aspects. Since advanced ICT allows companies to gather and analyze data extensively, the monitoring of the environmental performance indicators and the intervention, continuous development can be more efficient. Environmental sustainability is not the privilege of large companies, middle size companies are also intensely dealing with this important issue.

Keywords: **environmental performance, ICT, information technology, sustainability**

Tanulmányukban a szerzők a vállalatok magas szintű információs és kommunikációs technológiákban (ICT) való jártassága és környezeti teljesítménye közötti kapcsolatot vizsgálják. Feltételezéseik szerint azok a vállalatok, amelyek fejlett ICT-t alkalmaznak, környezeti szempontból is jobban teljesítenek. Az ICT fejlettséget Pham modellje segítségével mérik, míg a környezeti teljesítmény megítéléséhez Schultze és Trommer megközelítését alkalmazzák. A modelleket és a fent felvázolt összefüggést statisztikai módszerekkel tesztelték, amelyhez a Versenyképességkutatás adatbázisát használták fel. Az eredményeket tekintve elmondható, hogy pozitív kapcsolat van a vállalatok ICT-fejlettsége és környezeti teljesítménye között több szempontból is. Mivel a fejlett ICT jobb adatgyűjtést és elemzést tesz lehetővé, a környezeti teljesítmény mérése és a beavatkozás is hatékonyabb lehet. A felelős környezeti gondolkodás nem csak a nagyvállalatok privilégiuma, a középvállalatok is élénken foglalkoznak a témával. A magántulajdonban lévő vállalatok környezeti teljesítménye jellemzően jobb, mint az állami tulajdonban lévőké.

Kulcsszavak: **környezeti teljesítmény, ICT, információtechnológia, fenntarthatóság**

Funding/Finanszírozás:
The authors did not receive any grant or institutional support in relation with the preparation of the study.

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This article was received: 16. 09. 2020, revised: 19. 10. 2020, accepted: 21. 10. 2020.
A cikk beérkezett: 2020. 09. 16-án, javítva: 2020. 10. 19-én, elfogadva: 2020. 10. 21-én.

Information technology, industrial digitalization, robotics, sustainability, circular economy, eco-efficiency – topics that raise the interest of researchers and professionals as well, and the success of the concepts also determine our future. Nowadays managers have to adapt to a highly dynamic business environment. According to the concept of dynamic capabilities (Eisenhardt & Martin, 2000) in order to cope with the dynamic environment, businesses need to acquire relevant knowledge, then transform them into capabilities and finally, use these capabilities to gain and sustain competitive advantage (Zahra & George, 2002).

This environment is determined by two concepts nowadays: sustainability – as demand from stakeholders at large (Seth, Sethia & Srinivas, 2011; Seuring & Müller, 2008; Kraus, Rehman & García, 2020) – and digitalization which has the potential to boost efficiency and provide better customer service of the companies (Becker, Knackstedt & Pöppelbuß, 2009; Lenka, Parida & Wincent, 2017; Demeter, Losonci & Nagy, 2020). Both of these concepts add to the overall competitiveness of companies and demand new capabilities and attitudes e.g. high level of willingness to innovate and cooperate with stakeholders. Could these intensely researched concepts work together, support each other and provide a more sustainable future?

In our paper, we investigate the possible connection between digitalization and sustainability, but we narrow digitalization to the use of Information and Communication Technologies (ICT) in companies. In our opinion it is important to analyze the different green practices and their popularity for further policy and managerial implications as well.

The paper is structured as follows: in the "Introduction" we summarized the role of ICT in companies and its effect on the environment. Then we formulated our hypotheses and the way we analyze the topic in the "Focus of the research" section. In the "Materials and methods" section, we introduce the Hungarian Competitiveness Study and its extensive questionnaire we used to test our research questions, along with the exact methodology we chose. The next section summarizes the results of the analysis, while the discussion part presents our new results and their relevance for science and industry. The "Conclusions" sums up the most important results and discusses the limitations of the study and future research directions. Our results will be useful for practitioners and policymakers as well. In our opinion, it is important to analyze the different environmental performance indicators and their popularity for further policy and managerial implications.

Literature review

The next section consists of a short review of the ICT related literature, highlights the importance of sustainability in the business sector and links ICT to environmental performance.

Information and communication technology (ICT) has gone through intense development and spread over the past decades. According to Weber and Kaufman's definition (Weber & Kaufmann, 2011, p. 684) ICT is understood "as technologies that support data and information processing, storage and analysis, as well as data and information transmission and communication, via the Internet and other means". In this means, we cannot imagine either our homes or workplaces without the presence of various ICT tools and numerous pieces of software are available to support our lives and work.

ICT technologies in business processes became indispensable in the digital era. ICT contribution to productivity and economic growth has been widely discussed (Ishida, 2015; Higón, Gholami & Shirazi, 2017). ICT also takes the main role in the economy transformation and become a vital source of competitive advantage (Becker et al., 2009; Powell & Dent-Micallef, 1997; Michalic & Buhalis, 2013). Although Ollo-Lopez and Aramendía-Muneta (2011) discovered no relationship between ICT and company competitiveness, they found that advanced ICT favours innovation, launching new products and services and implementing new processes which can enhance firm competitiveness eventually.

The level of ICT development maturity can be described in several ways (Pham, 2010; Chesher & Skok, 2000) based on the companies' policies towards ICT, the available hardware and software, and in connection with the users. There are also several indices to measure ICT development (e.g. Digital Opportunity Index and ICT Opportunity Index by International Telecommunication Union) on the country level and individual/household level as well.

About sustainability, we can agree that the greatest challenge of the 21st century is to tackle climate change and set our society on a sustainable path. Since the first definitions of sustainable development in the 1980ies, a very slow transition has started in the business sector. As Bansal and Roth (2000) point out, environmental protection can be important for companies because of maintaining competitiveness, complying with legislation, and because of internal beliefs. Nowadays operating a company sustainably and responsibly is necessary in order to meet customer demand and be able to compete in the current business environment. Companies are expected to improve their environmental performance firstly because they have to comply with government regulations and in some cases, taxes are connected to emissions to the environment. Customers and business partners may also put them under pressure since customers want sustainable products and services, while investors want new business opportunities, and market development (Antoni & Jie, 2012). According to the ISO14001 standard's definition, environmental performance means the "measurable results of an organization's management of its environmental aspects" (ISO14001). Corporate environmental performance and environmental performance indicators have very diversified literature. Measuring environmental performance has become increasingly popular as its strategic role was recognized: green management was proven to enhance the long-term competitiveness and economic performance (Rao & Holt,

2005 in Tuni, Rentizelas & Duffy, 2018). The current methods for environmental performance evaluation are the measurement of environmental performance and evaluation of the conditions of material balance (Coelli, Lauwers & Huylenbroeck, 2007 in Song, Fisher, Wang & Cui, 2018), strategic environmental assessment (SEA) (Zhu & Ru, 2008 in Song et al., 2018), ecological footprinting (Bagliani, Galli, Niccolucci & Marchettini, 2008 in Song et al., 2018), cost-benefit analysis (Mouter, Annema & Van Wee, 2013, in Song et al., 2018), data envelopment analysis and life cycle assessment methods (Song et al., 2018).

The following discussions show examples of the potential of ICT on the possible improvement of environmental performance. It is emphasized that ICT tools can enable organizational practices and processes that improve environmental and economic performance (Melville, 2010). Researchers found that IT improves the management of talent, which in turn enables execution of a more environmentally sustainable operations strategy and increase firm performance (Benitez-Amado, Llorens-Montes & Fernandez-Perez, 2015). In ASEAN countries, a relationship was found among ICT, economic growth and CO_2 emission (Lee & Brahmasrene, 2014). They proved that ICT has a significant positive effect on both.

We can see articles focusing on the environmental effects of ICT. Cai, Chen and Bose (2013) found a positive relationship between IT and environmental sustainability strategy in companies, and they also find this important from the competitiveness point of view. It was proved that IT supports the coordination of product design and manufacturing, and strengthen the effect of environmental practices (Gimenez, Sierra, Rodon & Rodriguez, 2015). From another point of view, it was propounded that CSR reporting is a highly complex process and requires a large amount of data, which need to be stored, processed and analyzed (Watts, 2015). ICT can support transparent processes on a high level, with improved accuracy. Pekovic, Grolleau and Mzoughi (2018) analyzed the effects of environmental investments – including machinery, equipment to treat, measure, control or restrict pollution, which obviously need IT support – on the economic performance of firms, and they found that there is an optimal level of environmental investments which have a positive effect on net profit.

There are some papers that list the pro and con examples and highlight the controversial effects of ICT on environmental performance (Ishida, 2015; Yi & Thomas, 2007). They state that ICT supports economic growth, social development and environmental protection, although computers contain parts that are toxic, and to produce semiconductor wafers manufacturers use a considerable amount of water and energy. Research compared on-line and offline book retailers and concluded that it cannot be decided which is more energy efficient (Matthews, Williams, Tagami & Hendrickson 2002).

To sum up the controversial effects of ICT development from an environmental perspective, we can confirm that the spread of ICT tools and the increase of their capacity and performance enhance the need for energy, and a large amount of electronic waste pollutes the environment (Yi & Thomas, 2007, Radu, 2016). On the other hand, improvement of ICT and consequently the increasing efficiency of the companies and/or production processes might save us energy, waste, pollution or workload (Radu, 2016).

According to Subburaj & Kulkarni (2014), there are green or environmental ICT systems which can support environmentally sustainable business operations. These are hardware and software solutions that have a low environmental impact or contribute to reducing the environmental impact of an industry or society (Cecere, Corrocher, Gossart & Ozman, 2014; Radu, 2016).

In the above-mentioned papers, environmental performance is usually captured by CO_2 or other kinds of emission. We identified that as a *gap* since environmental performance should not be narrowed down to emission, it is a more complex phenomenon. Environmental performance of an organization is determined by several factors (Butti, Guarnaccia, Cosentino, Leonardi, Caruso et al., 2019; Gaviglio, Bertocchi & Demartini 2017), e.g. management approach, input and output of material and energy, position and strength in the supply chain it operates in and so on. This is what we would like to focus our paper on. How can an extensive environmental performance measurement be supported by ICT?

Focus of the research

There is already a current discussion (Hilty, Lohmann & Huang, 2011; Ollo-Lopez & Aramendía-Muneta, 2011; Melville, 2010; Wang, Sanchez Rodriguez & Evans, 2015; Evangelista, Santoro & Thomas, 2018; Kayikci, 2018) on the use of digitalization and its effects on environmental performance, which we would like to contribute to. However, our viewpoint is different from the current articles, since we explored the relationship between the use of ICT and environmental performance and did not measure the effects of the two on each other. *Our hypothesis is that a higher level of ICT development in a company results in improved environmental performance.* "You can manage what you measure, and you manage what you care about", says Steve Howard in a Ted Talk about sustainability (Howard, 2013). Our starting point is that ICT enables companies to measure and manage data, which can give insight into their environmental performance. On the other hand, ICT-use requires organizational capabilities that support innovation, which is also a key element, that can further environmental sustainability within an organization (e.g. ecodesign, environmental management, process innovation). To analyze this hypothesis, we apply two models: one, which helps us to assess a company's ICT maturity and another one which interprets environmental performance in a complex manner, not only along with emissions. With the help of these models, we explore in-depth how the different ICT development stages affect environmental performance.

One of the models applied, measures the maturity of ICT in a company. Since ICT has a great potential to

transform a company's operations and has a key role in data collection and analysis (e. g. building corporate knowledge and sharing it within the firm) (Pham, 2010; Chesher & Skok, 2000), it is not enough to report on what kind of hardware and software is used at the company. ICT has to be analyzed with a wider scope if it has a strategic role in the company, the types and the variety of tools, and the way they are used. For this reason, the ICT development was analyzed along four aspects suggested by Pham (2010): ICT policy, infrastructure, applications and human resource. ICT policy refers to written or unwritten rules, procedures and ways of doing business in an enterprise. Infrastructure covers the devices and services which help the company in storing, processing, communicating, and sharing information. Applications refer to the software which help to do business. Human resource issues deal with ICT literacy, skills and also innovation skills.

The sustainability-related analysis focuses on environmental sustainability based on the multidimensional environmental performance model suggested by Schultze and Trommer (2012). This model was chosen because the environmental performance of an organization is determined by different factors (Butti et al., 2019; Gaviglio et al., 2017), not exclusively by CO_2 and other emissions which is widely used in the related literature (Lee & Brahmasrene, 2014; Ishida, 2015; Wang et al., 2015). The Schultze-Trommer-model distinguishes operational and strategic factors influencing environmental performance, and on operational level, it separates performance indicators related to the inputs, the processes, the outputs and the outcome. This way this model is complex enough to get a picture of a company's environmental pursuit.

In the next chapter, we introduce the materials and methods we used to test Pham's and Schultze-Trommer's models.

Materials and methods

Database

The hypothesis will be explored by using statistical analyses. The database has been prepared by the Hungarian Competitiveness Research Centre (HCRC) which operates at Corvinus University of Budapest and surveys the companies' competitiveness in approximately every five years. The first Hungarian Competitiveness Survey was carried out in 1995 and since then, five others followed. We have to note that the questionnaire was originally made for assessing the companies' competitiveness form various dimensions. We selected questions from the questionnaire which were suitable for measuring the interdependency of the ICT development stage and environmental performance in our study. However, we have to note, that since the survey had a different original purpose, only a limited number of questions or variables were suitable for our aims. Although the database is from 2013 (HCRC, 2013), we have revealed many interesting connections between ICT development and environmental performance. The relevance of the topics is evergreen, but the technological environment of the recent years has brought substantial developments that indicate that it might be worth to continue the research in the future.

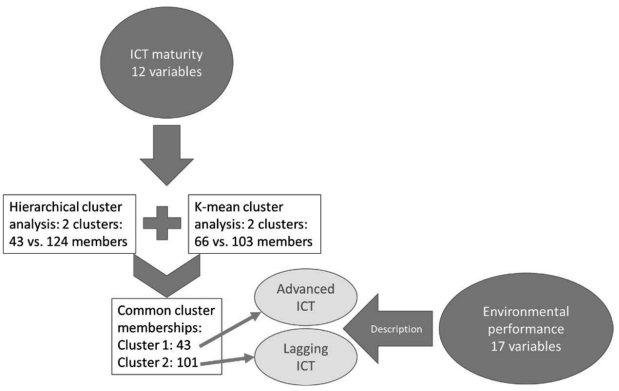
The questionnaire of the survey is almost 100 pages long and can be divided into four blocks. Within each block, chapters cover a wide range of management topics. The first block is dedicated to the CEO and the board, dealing with issues like the basic data about the firm, the internal and external environment, strategy, and management structure of the company. The CEO block also deals with human resources management and controlling topics. The second block is dedicated to the CFO, reviewing the finances, investments and controlling issues. The third block targets the production (or service) managers, requesting data about the operations processes, the supporting hardware and software infrastructure, innovation, logistics and supply chain management and the environmental protection. The fourth block targets the sales or marketing directors, aiming to gather data about the general market position of the company, the long-term relationships, the marketing activity, its assessment and effectiveness. The questionnaire applied mainly multiple-choice or Likert-scale methods and open-ended questions, too. In our analysis, we used questions of the first (CEO) and the third, production blocks (see Table 1 and 2).

Statistical methods

We applied cluster analysis to separate companies in the sample which are well-developed from ICT point of view, and which are not. After having the clusters, we describe their state of ICT development and give a description about their environmental performance, the green practices and environmental management tools they apply. The logic of the analysis can be seen in Figure 1.

Figure 1.

Logic of the analysis



Source: own compilation

We selected 12 questions in accordance with the ICT maturity model (Pham, 2010), which we think reveals if the respondent company is developed in ICT or not. During the selection, we had to consider the variables and scales and standardize them, where necessary. It was also a problem that in case of many questions so many answers were missing that it distorted the results or made

it impossible to interpret. Consequently, we had to exclude them. Table 1 and 2 show the final questions used for the analysis.

Table 1.

Selected questions to assess ICT maturity (own edition)

Maturity dimensions (Pham, 2010)	Questions	Answer options
ICT Policy	Is there a written ICT strategy at your company?	Yes/No
Infrastructure	Do you use server virtualization in your company?	4-point scale, where 1: we use it 2: it is under implementation 3: we plan to implement within 2 years 4: we are not planning at all
	Do you use cloud in your company?	
	Do you use open source system(s) in your company?	
	Do you use mobile phones and/or tablets in your company?	
Applications	Do you use ERP system in your company?	4-point scale, where 1: we use it 2: it is under implementation 3: we plan to implement within 2 years 4: we are not planning at all
	Do you use Business Intelligence system in your company?	
	Do you use Expert system in your company?	
	Do you use workflow / groupware in your company?	
HR	The output of the company contains high level of innovation	5-point scale, where 1: the statement is not valid for the company at all 3: the statement is valid more or less 5: the statement is valid in every case
	To plan and design our products we use innovative IT tools.	
	To manufacture our products we use innovative IT tools.	

Source: own compilation

The *ICT policy* was measured by whether there is a written IT strategy at the company or not. *Infrastructure* was captured by innovative solutions like cloud and server virtualization, which means, that companies hire data storage equipment and space at server operators that have huge server parks with different performance characteristics and can offer customized portfolio, fitting to the actual needs. Application of open-source systems allows companies to have updates frequently and if they have their own ability, to customize the software on their own. It is even more common at companies which offer user-friendly mobile phone or tablet applications. The spread of these devices within a company might also indicate the development stage of ICT.

The most basic selected *ICT application* was the ERP system since the use of this is essential to have processes under control within a company and be able to analyze and give structured reports on them. ERP is also important because many other IT tools and solution are built on it and interconnected with it. Using workflow and groupware indicate that a company has well-defined administration, problem-solving routes, the tasks are allocated to workers clearly. On the way of digitalization, the most important thing is to start collecting data on core processes and to analyze them. Having rapidly growing databases at companies increased the need for alternative data storage systems, which can substitute and disencumber corporate data warehouses and servers. The data also have to be analyzed and used in decision making properly. Application of business intelligence and expert systems are developed solutions already. Business intelligence assures that the data for different business areas are analyzed and reported. Expert systems use algorithms, maybe artificial intelligence to interpret the information gathered from the data and help top management in making right decisions. The latter question mainly supports the technological background of developed ICT activity in a company.

The model considers *human resource* issues widely, including ICT literacy, ICT skills and innovation skills also. Product/service innovation is typically a task requiring creativity and human input, not suitable for automation. We consider innovation strongly connected to people and the use of IT tools represents the person-machine symbiosis, which can be a determinant of ICT maturity as well. Accordingly, we investigated the innovation content of the companies' products or services, whether they support the design and planning of products and services by IT and how much the manufacturing process of the products/services is supported by IT. We used the latter questions to run cluster analyses which will be introduced in Analysis chapter.

Environmental performance

As a second step, we selected environmental sustainability related questions from the HCRC and assumed that if the answers are positive, the green practice is present at the company, so we considered the answers as indicators. For example, if a company answered that they did dedicate resources to the reduction of water use in the production processes we assumed that they have some green initiatives implemented for this goal, which we counted as an environmental indicator used.

The description of the clusters from an environmental performance point of view is based on the multidimensional environmental performance model suggested by Schultze and Trommer (2012). The recent literature and other, non-academic sources almost exclusively use the greenhouse gas emissions and CO_2 emissions (Hilty et al., 2011; Wang et al., 2015; Konar & Cohen, 2001) to determine environmental performance. We chose the model described by Schultze and Trommer (2012) because in our opinion it is important to draw attention to the fact, that environmental performance of an organization

is determined by several factors, not exclusively by emissions. To capture the environmental performance indicators of the model, we selected 17 questions from the HCRC questionnaire, as it can be seen in Table 2.

Table 2.

The questions used in the HCRC survey according to multidimensional environmental performance model suggested by Schultze & Trommer (2012)

	Environmental performance indicators	Questions	Answer options
I. Operational indicators			
	I./A Input oriented indicators		
	Energy	Did the company dedicate resources to the reduction of energy use in production processes?	Yes/No
	Water	Did the company dedicate resources to the reduction of water use in production processes?	Yes/No
	Material use	Did the company dedicate resources to the reduction of material use of production?	Yes/No
	I./B Process indicators		
	Recycling	Did the company dedicate resources to the reuse of waste materials within the company operations?	Yes/No
	Reuse of materials	Did the company dedicate resources to the reuse of products?	Yes/No
	Elimination of hazardous materials	Did the company dedicate resources to the elimination of hazardous input materials?	Yes/No
	Packaging recycling	Did the company dedicate resources to the recycling of packaging?	Yes/No
	Reduction of packaging	Did the company dedicate resources to the reduction of packaging materials for product units?	Yes/No
	Environmental criteria for suppliers/ supplier evaluation	Does the company have written environmental criteria set for suppliers?	Yes/No
	I./C Output oriented indicators		
	Environmental performance measurement system	Is environmental performance measurement present by the company?	Yes/No
	Environmental accounting	Is environmental accounting system present by the company?	Yes/No
	I./D Outcome oriented indicators		
	Training of employees	Is an environmental training program in place for employees?	Yes/No
	Environment-related criteria in employee performance measurement	Is there environment-related criteria present in employer evaluation?	Yes/No
	Environmental auditing	Is there regular auditing of the environmental management practices?	Yes/No
II. Strategic indicators			
	Manager/ department responsible for environmental issues within the organizational	Is at least middle managerial level responsible for environmental issues within the organization?	Yes/No
	Environmental policy, goal setting	Does the organization have a written environmental policy?	Yes/No
	Sustainability reporting	Does the organization have a publicly available environmental or sustainability report?	Yes/No

Source: own compilation

Many questions of the original questionnaire refer to the resources dedicated to certain "green" activities (for example: Did the company dedicate resources to the reduction of energy use in production processes?) and these are yes/no questions. We are aware of the limitation that this type of questions holds: the final result of dedicating resources to a certain activity might not turn out as expected (in this case, a better environmental performance).

The *operational* block includes *input-oriented* indicators in form of energy- and water use, along with material use. This block also includes environmental sustainability indicators of service and production processes, which refer to the resources dedicated to recycling, reuse of materials, elimination of hazardous materials, reduction of packaging, or packaging recycling. We also considered environmental sustainability-based supplier evaluation as a *process* indicator. *Output* oriented indicators in this model include environmental performance measurement system used by the company and also environmental accounting.

Several questions were also selected from the HCRC survey for the *outcome*-oriented indicator group as well, which include regular auditing of environmental management system, training of employees in terms of environmental protection and environment-based employee evaluation practices.

Strategic indicators include if there is at least a middle managerial level is responsible for environmental issues within the organization, if the organization has written environmental policy and if it publishes environmental or sustainability reports. This is important, since in this framework, environmental performance refers to operational indicators and corporate behaviour in form of strategic indicators too thus gives a reliable and valid picture of a company's attitude towards environmental sustainability along 17 dimensions.

The 17 dimensions of environmental performance are used for identify the characteristics of clusters we produce along with the ICT development in Analysis chapter.

Analysis and results

In the following section, we introduce the analyses we have carried out. The accidental multicollinearity of the variables (see Table 3 and 4) allocated to Pham's model was tested by Pearson's correlation coefficient. In only two cases was *r* higher than 0.7 while all other correlations are acceptable (Sajtos & Mitev, 2007) so the variables are suitable for analysis. After we made sure that the selected questions are suitable for analysis, two cluster analyses were run. By using SPSS 25 statistics program, first, a hierarchical cluster analysis was carried out (between-groups linkage method) which produced two clusters, with a population of 43 and 124 companies. Hierarchical methods can be used easily and can provide reliable results on a large sample (Sajtos & Mitev, 2007). To test the results of the hierarchical cluster analysis, we ran a K-mean cluster analysis, too. We obtained two clusters again with a population of 66 and 103 companies, and the membership of the clusters almost overlap, 17 companies changed place between clusters. As ultimate results, we accepted the cluster memberships where the two methods gave the same result. This way, the first cluster contains 43, the second 101 companies.

The difference between Cluster 1 and 2 in ICT use is revealed in Table 3. In order to have reliable results, cross-table analysis was run to compare the results of the two clusters, and the difference was tested by Cramer's V on a 5% significance level. Differences of the clusters' results proved statistically significant. Based on these differences, we named Cluster 1 as Advanced in ICT and Cluster 2 as Lagging in ICT.

Table 3.
Results of clusters' ICT performance (own edition)

Maturity dimension	Questions	Cluster 1 Advanced ICT	Cluster 2 Lagging ICT	Sig.
ICT Policy	Written ICT strategy	70%	36%	.000
Infrastructure	Server virtualization	53%	11%	.000
	Cloud	27%	12%	.026
	Open source system(s)	58%	15%	.000
	Mobile phones and/or tablets	79%	33%	.000
Applications	ERP system	65%	17.5%	.000
	Business Intelligence system	93%	7%	.000
	Expert system	72%	0%	.000
	Workflow / groupware	65%	7%	.000

Note: % means that this % of companies in the given cluster uses a method or a tool

Source: own compilation

Regarding ICT policy, almost double of Cluster 1 companies have a written ICT strategy than Cluster 2 companies. Infrastructure dimension suggests that ICT capabilities are better in Cluster 1 firms since they can develop open-source software on their own. It also seems that firms trust servers more – even virtual ones– to store their data, than cloud solutions. The share of mobile phone/tablet applications are also more frequent in Advanced ICT cluster, which requires hardware and software engineering capabilities as well. The impressive difference can be seen between the two clusters in terms of the applications. Software that can support processes, help to make them more transparent and optimized are applied by Advanced ICT cluster extensively, while in Cluster 2 their share is very low. To complete the human resources dimension with the context of innovation we used ANOVA F-probe to compare the cluster means. Cluster 1 outshines

Cluster 2 in all aspects, as it can be seen in Table 4. Results suggest that innovativeness and IT support is more typical in Cluster 1 than in Cluster 2.

Table 4.

Compare of means with ANOVA to measure human resources dimension with the context of innovation

	Cluster 1. Advanced ICT	Cluster 2. Lagging ICT	Sig.
Innovative product, service	3.21	2.15	0.000
IT-aided product/service design and planning	3.26	2.12	0.000
IT support of manufacturing	3.28	2.28	0.000

Note: respondents assessed if they have the above technology on a 5-point Likert-scale, where 1 meant they do not use it, 5 meant they use it extensively

Source: own compilation

We also analyzed the general characteristics of the clusters and got significantly different data. Results say that advanced ICT firms mainly operate in the processing industry, most of them employ more than 100 people and according to the turnover data, third of them are large, almost two-third are middle-size companies. Most of the lagging ICT firms have less than 100 employees, the share of SME-s is more than 80 per cent. The firms in this cluster mainly operate in the processing industry and commerce.

The focus of our analysis was to show, how the two clusters differ in environmental performance. Results of the clusters were compared by SPSS 25 again, applying 5% significance level and reliability was tested by Phi and Cramer's V. Not all the results are statistically significant (11/17 are), but they provide possibilities for discussion (Table 5).

Table 5.

Results of clusters' environmental performance

Environmental performance indicators (Schultze and Trommer, 2012)	Cluster 1 Advanced ICT	Cluster 2 Lagging ICT	Sig.
I. Operational indicators			
I/A Input oriented indicators			
Energy	97%	82%	.044
Water	77%	56%	.052
Material use	85%	67%	.082
I/B Process indicators			
Recycling	75%	46%	.01
Reuse of materials	82%	31%	.000
Elimination of hazardous materials	86%	51%	.002
Packaging recycling	64%	39%	.055
Reduction of packaging	72%	45%	.015
Environmental criteria for suppliers/supplier evaluation	60%	34%	.004
I/C Output oriented indicators			
Environmental performance measurement system	50%	24%	.013
Environmental accounting	51%	20%	.000
I/D Outcome oriented indicators			
Training of employees	54%	30%	.009
Environment-related criteria in employee performance measurement	28%	22%	.445
Environmental auditing	56%	27%	.002
II. Strategic indicators			
Manager/department responsible for environmental issues within the organizational	70%	56%	.004
Environmental policy, goal setting	79%	30%	.000
Sustainability reporting	34%	19%	.067

Note: % means that this % of companies in the given cluster uses a method

Source: own compilation

Regarding input and process-oriented indicators, questions measured whether the companies spent on different projects to reduce their environmental footprint. Both clusters made some efforts: 97% of Cluster 1 and 82% of Cluster 2 companies reduced the energy consumption of manufacturing (service) process, which is a statistically significant difference (5% significance level) but shows efforts of both clusters towards economically advantageous green initiatives. Analyzing the output-oriented indicators (I/C), 50% of the Cluster 1 companies have environmental performance measurement system in place, while only 24% of those in Cluster 2. Cluster 1 and 2 companies show a significant difference in environmental accounting as well by 50% and 21% of the companies using this environmental management tool. Among the outcome-oriented indicators (I/D) two questions proved to be statistically significant: 54% of Cluster 1 companies offer environmental training to employees and 56% of Cluster 1 firms use environmental auditing. Finally, strategic indicators (II.) show that a large share (79%) of advanced IT cluster companies have written environmental policy while in Cluster 2 only 30% sets formal targets.

Discussion

In the paper, we analyzed the level of ICT use and the environmental performance of companies based on two theoretical models. Some previous scientific papers already connected ICT and environmental sustainability before (Ishida, 2015; Ollo-Lopez & Aramendía-Muneta, 2011; Yi & Thomas, 2007; Gimenez et al., 2015), but either they used a technology-oriented ICT approach (Becker et al., 2009; Weber & Kauffman, 2011; Gimenez et al., 2015) or interpreted sustainability only through output/process-based indicators (Ishida, 2015; Higón et al., 2017; Gimenez et al., 2015).

Our contribution is that we discuss both ICT maturity and environmental performance indicators from a broad perspective. In ICT literature, we found that papers interpret ICT development based mainly on the technological background (Weber & Kaufmann, 2011; Ishida, 2015), but the model we applied pointed out that ICT has an important role in organization and innovation-related aspects as well (Ollo-Lopez & Aramendía-Muneta, 2011; Pham, 2010). The choice of the multidimensional environmental performance model was even more important. In the literature, we found mainly process (material and energy consumption) (Yi & Thomas, 2007; Higón et al., 2017) and output (GHG and/or CO_2 emission) oriented indicators (Lee & Brahmasrene, 2014), although there are many other indicators – input, outcome and strategy – which are also important in connection with a company's environmental performance (Schultze & Trommer, 2012).

The cluster analysis based on the variables seen in Table 3 and 4 produced us two clusters being substantially different from the ICT development point of view (See Table 3 and 4). The clusters differ not only in the aspects we have used for cluster analysis, but in some other respects. We found evidence for the statement of Ollo-Lopez & Aramendía-Muneta (2011) about the positive effects of ICT on new product development, since advanced ICT companies were able to launch new products and services to the market three times more than lagging ICT firms. The experiences of Benitez-Amado et al. (2015) on the relationship between ICT and knowledge management was also proved, when we found that 53% of advanced ICT companies were able to renew the knowledge management system in the company, while only 14% in the lagging cluster did so.

Regarding the environmental performance differences of the clusters, we were not able to evince any controversial effect of ICT use on the environment as Yi and Thomas stated (2007), but we can say that advanced ICT helps companies to gather more data on the consumption of resources and it can be a basis of optimization. According to our study, there is a statistical connection between the level of ICT use and environmental performance and we have some promising results, as advanced ICT companies are ahead of the lagging group in many environmental practices as it is shown in Table 5. But this study was not able to prove if the statistical connection is a casual relationship, it requires further investigation. What we revealed is that advanced ICT companies use various methods to gather (ERP, BI), store (server virtualization and cloud) and process data (expert system, BI, workflow), and it results in a significantly better application of environmental accounting and environmental performance measurement system. This latter finding exceeds the ascertainment of Watts (2015) who proved the importance of ICT in CSR reporting.

By using the environmental performance model of Schultze & Trommer (2012), we could compare the clusters' environmental performance in detail, as it was presented in Table 5. We concluded that "conscious" environmental performance management could not be carried out without the transparent operations in the company, which can be assured by sophisticated ICT solutions. Input use (water, energy, material) can be controlled by the big amount of data being collected, stored, and processed in the IT systems. Our results say that the Cluster 1 companies using ICT on a more advanced level have significantly better environmental performance in 11 out of 17 dimensions. The results correspond with the results of Melville (2010) and Gimenez et al. (2015) who emphasize that ICT tools can enable organizational practices and processes that improve environmental and economic performance. We also found that it is worth to interpret environmental performance in a wider sense, and add input, outcome and strategic dimensions to process and output-oriented indicators (Schultze & Trommer, 2012; Butti et al., 2019; Gaviglio et al., 2017). Strategic indicators are quite important, environmental protection needs to be a strategic issue within a company (Benitez-Amado et al., 2015). We found that strategic viewpoint is quite strong in advanced ICT companies since a third of them produce sustainability reports. Advanced ICT companies performed better in all aspects, and the difference was outstanding (and significant) in case of almost all strategic indicators, as well as in the most frequently used output and process-oriented indicators. The ICT maturity of the companies can play a great role in supporting the environmental sustainability-related data collection and processing especially in case of operational indicators.

As a summary, we can conclude that our original assumption – the higher level of ICT development in a company results in increasing environmental performance – is supported by the results, and it is worthy of further research.

Conclusions

The topic of sustainability and digitalization are among the most important and most researched topics nowadays. We used an ICT maturity model (Pham, 2010) and an environmental performance model (Schultze & Trommer, 2012) and filled them with analyzable indicators from the HCRC study in each dimension. This way, we made a dual theoretical contribution: on one hand, we tested two models and on the other hand, we successfully connected the concept of environmental performance to ICT maturity.

With the cluster analysis we differentiated two groups of companies with significantly different ICT capabilities. We compared the environmental performance and the steps companies made towards improving environmental performance in case of the two clusters, and found significant differences, too.

The different behaviour of the representative variables of the environmental performance in the two clusters allows us to describe these behaviours in-depth and to point out the intuition of a possible relationship which is worthy of further analysis in the future. The

environmental performance of advanced ICT companies can be subject of further in-depth analyses, to discover the type of additional effects on companies' overall performance. Another research project can be about the motivating factors of furthering the connected use of the two concepts to increase more competitiveness.

Our research has limitations. The database we used was prepared for different purposes, we were only able to use secondary data of a questionnaire which was already polled. It was difficult to find questions suitable to measure the different dimensions. Since we have promising results, it would be a good further study to edit a questionnaire exclusively to discover the probable casual relationship of ICT, digitalization, environmental performance and sustainability. Another limitation is the size and geographical coverage of the sample. The original sample contained 300 companies, but due to exclusions, only 144 remained and have been classified into advanced ICT cluster (43 companies) and lagging ICT cluster (101 companies). These cluster sizes, since they are not even representative, limit the general validity of our conclusions. The sample was collected in Hungary, and probably we could have different results if we analyze a more developed country or a cross-country sample. The result helped us to reveal interesting new research ideas described above which we intend to work with in the future.

The results can be useful for professionals since it shows that in the case of the companies that are advanced in ICT it is worth to make analyses of environmental performance. These companies probably have all the data necessary to monitor and evaluate their environmental performance, and it might help to make their operations more transparent and consequently, effective. Transparency may support convincing investors, stakeholders and customers, not to speak about a good reputation and corporate brand.

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ANUP CHOWDHURY – NIKHIL CHANDRA SHIL

CONCEPTUALISING MANAGEMENT CONTROL SYSTEMS: ILLUSTRATIVE EVIDENCE FROM LITERATURE ON THE AUSTRALIAN BUSINESS SECTOR

A MENEDZSMENTKONTROLL-RENDSZEREK MEGKÖZELÍTÉSEI: PÉLDÁK AZ AUSZTRÁL ÜZLETI SZEKTOR IRODALMÁBÓL

This study is an attempt to conceptualise management control systems. Management control systems can be viewed as a broader concept which includes different components and used for varying purposes. In an organisation, control is applied at different levels and is directly related with employees of the organisation concerned. To comprehend the basics of management control systems the present study will explore the typography of the control mechanisms. Management control systems can be viewed as technical activity which is implemented in different ways in different countries. In the Australian business sector these control tools have been widely used. This study will review the experiences of implementing management control systems in the Australian business sector. Though the present study is based on Australian business sector it has policy implications to other countries and is expected to indicate potential usefulness to management control practices.

Keywords: **management control systems, business sector, Australia**

Ez a tanulmány kísérletet tesz a menedzsmentkontroll-rendszerek konceptualizálására. A menedzsmentkontroll-rendszerekre tágabb koncepcióként tekint, amely különböző összetevőket tartalmaz és különböző célokra használható. Egy szervezetben az ellenőrzést különböző szinteken alkalmazzák, és közvetlenül kapcsolódik az érintett szervezet alkalmazottaihoz. A menedzsmentkontroll-rendszerek alapjainak megértése érdekében jelen tanulmány a vezérlési mechanizmusok tipográfiáját vizsgálja. A menedzsmentkontroll-rendszerek technikai tevékenységnek tekinthetők, amelyeket különböző országokban különböző módon alkalmaznak. Az ausztrál üzleti szektorban ezeket az ellenőrzési eszközöket széles körben alkalmazzák. Ez a tanulmány áttekinti a menedzsmentkontroll-rendszerek bevezetésének tapasztalatait az ausztrál üzleti szektorban. Habár jelen tanulmány az ausztrál üzleti szektoron alapul, ennek vonatkozásai más országokra is érvényesek, és várhatóan jelzi a menedzsmentkontroll-gyakorlatok lehetséges hasznosságát.

Kulcsszavak: **menedzsmentkontroll-rendszerek, üzleti szektor, Ausztrália**

Funding/Finanszírozás:
The authors did not receive any grant or institutional support in relation with the preparation of the study.

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This article was received: 05.02. 2020, revised: 26. 09. 2020, accepted: 05. 10. 2020.
A cikk beérkezett: 2020. 02. 05-én, javítva: 2020. 09. 26-án, elfogadva: 2020. 10. 05-én.

Management control systems have been widely used in the business sector. It is a vast area and a substantial literature on the area exists. Hofstede (1981) argued that there are no universally accepted definitions of the words ‘‘management’’ and “control”, but he mentioned that the word “management control” is a pragmatic concern for results obtained through people. Emmanuel and Otley (1989) argued that control is concerned with a process and by this process a system adapts itself to its environment.

Management control systems can be viewed as broader concept which includes different components and used for varying purposes. Berry et al. (2009) reviewed the recent literature of emerging themes in management control based on published researches. They (2009) classified the themes into several groups: decision-making for strategic control, performance management for strategic control, control models for performance measurement and management, management control and new forms of organisation, control and risk, culture and information technology. Though a significant body of literature exists on management control research, Berry et al. (2009) claimed that management control research has been conducted from a narrow focus, usually on formal financial controls, with the omission of social control, clan control, culture and context. Otley et al. (1995) also expressed the opinion that management control has primarily been developed in an accounting-based framework which has been unnecessarily restrictive. Abernethy and Brownell (1997) argued that accounting information is limited to the exercise of control based simply on outputs and ignores its potential role as a form of behaviour control. On the other hand, Picard and Reis (2002) argued that most accounting research addresses management control issues, which focuses on controlling people rather than strategy formulation or tasks. Parker (1986) pointed out that accounting control have followed and lagged developments in the management literature and criticised accounting models of control for offering only imperfect reflections of management models of control. Therefore, organisations will need to design their control systems around a variety of non-accounting controls (Rockness & Shields, 1988; Foster & Gupta, 1994; Abernethy & Stoelwinder, 1995). Abernethy and Brownell (1997) argued that non-accounting controls, specially personnel forms of control, contribute to organisational effectiveness, particularly where task characteristics are not well suited to the use of accounting-based controls.

Therefore, management control systems are directly related with employees of the organisation concerned. Lewis et al. (2019) identified the tension between management control and employee empowerment. Lewis et al. (2019) explored that neither structural nor psychological empowerment is the only factor for behavioural response to management control. Lewis et al. (2019) concluded that socio-ideological control and systems of accountability is also important element for empowerment.

From the above discussion it seems that the key focus of management control research rests on financial control and little attention has been paid on the social or cultural components of control. However, management control continues to be a fertile field of research development (Berry et al., 2009) and develops regularly embracing new concepts in it. However, management control systems can be viewed as technical activity which is performed in innovative and customised ways in different countries under the common tenets. Due to the authors’ practical exposure with Australian business sector and motivated from the wide applicability of management control systems in Australian business sector, this study deploys an earnest effort to review the experiences of implementing management control systems in the Australian business sector. It is expected that the review makes significant contribution to practitioners and professionals of business sector from other regions in their management control thinking.

LITERATURE REVIEW

Studies on management control systems are abundant in literature but not saturated. This section presents few relevant literatures related to the context that will help the readers, particularly those who are new to this research area, to develop a conceptual understanding on management control systems and its application to wider business sector.

Control

The term ‘control’ is synthesised from various perspectives by different researchers based on their interactions with societal context. Emmanuel and Otley (1989) mentioned that a process is said to be controlled when it fulfils four basic conditions: Firstly, there must be the objectives of the process. Secondly, the output of the process must be measurable in accordance with the dimensions defined by the objectives. Thirdly, a predictive model of the process is required and finally, there must be a capability of taking action. They claimed that the absence of any of these pre-conditions the process can no longer be said in control.

Keeping away from mentioning some conditions, Anthony (1988) investigated it as a mechanism of implementing strategies. Anthony (1988) argued that control process consists of four steps. First, a standard of desired performance is specified. Second, there is a means of sensing, what is happening in the organisation and communicating to a control unit. Third, control unit compares this information with the standard. Fourth, if there is any deviation with the standard, control unit directs to take corrective action, and this is conveyed as information back to the entity which he termed as ‘feedback’.

Tricker and Boland (1982) also considered control as a feedback process and mentioned that outputs are monitored and compared with standards to determine whether objectives are being attained or not. If outputs are within standards the system is considered to be in control. If not, the manager must take action. They (1982) also pointed out the necessary actions which may be the change inputs, a change in organisational process or a revision of the

model. Merchant and Van der Stede (2007), on the other hand, argued that in the broadest sense, control systems can be viewed as having two basic functions: strategic control and management control. They viewed that strategic control has an external focus, and the managers think how an organisation, with its strengths, weakness, opportunities, and limitations can compete with the other firms in the same industry. On the other side the focus of management control issues is primarily internal, and the managers think about how they can influence employees' behaviour in desired ways. The next section discusses relevant literature on management control.

made by Merchant and Van der Stede (2007). One is strategic and the other is operational. Strategic issues are related to the general stance of the organisation towards its environment and by the term operational issues they meant the effective implementation of plans designed to achieve overall goals. They (1989) further mentioned that management control can be seen as the mediating activity between strategic planning and operational control. Emmanuel and Otley (1989) argued that management control is integrative because it involves the whole organisation. The various dimensions of management control as advocated by Emmanuel and Otley (1989) is summarised in Table 1 below to provide a comprehensive outlook on management control. They (1989) added that unlike strategic and operational control, management control is essentially routine affair, reporting on the performance of all aspects of an organisation's activity on a regular basis, so the areas are systematically reviewed.

Table 1

Dimensions of management control

Features	Strategic planning	Management control	Operational control
Focus	One aspect at a time	Whole organisation	Single task
Persons involved	Top management, staff specialists	Top management, line managers	First-line supervisors
Nature of information	Tailor-made	Integrated	Tailor- made
	External	Mainly internal	Internal
	Predictive	More historical	Real-time
Types of cost	Committed	Managed	Engineered
Time horizon	Years	Months	Days
Source academic discipline	Economics	Social psychology	Physical science and technology

Source: Emmanuel & Otley, (1985, p. 75).

Management Control

The control literature covers a wider area which is narrowed down in management control literature to give it a targeted focus on improving performance of businesses in some selective accounting and non-accounting areas. Tricker and Boland (1982) argued that management control in any organisation depends on a set of factors. These are: the organisation structure and management style, the internal situation of the enterprise and the environmental situation of the enterprise which incorporates sociological, political and economic factors.

To give it a specific focus, Macintosh (1994) called the management control systems as management accounting and control systems. Macintosh (1994) argued that management accounting systems are only and very important part of the entire spectrum of control mechanisms which is used to motivate, monitor, measure, and sanction the actions of the managers and the employees in the organisations. Anthony et al. (1972) mentioned that the purpose of the management control systems is *goal congruence* that it encourages mangers to take actions that are the best interests of the company. Anthony et al. (1972) further argued that it is a total system which embraces all aspects of the company's operation.

Emmanuel and Otley (1989) made it wider and viewed that management control is a process by which managers attempt to ensure that their organisation adapts successful actions to its changing environment. Emmanuel and Otley (1989) pointed out that management control is concerned with two issues which is very much similar to the proposal

Management Control Systems

The term 'management control systems' was first outlined in the seminal work of Robert Anthony (1965) where he defined it as 'the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organisation's objectives' (p. 17, quote from Ferreira & Otley, 2009, p. 264). In line with Anthony (1965), Lorange and Morton (1974) mentioned that the fundamental purpose of management control systems is to assist management to accomplish the goals of the organisations. According to Maciariello (1984) management control systems is concerned with the coordination, information processing, and resource allocation dimensions of the management process. Maciariello (1984) argued that the purpose of management control system is to assist management in the allocation of its human, physical and technological resources to attain the goals and the objectives of an organisation. Lorange and Morton (1974) provided a framework for management control systems which identifies the pertinent control variables, the good short-term plans, the short-term plan tracking process and diagnosis the deviations.

Anthony and Govindarajan (2004) also viewed management control systems as a process and mentioned that by this process managers influence other members of the organisation to implement the organisation's strategies. Anthony and Govindarajan (2004) mentioned that there are two views: one is management control systems must fit the firm's strategy. According to this view strategy is first developed through a formal and rational process, and then strategy dictates the design of the firm's management process. The alternative perspective states that strategies emerge through experimentation, which is influenced by the firm's management systems. So, this view explains management control systems can impact the development of strategies. Anthony and Govindarajan (2004) claimed that when firms operate in industry contexts where environmental changes are predictable, they can develop strategy first and then design management control systems to execute the strategy but in a rapidly changing environment, it is difficult for the firms to develop strategy first and then design management systems to execute the chosen strategy. Anthony and Govindarajan (2004) mentioned that in this context strategies emerge through experimentation that is significantly influenced by the firm's management control systems. They (2004) pointed out that management control involves a variety of activities and these are planning, coordinating, communicating, evaluating, deciding and influencing. They (2004) mentioned that the elements of management control systems include strategic planning; budgeting; resource allocation; performance measurement, evaluation and reward; responsibility centre allocation; and transfer pricing. They (2004) mentioned another important dimension of management control which is task control. According to them task control assures that specified tasks are carried out efficiently and effectively. They (2004) argued that task control does not even require the presence of human beings. Machine tools, computers and robots are mechanical task control devices. They pointed out that task control systems are scientific on the other hand management control systems are behavioural. They mentioned that management control in service industries is somewhat different from management control in manufacturing companies. Anthony and Govindarajan (2004) identified some factors that have an impact on most service industries are the absence of inventory buffer, difficulty in controlling quality, labour intensive and multi-unit organisation. In a changing environment different types of control mechanisms are used in different organisation to achieve the goals of the organisation. The next section discusses these different types of management control systems.

ANALYSIS AND DISCUSSION

This section explains various typographies of management control systems and tries to integrate the application of management control systems in Australian business sector as evident in different research findings. Organisations adopt different types of control mechanisms to cope with the problems of organisational complications. It has been observed that like other countries Australian business sector has also adopted various tools of management control systems.

Formal vs. Informal Management Control Systems: Maciariello and Kirby (1994)

One of the important typographies found in management control systems is formal and informal categories of management control systems as advocated by Maciariello and Kirby (1994). They mentioned that control systems come in many shapes and forms. They (1994) divided it into two systems: formal and informal. Each of these systems is further subdivided into its subsystems and each subsystem has different elements.

In a formal system formal documentation of the structures, policies and procedures assist members of the organisation in performing their duties. Maciariello and Kirby (1994) referred to this model as supportive management systems model. They subdivided formal control processes into its planning and reporting dimensions. Then they considered an integration of the two interrelated processes. They (1994) mentioned that formal planning processes are strategic planning and operational planning. Strategic planning is the formal framework within which an organisation decides upon its goals and objectives, key strategies, and capital allocations. Abernethy and Guthrie (1994) studied 49 business units in Australia to examine differences in the design parameters of management information systems in firms adopting different strategic priorities. The findings indicated that the effectiveness of business units is dependent on a match between the design of the information system and the firm's strategic posture which supports the proposition of Maciariello and Kirby (1994). On the other hand, operational planning system works for the coordination of organisational activities to achieve the nearest term objectives. Abernethy and Lillis (1995) studied the impact of manufacturing flexibility on management control system design of manufacturing firms in Melbourne, Australia. The findings of the study indicated that integrative liaison devices were a critical form of control in managing the implementation of flexible manufacturing strategies which is very important in operational planning.

In the formal reporting process detailed reports are prepared to assess progress against both the strategic plans and the operational plans of the organisations. Aberenthy and Guthrie (1994) claimed that it is desirable that a fair amount of integration is needed between these two processes. The subsystems of formal control processes are management style and culture, infrastructure, rewards, coordination and integration mechanisms and control process. Management style and Cultural subsystems consists of the elements of prevailing style that is external/internal or mixed, principal values such as norms and values. The elements of infrastructure of formal control systems are the organisation structure, patterns of autonomy and measurement method such as responsibility centres, transfer pricing. Rewards in

the formal control processes are individual rewards and group rewards, short term and long term, promotion policy. Formal coordinating mechanisms are standing committees on strategy or operations, formal conferences, and involvement techniques. Finally, the elements of formal control processes are strategic planning such as capital budgeting, operations planning such as cost accounting and budgeting, and reporting systems such as strategy/project management and operations/variance analysis. Some researchers have studied related issues in Australian business sector. Laing and Perrin (2018) surveyed 50 randomly selected printing firms in Australia. They (2018) studied the impact of management accounting methods deployed in the printing industry in Australia to allocate overhead. They (2018) observed that instead of activity-based costing main method used in this industry is absorption costing. The main reason not to use activity-based costing is that it is too complex, time consuming and costly as well. Comparing to absorption costing, activity-based costing provides less satisfaction to the users. In another case, Hoque (2014) conducted a mail-out survey on Australian manufacturing firms to identify the drivers of management control systems change. Hoque (2014) observed that a change in management accounting and control systems was significant and positively associated with greater organisational capacity to learn and in a more deeply competitive environment. Hoque (2014) further claimed that firm size and decentralisation were not extremely significant with changes in management accounting and control systems. All these studies support the presence of formal control processes in Australian business sector.

Maciariello and Kirby (1994) further argued that all organisations have informal dimensions. These dimensions are the interpersonal relationships that are not shown in the formal organisation chart. Like the formal control process, informal control process has the same sub systems. The elements of management style and cultural subsystem in the informal process are also same as formal control processes. In infrastructure subsystem, the elements are personal contacts, networks, and emergent roles. Informal rewards are usually more intrinsic in nature and these rewards contribute significantly to organisation success. The elements of informal rewards subsystems are recognition, status oriented intrinsic such as performance oriented and stature oriented and personal contact. The elements of coordination and integration subsystems are based upon trust, simple/direct/personal, telephone conversations and personal memos. Finally, the elements of informal control processes are search/alternative generation, uncertainty coping and rationalisation/ dialogue. In a study, Murthy and Guthrie (2012) observed work life balance initiatives by studying the organisational actions introduced by the managers in an Australian financial institution. They (2012) used narrative approach to analyse different internal and external documents and also collected self-accounts of employees. Findings of the study revealed that management used balance initiative to manage physical and emotional health of employees. They (2012) observed that main focus of the management was on community volunteering which satisfied employee expectation. It showed benefit for the organisation in terms of marketing and branding. Murthy and Guthrie (2012) concluded that this initiative was helpful to motivate employees to work towards organisational goals informally.

Action, Total, Ideological and Ecological Control: Czarniawska-Joerges (1988)

Czarniawska-Joerges (1988) argued that organisational control is a form of influence, steering or regulation exerted by managerial levels vis-à-vis non-managerial levels in organisations. She (1988) mentioned four types of control systems. Her (1988) first type of control system is action control which may take the form of supervision, technical norms, calculative rules or bureaucratic regulations. She (1988) mentioned that this type of control is appropriate for contract-based employment. Her second type of control is total control which can be brought about by controlling the totality of a person, by influencing physical and/or psychological integrity. She (1988) mentioned ideological control as third type of control which is oriented at the ideologies held by organisational members. In a study, Wang and Dyball (2018) studied the impact of management control systems on fairness and performance. They surveyed 232 Australian inter-organisational relationships. Their study revealed that social controls could improve procedural, distributive and interactional fairness. Czarniawska-Joerges (1988) mentioned ecological control as final type of control which is related in creation of good work conditions. Attracting new members in the organisation are the example of ecological control.

Result, Action and Cultural Control: Merchant and Van der Stede (2007)

Merchant (1982), Groot and Merchant (2000), Merchant and Van der Stede (2007) mentioned that for the control problems managers must implement one or more control mechanisms or devices that are referred to as management controls and the collection of control mechanisms are termed as a management control systems. Merchant and Van der Stede (2007) suggested three types of management control systems. These are: results control, action control and personnel / cultural control.

Merchant and Van der Stede (2007) mentioned that results control involves rewarding employees for good results or punishing them for poor results. Rewards may be monetary or non-monetary incentives. A well-known example of results control is pay for performance. They argued that results controls create meritocracies and in meritocracies rewards are given to most talented and hard-working employees rather than long tenured or socially connected employees. They (2007) observed that in many organisations this type of controls is widely used for controlling the behaviours of employees and it acts as empowering employees. The results controls are necessary for the implementation of decentralised forms

of organisation that has largely autonomous responsibility centres. According to them results control requires four steps:

a. defining performance dimension,
b. measuring performance,
c. setting performance targets, and
d. providing rewards or punishment.

The first step comprises defining performance dimension. The predetermined goal and the measurement made are very important to shape the employees' views. If the measurement dimension is not defined correctly the organisational objectives will not be achieved and the result controls will mislead the employees to do the wrong things.

The second step is the measuring performance. It is a critical element of results control systems. It involves the assignment of numbers to objects. Merchant and Van der Stede (2007) mentioned that many objective financial measures such as net income, earning per share, and return on assets are now widely used. They (2007) also mentioned some nonfinancial measures such as market share, growth (in units), customer satisfaction, and the timely accomplishment of certain tasks. There are also some measurements those involve subjective judgments. For example, managers can be evaluated whether they are "being a team player" or "developing employees effectively'. For higher level mangers most of the measures are defined in financial terms and the measures may be either market-based performance indicators such as (stock price or returns) or accounting profits or returns (such as return on equity). Lower-level managers can be evaluated in terms of operational data.

Another important element of results control system is setting performance target. This is the standard which the employees try to achieve. Merchant and Van der Stede (2007) argued that performance target affect behaviour in two basic ways. First, as the targets are established earlier, they stimulate action and improve motivation to achieve the desired target. Second, performance targets provide the employees to interpret their own performance.

The final element of results control is providing rewards or punishments. The rewards are the motivational factors for the employees. Rewards may be monetary or non-monetary incentives. It includes salary increases, bonuses, promotions, job security, job assignments, training opportunities, freedom, recognition, and power. On the contrary, punishments are the things which employees dislike. Punishments may be demotions, supervisor disapproval, and public embarrassment, failure to get rewards earned by peers or in extreme case loss of job. Some of the examples of rewards and punishments are provided in Table 2. Merchant and Van der Stede (2007) aptly concluded that a well-designed result control system can help to produce the desired results and it is a necessary element for employee empowerment.

Chenhall and Langfield-Smith (2003) examined the history of strategic change and the development of a performance evaluation and compensation scheme, a control tool based on gain sharing, in a manufacturing company in Sydney over a 15-year period. Data were collected through interviews. The researchers had access to a range of company documents and reports. The researchers also drew other company reports and documents including newsletters, correspondence between consultants, evaluation and assessments of head office, memos and reports, financial reports and trade union documents. The findings of the study illustrated that the researched organisation adopted team-based structures to enhance employee enthusiasm to work towards sustaining strategic change. Furthermore, the adoption of teams promoted personal trust and the sharing of values and goals. Perera et al. (1997) also studied management control systems in manufacturing firms in Sydney, Australia to investigate whether firms that maintained a customer-focused manufacturing strategy also maintained an emphasis on non-financial measures in their performance systems.

According to Merchant and Van der Stede (2007) second type of control system is actions controls which are the most direct form of management control. They pointed out that this type of control involves ensuring employees to perform or not to perform certain actions which are known to be beneficial or harmful to the organisation. This type of control are effectively useable only when managers know what actions are desirable or undesirable and the managers have the ability to make sure that the desirable actions occur or the undesirable actions do not occur. They (2007) mentioned four basic forms of action control:

a. behavioural constraints,
b. preaction reviews,
c. action accountability, and
d. redundancy.

Table 2.

Positive and negative rewards

Types of Rewords	Titles
Positive	Autonomy, Power, Opportunities to participate in important decision-making processes, Salary increases, Bonuses, Stock options, Restricted stock, Praise, Recognition, Promotions, Titles, Job assignments, Office assignments, Reserved parking places, Country club memberships, Job security, Vacation trips, Participation in executive development programmes, Time off
Negative	Interference in job from superior(s), Loss of job, Zero salary increases, Assignment to unimportant tasks, Chastisement (public or private), No promotion, Demotion, Public humiliation

Source: Merchant & Van der Stede (2007, p. 369)

Behavioural constraints can be considered as a negative form of action control. It prevents people from doing things that should not be done. The constraints can be applied physically or administratively. The examples of physical constraints are locks on desks, computer passwords and restricted entry to the valuable inventory area and sensitive information source. Some behavioural constraints devices are technically sophisticated and expensive, such as magnetic identification-card readers, voice-pattern detectors, and fingerprint or eyeball-pattern readers. Administrative constraints can also be used to place restrictions on an employee's abilities to perform all or a part of specific acts. It involves the restriction of decision-making authority. Separation of duties can also be treated as an administrative control. It involves dividing up the tasks necessary for the accomplishment of certain sensitive duties among the various employees.

Sundin and Brown (2017) conducted a qualitative case study on a large Australian listed property trust. They (2017) investigated agent's interests integrated with environmental objectives using management control systems. They (2017) observed both single and multiple objectives. In single objective, they identified relationships between environment and management control systems. In multiple objectives, they identified priorities among environment, economic trade-offs and management control systems.

Another important element of action control is pre-action review. Merchant and Van der Stede (2007) mentioned that pre-action reviews incorporate scrutiny of the action plans of the employees being controlled. Pre-action reviews appear in different forms, some of them are formal and others informal. Formal pre-action reviews are needed during organisational planning and budgeting process. An informal talk between a superior and a subordinate on the progress of a specific project is an example of informal pre-action review.

Action accountability means employees are accountable for the actions they take. Merchant and Van der Stede (2007) mentioned that the functioning of action accountability controls requires defining what actions are acceptable or unacceptable, communicating those definitions to employees, observing or otherwise tracking what happens, and finally, rewarding good actions or punishing actions that deviate from the acceptable. Actions for which employees are to be held accountable can be communicated either administratively or socially. Administrative modes of communication comprise the use of work rules, policies and procedures, contract provisions, and company codes of conduct.

In a study, Baird and Schoch (2013) observed the outsourcing practices adopted by Australian private sector organisations. They (2013) also compared the level of outsourcing between private and public sector organisations. Their research assessed the influence of management control systems on outsourcing success. Findings revealed that compared to public sector outsourcing private sector outsourcing is not successful. They (2013) concluded that outsourcing success depends on tightness of control. In a separate study, Langfield-Smith and Smith (2003) explored the design of management control systems and the role of trust in outsourcing relationships. They observed that since the early 1990s, there has been significant growth in outsourcing, in both public and private sector. It was applied not only to manufacturing activities but also to administrative and management functions. They (2003) conducted a case study, and an Australian energy company was their research site. Data were collected through semi structured interviews with the managers in the electricity firm who were involved in the decision to outsource the operation and in the ongoing management of the outsourced functions. The findings of their study revealed that the characteristics of the outsourcing transactions seemed to meet the requirements of a trust-based pattern of control rather than a market based or bureaucratic based pattern. They (2003) identified that control was achieved through the development of outcome control and social controls and through development of trust, particularly goodwill trust.

According to Merchant and Van der Stede (2007) redundancy means assigning more employees or machines to a task. In fact, it is the backup of employees or machines to perform the task satisfactorily. Redundancy is common in computer facilities, security functions, and other critical operations. However, it is infrequently used in other areas because it is expensive. Moreover, assigning more than one employee to the same task usually results in conflict, frustration, and/or boredom. Merchant and Van der Stede (2007) pointed out that action controls can also be used to identify whether they prevent or detect undesirable behaviours. Most action controls are aimed at preventing undesirable behaviours.

Merchant and Van der Stede (2007) classifies personnel and cultural control as the third form of control. According to them personnel controls build on employees' natural tendencies to control and or motivate themselves. They (2007) argued that personnel controls provide any of three fundamental purposes. First, some of them clarify expectations. They help to make sure that each employee understands organisation's expectations. Second, some of them help to make sure that each employee is capable to do a good job and they have all the qualities such as experience and intelligence and also the necessary resources are available such as information and time needed to do a good job. The third purpose of personnel control is some of them help to make sure that each employee will engage in self-monitoring. Self-monitoring is an inner force that pushes most employees to want to do a good job, and the employees are committed to achieve the organisation's goals. Petroulas et al. (2010) examined generational workplace preferences for management control systems. They (2010) undertook an exploratory study of three generations and their management control preferences in a large Australian Professional services firm. Results indicated that each generation presented different characteristics and these differences were linked to generational management control preferences specifically in goal setting, performance evaluation,

administrative controls and incentives. Merchant and Van der Stede (2007) identified three major methods of implementing personnel controls. These are: Selection and placement, Training and Job design and provision of necessary resources.

Selection and placement involve finding the right people, giving them a good working environment and at the same time providing them the necessary resources to do a specified job. It will certainly increase the probability that the job will be done correctly. In general, firms devote substantial time and effort to employee selection and placement, and a large literature describes how these tasks should be done properly. Merchant and Van der Stede (2003) mentioned that much of this literature describes an effective selection and placement depends on employee's education, experience, past success, personality and social skills.

Training is another method of personnel controls. It can be used to ensure that employees are well informed about the assigned tasks and they are also fully aware of the results and actions that are expected from them. It will give the employees a greater sense of professionalism and in this context, it can also have positive motivational effects. Many organisations use formal training programme such as in classroom settings, to improve the skills of their personnel and also much training programme takes place informally, such as through employee mentoring.

Job design the other type of personnel control encompasses designing jobs in such a way that the employees can do their tasks with a high degree of success. To show a better performance in the job, employees need a particular set of resources. These resources are highly job specific, which includes such items as information, equipment, supplies, staff support, decision aids or freedom from interruption.

Cultural controls of an organisation consist of a set of shared meanings, values, social norms and beliefs that are rooted in that organisation and which influence the actions of the members of that organisation. Merchant and Van der Stede (2007) mentioned that cultural controls can be used effectively where members of a group have emotional ties to one another. The cultural norms are organised in written and unwritten rules that shape employees' behaviours. Strong organisational cultures cause employees to work together in an energetic and well-coordinated fashion. Merchant and Van der Stede (2007) suggested five important methods of shaping culture, and thus effecting cultural controls, are: codes of conduct, group-based rewards, intra organisational transfers, physical and social arrangements and tone at the top.

Merchant and Van der Stede (2007) mentioned that codes of conduct are formal, written documents which provide general statements of corporate values and commitments to stakeholders and ways in which top management would like the organisation to function. Each of these codes or statements guides the employees to understand what behaviours are expected in the absence of clearly defined rules or principles. These statements may include about the quality and customer satisfaction, fair treatment of staff and suppliers, employee safety, innovation, risk taking, adherence to strict ethical principles, open communications, a minimum of bureaucracy, and willingness to change.

Group based reward is considered as an important form of cultural control. It is based on collective achievement and includes bonus, profit-sharing, or gain sharing plans. These rewards may be given on overall corporate or divisional performance, in terms of growth, or on the basis of profits or accounting returns. Intra organisational transfer is another choice to transmit culture. Merchant and Van der Stede (2007) argued that employees are transferred throughout the organisation to give them a better understanding about the organisation and at the same time to improve the socialisation of the employees. They further argued that employee rotation is also sometimes effective in reducing the occurrence of fraud because it prevents employees from becoming too familiar with certain entities, activities, colleagues, and/or transactions.

Physical and social arrangements can also shape organisational culture. Physical arrangements include office plans, architecture, and interior decor. Social arrangements may be dress codes and vocabulary. Merchant and Van der Stede (2007) mentioned that corporate managers can shape culture by setting the proper tone at the top. In a corporate culture, managers are regarded as role models. They cannot say one thing and do another. Their statement should be consistent with the type of culture they are trying to create and at the same time their behaviours should be consistent with their statements.

Beliefs, Boundary, Diagnostic and Interactive Control Systems: Simons (1995)

Simons (1995) defined management control systems as the formal, information-based routines and procedures managers use to maintain or alter patterns in organisational activities. Taylor et al. (2019) conducted a case study on an Australian technology start-up company over a twelve-month period. They (2019) showed to achieve innovation, management control systems can promote in generating ideas and 'buy-in' across all functional areas. However, Simons (1995) identified four basic levers of management control: beliefs, boundary, diagnostic and interactive control systems. A beliefs system is a formally communicated and systematically reinforced set of explicit organisational definitions. It includes basic values, purpose and direction of the organisation. A formal belief system is created and communicated through credos, mission statements, and statement of purpose. Simon's beliefs system is comparable with Merchant and Van der Stede's (2007) personnel control. Boundary systems delineate the acceptable domain of activity and establish limits, based on defined business risks, to opportunity seeking. Boundary systems correspond to Merchant and Van der Stede's (2007) action controls. Simon's third lever of control systems is diagnostic control systems. Simon

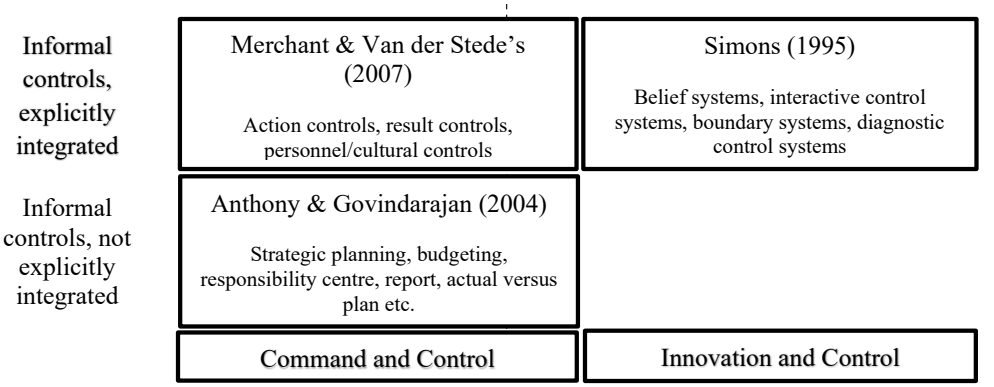
defined it as the backbone of traditional management control, and it is designed to ensure predictable goal achievement. It is formal information systems managers use to monitor organisational outcomes and correct deviations from present standards. These systems are similar to Marchent and Van der Stede's (2007) results control. Simon's last lever of control is interactive control systems which stimulate search and learning, allowing new strategies to emerge as participants throughout the organisation respond to perceived opportunities and threats and many systems can be used interactively. In a study, Alam and Nandan (2010) explored the nature of context specific issues and challenges facing small accounting practices in Australian regional and rural centres. They (2010) used a qualitative case study. Data were collected through semi-structured interviews with the managers and owners and from relevant archival documents. They (2010) observed that these firms faced a continuously changing environment which required innovative strategies and structures. Furthermore, they argued that there were significant differences between small accounting practices and specifically how they addressed their contextual uncertainties.

Su et al. (2017) surveyed 343 general managers of Australian manufacturing organisations. They (2017) tried to explore relationships of Simon's (1995) integrative and diagnostic management control systems on organisational life cycle. Their study revealed that both control mechanisms are significant at birth and growth stage than maturity and revival stage. In another study, Su et al. (2013) surveyed 1,000 General Managers in Australian manufacturing business units. Their objective was to observe the relationships between management control systems and organisational life cycle. Their study revealed that three types of control mechanisms input, behaviour and output have impact on life cycle. Su et al. (2013) showed that at birth and growth stage of an organisation, behaviour and input controls are very significant. However, birth, growth, maturity and revival stages both type of controls are significant.

Moores and Yuen (2001) conducted a study adopting a configurationally approach that captured the variables of strategy, structure, leadership and decision-making style and the relationships of these with management accounting systems from an organisational life-cycle perspective. The clothing and footwear industry in Australia were selected as the research sample. Data were collected by mail survey and field studies, with questionnaires sent to the chief executive officers of businesses targeting over 600 establishments. The researchers conducted interviews and collected documentary evidences in their field work. The findings of the study revealed that formality in management accounting systems changed to complement organisational characteristics across life-cycle stages. Baines and Langfield-Smith (2003) examined the relationship between the changing competitive environment and a range of organisational variables to management accounting change. The study was based on a postal survey. Questionnaire was sent to the general managers of 700 manufacturing organisations in Australia. The firms selected were independent business units in large firms or companies. The findings of the study indicated that in an increasingly competitive environment increased focus on differentiation strategies are needed. The study identified that these strategies influenced changes in organisational design, advanced manufacturing technology and advanced management accounting changes. Based on the analysis of different typographies of management control system, a synthesis of management control systems is presented in Figure 1. with reference to three representative works which is adapted from (Straub & Zecher, 2013).

Figure 1.

Comparison of the MCS concept



Source: adapted from Straub & Zecher (2013, p. 252)

CONCLUSION

The objective of the present study is to understand the basics of management control systems and review the research literature related to management control systems on Australian business sector. The research literature reveals that a variety of 'styles of use' are associated with the control systems. The study noted that in Australia numerous studies have explored issues

on management control in the business sector (see Appendix 1 for a summary). The illustrative literature identified that numerous studies have been undertaken to explore management control systems in different contexts. From the literature it has been identified that the key focus of management control research in Australia is on financial control and little attention is paid on people, culture, strategy and action or tasks. At the same time, it was also observed that many of them were conducted using quantitative research approaches such as surveys which allows findings to be generalised, but do not allow for an in depth understanding of how and why these control technologies exist. There is still a dearth of closely observed studies such as the case study approach describing the experiences of organisations using these control technologies. As Australia is pioneer in driving business growth through implementing various management control systems, this conceptual study can help the beginners to contextualise the issue and supports them in devising tailored management control systems for their particular organisations.

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Appendix 1.

Summary of management control systems literature in the business sector- Australian perspective

Authors (Date)	Research Topic	Findings
Taylor et al. (2019)	Case study on management control systems of an Australian technology start-up company.	They (2019) showed to achieve innovation, management control systems can promote in generating ideas and 'buy-in' across all functional areas.
Laing & Perrin (2018)	Impact of management accounting methods deployed in the printing industry in Australia	Observed that instead of activity based costing main method used in this industry is absorption costing. The main reason not to use activity based costing is that it is too complex, time consuming and costly as well. Comparing to absorption costing, activity based costing provides less satisfaction to the users.
Wang & Dyball (2018)	Studied the impact of management control systems on fairness and performance.	Their study revealed that social controls could improve procedural, distributive and interactional fairness.
Su et al. (2017)	Relationships of Simon's (1995) integrative and diagnostic management control systems on organisational life cycle.	Their study revealed that both control mechanisms are significant at birth and growth stage than maturity and revival stage.
Sundin & Brown (2017)	Agent's interests integrated with environmental objectives through the use of management control systems.	Observed both single and multiple objectives. In single objective they identified relationships between environment and management control systems. In multiple objectives, they identified priorities among environment, economic trade-offs and management control systems.
Hoque (2014)	Survey on Australian manufacturing firms to identify the drivers of management control systems change.	Observed that a change in management accounting and control systems was significant and positively associated with greater organisational capacity to learn and in a more deeply competitive environment. Hoque (2014) further claimed that firm size and decentralization were not extremely significant with changes in management accounting and control systems.
Baird & Schoch (2013)	Outsourcing practices adopted by Australian private sector organisations.	Findings revealed that compared to public sector outsourcing private sector outsourcing is not successful. They (2013) concluded that outsourcing success depends on tightness of control.
Su et al. (2013)	The relationships between management control systems and organisational life cycle.	Study revealed that three types of control mechanisms input, behaviour and output have impact on life cycle. Su et al. (2013) showed that at birth and growth stage of an organisation, behaviour and input controls are very significant.
Murthy & Guthrie (2012)	Work life balance initiatives and organisational actions introduced by the managers in an Australian financial institution.	Findings of the study revealed that management used balance initiative to manage physical and emotional health of employees. They (2012) observed that main focus of the management was on community volunteering which satisfied employee expectation. It showed benefit for the organisation in terms of marketing and branding.
Alam & Nandan (2010)	The nature of context specific issues and challenges facing small accounting practices	There were significant differences between small accounting practices and specifically how they addressed their contextual uncertainties.
Petroulas et al. (2010)	Generational workplace preferences for management control systems.	Results indicated that each generation presented different characteristics and these differences were linked to generational management control preferences specifically in goal setting, performance evaluation, administrative controls and incentives.

Baines & Langfield-Smith (2003)	Relationship between the changing competitive environment and a range of organisational variables to management accounting change	An increasingly competitive environment has resulted in an increased focus on differentiation strategies. These strategies has influenced changes in organisational design, advanced manufacturing technology and advanced management accounting changes.
Langford-Smith & Smith (2003)	Design of management control systems and the role of trust in outsourcing relationships.	The characteristics of the outsourcing transactions seemed to meet the requirements of a trust based pattern of control rather than a market-based or bureaucratic-based pattern.
Chenhall & Langfield-Smith (2003)	Strategic change and the development of performance evaluation and compensation scheme	Adopted team-based structures to enhance employee enthusiasm to work towards sustaining strategic change.
Moores & Yuen (2001)	Strategy, structure, leadership and decision-making style and their relationships with management accounting systems from an organisational life-cycle perspective	Management accounting system formally changed to complement organisational characteristics across life-cycle stages.
Perera et al. (1997)	Customer-focused manufacturing strategy and the use of operations based non-financial performance measures	Support is found for the hypothesized association between customer-focused strategy and the use of non-financial performance measures but not for the link to organisational performance.
Abernethy & Lillis (1995)	Impact of manufacturing flexibility on management control system design of manufacturing firms	Integrative liaison devices are a critical form of control in managing the implementation of flexible manufacturing strategies.
Aberenethy & Guthrie (1994)	Strategy and management information system design	The effectiveness of business units is dependent on a match between the design of the information system and the firm's strategic posture.

ENDRE MIHÁLY MOLNÁR - ERIKA JÁKI

WHAT QUALITIES DO GOVERNMENT-OWNED VENTURE CAPITAL INVESTORS SEEK IN A NEW VENTURE? – A COMPARISON OF INVESTMENT CRITERIA ACROSS PRE-SEED, SEED, AND EXPANSION STAGE STARTUPS

MILYEN TULAJDONSÁGOKAT KERESNEK AZ ÁLLAMI TULAJDONÚ KOCKÁZATI TŐKEBEFEKTETŐK EGY ÚJ VÁLLALKOZÁSBAN? – A BEFEKTETÉSI KRITÉRIUMOK ÖSSZEHASONLÍTÁSA INKUBÁCIÓS, MAGVETŐ ÉS NÖVEKEDÉSI SZAKASZÚ INDULÓ VÁLLALKOZÁSOK TEKINTETÉBEN

Private venture capital (VC) investors usually do not invest in early life-cycle stage startups such as seed and pre-seed companies, since investment size typically doesn't reach investment thresholds. The entry of governments with fund managers to venture capital markets presents seed and pre-seed companies with the opportunity to receive funding. This paper examines the main investment preferences of Hungarian government-owned venture capital investors regarding pre-seed, seed, and expansion stage startups. Verbal protocol analysis enabled examination of the screening process in real-time in all three life-cycle stages. It is found that governmental VC funds mostly value financial indicators followed by market-related qualities while private VCs value these characteristics in alternate formation. However, in the pre-seed stage, the financial acumen and capabilities of management teams form the main criteria in similarity to angel investors. Governmental VCs also greatly seek innovational value in target firms.

Keywords: **venture capital, governmental venture capital, seed investment, investment criteria, startup financing, business plan**

A magánpiaci kockázati tőkebefektetők jellemzően nem fektetnek be olyan korai fázisú induló vállalkozásokba, mint a magvető és inkubációs fázisú cégek, mivel a befektetési nagyság nem éri el a küszöbértéket. Az állam belépése a kockázati tőkepiacra a saját alapkezelőivel lehetőséget nyújtott magvető és inkubációs fázisú cégeknek a finanszírozású megszerzésére. Ez a cikk a magyar állami tulajdonú kockázatitőke-befektetők főbb befektetési preferenciáit elemzi az inkubáiós, magvető és növekedési fázisú induló vállalkozások tekintetében. A szerzők a verbal protocol elemzés segítségével képesek voltak valós időben adatokat gyűjteni a befektetések szűrési folyamatáról mindhárom fejlettségi életszakaszban. Azt találták, hogy az állami kockázati tőkés a pénzügyi és célpiaccal kapcsolatos tulajdonságokat értékeli a legtöbbre, pont fordítva a magánpiaci kockázati tőkésekhez képest. Az inkubációs szakaszban viszont a pénzügyi és menedzsmenttulajdonságok a legfontosabbak nekik, mint ahogy az üzleti angyaloknak is. Az állami kockázati tőkések továbbá nagy hangsúlyt fektetnek a céltársaságok innovációs értékére.

Kulcsszavak: **kockázati tőke, állami kockázati tőke, magvető befektetés, befektetési kritérium, startup finanszírozású, üzleti terv**

Funding/Finanszírozás:
The present publication is the outcome of the project „From Talent to Young Researcher project aimed at activities supporting the research career model in higher education", identifier EFOP-3.6.3-VEKOP-16-2017-00007 co-supported by the European Union, Hungary and the European Social Fund.

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This article was received: 26. 03. 2020, revised: 03. 08. 2020, accepted: 14. 09. 2020.
A cikk beérkezett: 2020. 03. 26-án, javítva: 2020. 08. 03-án, elfogadva: 2020. 09. 14-én.

Investment preferences of venture capital investors have drawn substantial attention from researchers (for example, Tyebjee & Bruno, 1984; Macmillan et al., 1987; Robinson, 1987; Khan, 1987; Sandberg & Hofer, 1987; Hall & Hofer, 1993; Zacharakis & Meyer, 1995; Muzyka et al., 1996; Zacharakis & Meyer, 1998; Shepherd, 1999; Mason & Stark, 2004; Zacharakis & Shepherd, 2005; Hsu et al., 2014). This interest was largely initiated by findings of Dorsey (1979), and Bruno and Tyebjee (1983), demonstrating that VCs are especially adept at choosing investments. Evolution of this research field followed a methodological path and dissection of the VC investment process with individual papers focusing on investment preferences in particular phases of the process. The literature in its current state tends to focus solely on the investment preferences of private VCs. This is not problematic in western economies where the majority of early-stage investments come from private actors. Currently however, such investments are primarily made by government-sponsored actors in the CEE (Central and Eastern Europe) region (Karsai, 2018; Jáki & Molnár, 2017; Daszyńska-Żygadło et al., 2016, Jáki & Molnár, 2021).

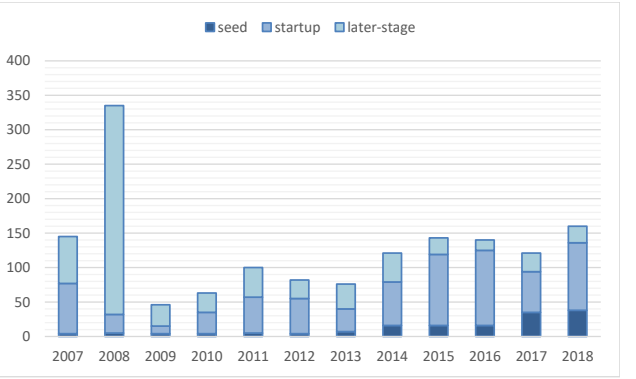
Governmental venture capitalists (GVCs) may have different preferences when choosing investments compared to private venture capitalists (PVCs). There are differences between actors concerning their investment approaches, including the target rate of return, motivation behind the investment, and ownership of managed funds. Currently, international literature lacks studies which investigate the investment preferences of GVC investors using reliable real-time methods and not just in regard to self-reporting by agents. Hence startup entrepreneurs in the CEE region typically need information on preferences of GVCs to become funded. This paper therefore aims to redress this balance.

In the CEE region, venture capital investment suffered setbacks following the 2008 financial crisis, but VC investments are currently increasing (see Figure 1). The structure of investment has also changed: the volume of seed investment increased from 4-5 million € annually between 2007-2012 period to 38 million € in 2018. The whole sector still has not re-attained the peak of 2008 in terms of investment volume but aided by EU venture capital programs, it is currently following a recovery trajectory.

Within the CEE region, Hungary presents a valuable setting to study this topic since venture capital investment volume was the highest in the region in 2018 (Invest Europe, 2019). Government policy in Hungary places significant emphasis on the development of the Hungarian startup ecosystem. This clear focus has been observed since the start of the Joint European Resources for Micro to Medium Enterprises (JEREMIE) program, which was a venture capital program financed by the European Union. Hungary participated in the program between 2009 and 2016, using obtained funds to stimulate the stagnant PVC market. PVC fund managers were selected to manage mostly state-provided sources in the framework of the program through hybrid funds and indirect involvement. In terms of investment volume the effort was successful as during the course of the program, venture capital investment increased dramatically in Hungary compared with previous years (see Figure 2).

Figure 1.

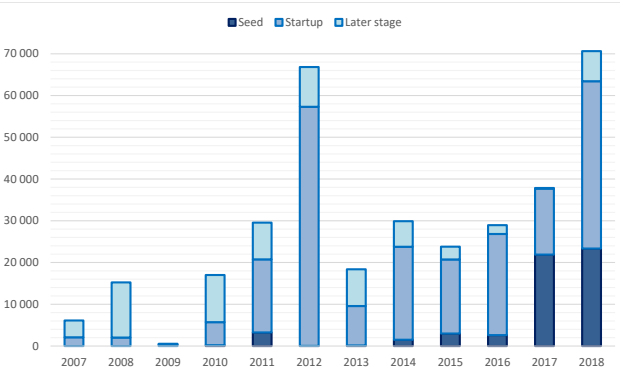
Venture capital investment volume in the CEE region between 2007 and 2018 in million EUR across different life-cycle stages



Source: Invest Europe (2019)

Figure 2.

Venture capital investment volume in Hungary between 2007 and 2018 in thousand EUR across different life-cycle stages



Source: Invest Europe (2017); Invest Europe (2019)

Other effects of the program are subject to debate in the literature (for example, Becsky-Nagy & Fazekas, 2015; Jáki et al., 2017; Karsai, 2018; Lovas & Illés, 2018; Berlinger, 2019; Kállay & Jáki, 2019).

One aim of the JEREMIE program was that of regional development with participating fund managers intending to invest in peripheral regions of Hungary. However in reality they tended to invest in companies headquartered in a peripheral region, but with actual operations taking place in the capital city. Additionally, almost all of the fund managers acquired majority shares in the target companies which can reduce the long-term motivation of founding members (Lovas & Illés, 2018). When analyzing data of firms receiving investment from JEREMIE funds, Fazekas and Becsky-Nagy (2019) found a negative relationship between firm growth and the equity share of VC in the firm. Furthermore, Fazekas (2018) found that

companies receiving funding directly from GVC funds performed better than those which received funding from JEREMIE sources thus indicating that private investor's motivation does not necessarily lead to improved company performance. In a later article (Fazekas & Becsky-Nagy, 2020), it is concluded that generally moral hazard may lead to poorer results of hybrid GVC-PVC investments compared to pure GVC investments.

Karsai (2017) suggested there is a range of best practices which governments of developed countries already learnt and acquired through the evolution of governmental VC programs, and that such best practices should be implemented in future domestic VC programs by CEE countries. Primarily, the duration of the program should be sufficiently short to influence the market as little as possible, bureaucratic requirements should be minimized, and data should be collected during the program to perform a final complete evaluation.

From 2016 the government continued to support development of the startup ecosystem by shifting focus away from hybrid funds and by directly investing state resources through state-owned fund managers as direct involvement. In initial stages of seeking startup financing (namely seed and pre-seed capital), companies can usually not depend on PVC financing, since investment sums are so small it is not economical for PVC providers to commit to funding. However, GVC fund managers tend to offer possibilities for very early-stage companies to receive initially small investments with the possibility of a follow-up round. Additionally, GVC investors can only acquire minority shares in target companies, which helps founders to be motivated in the longer term. In this regard, GVC can be regarded as complementary to PVC in Hungary. As can be observed in Figure 1, the overall investment volume started to increase again in 2017, and in 2018 reached its highest point in the decade which is in large part due to direct investment. Moreover, alternative sources of early-stage investments are also becoming more widespread, including investment from angel investors, incubators, accelerators, crowdfunding, or seed funds connected to corporations and universities (Karsai, 2019).

Startup companies face problems when applying for GVC financing in the earlier life-cycle stages such as pre-seed and seed investment. The literature tends to only deal with the preferences of traditional PVC investors which tend not to invest in early stage startup companies due to prominent market failures such as information asymmetries and transaction costs (Colombo et al., 2016; Lovas, 2015), hence there is a lack of VC investment preference research in such early phases. The question therefore arises as to how startup firms can predict investment preferences of VC investors in early-stage investments by studying literature on angel investment preferences. In general, this is not possible as the literature tends to indicate fundamental differences in the selection criteria of angel and VC investors due to different professional backgrounds, portfolio size, and approaches to dealing with risk (Hsu et al., 2014; Mason & Stark, 2004). This paper further aims to also solve this problem in order to assist startup companies in receiving a better understanding of qualities GVC investors seek in ventures in various life-cycle stages.

Literature Review of Investment Preferences studies

Investment preferences of venture capital investors have been examined by researchers from the early 1980s, originating in the USA by use of a variety of methods. With ongoing evolution in research methodology, the earliest papers mainly used questionnaire and interview instruments to find out more about how VCs select target companies.

Tyebjee and Bruno (1984) used structured interviews and questionnaires to identify five common factors behind VC investment decisions as follows: (1) Market Attractiveness, (2) Product Differentiation, (3) Managerial Capabilities, (4) Environmental Threat Resistance. This work laid the foundation for further studies by acting as a vanguard in discovering the main influential factors. Macmillan et al. (1987) aimed to validate results with a larger sample of VCs and found that the most important investment factor was in the consistent capabilities of management, as in "*irrespective of the horse (product), horse race (market), or odds (financial criteria) it is the jockey (entrepreneur) who fundamentally determines whether the venture capitalist will place a bet at all*" (Macmillan et al., 1987, p. 10). This observation is corroborated by Robinson (1987) who suggests that management teams need to be complete and must have acquired business skills through experience. Robinson (1987) also emphasizes the importance of the balance between technical skills needed for the production or provision of the service, entrepreneurial experience of key players, and requirements of the specific market. Khan (1987) used a decision-making model to estimate the impact of VC decisions on realized returns and found that creativity and resourcefulness of the entrepreneur in addition to the ability to enter new markets innovatively is the most significant determinant of realized profits on the investment. Dávid and Becsky-Nagy (2016) conducted a questionnaire to assess investment preferences of Hungarian VC providers who mostly indicated they prefer the capability of an investment to generate a return over any other given characteristic of an investment opportunity.

All the previously mentioned papers used questionnaires and interviews as the main data collection method. However, Sandberg and Hofer (1987) warned against the use of questionnaires in studies on VC investment preferences in that it was felt the decision-making process might be falsely simplified by such means. It was further suggested researchers use real-time methods, such as observation and verbal protocol as data gathering techniques to study this field. Subsequently, Zacharakis and Meyer (1998) indicated that methods such as questionnaires and interviews used in earlier works are most likely biased due to individuals being prone to

remember their experiences and preferences in a distorted manner through recall bias. Furthermore, respondents may try to justify their previous actions after the event in *post hoc* rationalization. Hence it may be extremely difficult for VC fund managers to become introspective about their own decision-making processes.

This gave rise to the use of verbal protocols as a real-time method based on observing VCs during the investment assessment process. Hall and Hofer (1993) conducted 16 verbal protocols with VCs by observing and recording how they evaluated startup investment proposals. They found that VCs tended to only read documents until they discovered a critical fault, thus resulting in immediate rejection. They also concluded that in the pre-screening phase VCs most valued the quality of the proposal and investor fit. In second-round funding assessments however VCs most valued startups recommendations from partners. Zacharakis and Meyer (1995) also used the verbal protocol analysis approach by involving two VC firms which had to partly evaluate their prior investment proposals, and partly evaluate those provided by researchers. It was found that VCs most valued innovative qualities of the startup's products or services. The study also concluded these must be introduced as early as possible in the business plan. Mason and Stark (2004) however not only studied VC investment preferences, but compared the investment preferences of business angels, bankers, and VCs using verbal protocol analysis. The study found that VCs mostly valued market growth potential, market demand, the presence of entry barriers, and the financial indicators of startups such as financial ratios, company value, and expected return on exit. However, quality of the management team was not found to be of much importance for VCs to thereby contradict the findings of the questionnaire-based studies of the 1980s. Analysis in this present paper builds on the preference comparison approach used by Mason and Stark (2004). There have also been other applications of verbal protocol analysis in the study of investment decision making processes in the early stage angel investor segment (for example, Smith et al., 2010; Harrison et al., 2015; Mason & Botelho, 2016).

Apart from verbal protocol analysis, a research method which became favored by VC investment decision researchers is that of conjoint analysis. This involves researchers posing a series of investment decision-pair choices to VCs which differ in terms of various pre-defined qualities, and tVCs are asked to select between them. Results are statistically analyzed to detect the main factors behind investment decisions. This method also provides a solution to the recall bias and post hoc rationalization problems, but gathered data tends to be less information-rich than data collected by verbal protocol analysis. Muzyka et al. (1996) conducted a conjoint analysis study using data collected from European VC managers who had to choose between 53 paired investment opportunities. They found leadership capabilities, experience, sales skills of the management team and sustainability of market share to be the most sought-after qualities by VCs. Shepherd (1999) also used conjoint analysis on data collected from Australian VC managers and found the industry experience and education of the management team and the strength of the competitors to be the most relevant factors. In their conjoint analysis study, Zacharakis and Shepherd (2005) found the same factors to be strong in addition to product differentiation and market growth potential. Finally, by use of conjoint analysis Hsu et al. (2014) found that angel investors place more emphasis on strategic readiness and affective passion than VC managers who prefer economic potential.

Research goals

This study examines the investment preferences of GVC investors in general and particularly in pre-seed, seed, and expansion stage investment phases using the real-time research method of verbal protocol analysis. It therefore provides a much-needed extension to the current literature on VC investment preferences by aiming to answer the following research question: *what qualities do GVC investors value in target companies in various life-cycle stages?*

It is intended to explore the qualities GVC investors will value overall and it is expected that GVC investors tend to mimic investment preferences of PVC investors. Based on the literature, this leads to an expectation for GVC investors to value market characteristics the most, followed by that of financial indicators (Zacharakis & Shepherd, 2005; Mason & Stark, 2004; Shepherd, 1999).

> *H1a: Overall, GVC investors value the market the most followed by financial indicators of target companies.*

Additionally, by using EU funds the Hungarian government launched the GINOP program as part of the 2014-2020 programming period with the explicit aim of developing the innovational capabilities of the economy (Palyazat.gov.hu, 2014). Many of the subprograms include investment into GVC funds, leading to an assumption that in overall terms GVC investors highly value the innovational quality of the product or service of a target company.

> *H1b: Overall GVC investors value the innovational value of the product highly within the product/service category.*

It is also expected to observe variations in the results of the three investment phases. In the pre-seed phase a suitable indicator of the GVC investor's preferences may be that of criteria used by angel investors, who tend to invest in the earliest life-cycle stages of startup companies. Angel investors are highly influenced by the personal qualities of entrepreneurs in their investment decisions because the problem of information asymmetries is very prevalent in the pre-seed phase (Hsu et al., 2014). It is expected that

management teams form the most important consideration in the early investment stages, given literature suggests that in these stages investors mainly base their decisions on the quality of management. This may be due to relatively little information available on the history of companies, thus it is generally hard to rely on financial data or projections (Hsu et al., 2014). Additionally, business plans formed in these stages are not necessarily very precise, since the product or service of the company is typically not finalized, leading to investors not placing strong emphasis on the quality of the business plan. Thus a hypothesis is formed that if the GVC faces similar problems in the pre-seed investment phase as angel investors, then it will follow a similar preference structure by placing the highest importance on management of the target company and less importance on the business plan and financial indicators.

H2a: In the pre-seed phase, the management of the target company is among the most valued characteristics by the GVC investor.
H2b.: In the pre-seed phase, the financial indicators of the company are among the least valued characteristics by the GVC investor.
H2c: In the pre-seed phase, the business plan of the company is among the least valued characteristics by the GVC investor.

Traditional VC investors tend not to invest in pre-seed companies due to the high transaction cost of investing and the lack of economies of scale in small investments. Thus they tend to prefer more developed startups which require larger investments. Thus in the seed and expansion stages, it is expected for GVC investors to invest according to the preference of PVC investors. There may however be a slight difference in that while PVC investors tend not to highly value the quality of business plans (Zacharakis & Shepherd, 2005; Mason & Stark, 2004; Shepherd, 1999), it is expected GVC investors may value them to a stronger degree. Furthermore, it is known that VCs connected to the government are subject to increased levels of bureaucracy (Karsai, 2017), an aspect which could be manifested in increased attention to the business plan structure as the basis for further record-keeping.

H3a: In the seed phase, the GVC investor values the market the most followed by the financial indicators of the target company.
H3b: In the seed phase, the GVC investor values the business plan of the target company among the top three characteristics.
H4a: In the expansion phase, the GVC investor values the market the most followed by the financial indicators of the target company.
H4b: In the expansion phase, the GVC investor values the business plan of the target company among the top three characteristics.

Differences between GVC and PVC investors in terms of industry focus, the goal of the investment, and regulation of the investment selection process may influence the final result. The implications of this study should help startups in assessing their readiness to approach GVC investors according to the current life-cycle stage of ventures and should also enable policy-makers to receive experience-based feedback on the realization of governmental investments.

Methodology

In this chapter, the sample base, data collection and analysis techniques are discussed.

Sample

The sample was collected in spring 2018 and consisted of three Hungarian GVC investment managers investing in pre-seed startups, three investing in seed startups, and three investing in expansion-stage startups, totaling nine GVC investment managers. They were identified with the help of an inside expert through expert sampling who was asked to suggest managers from each life-cycle specialization stage for the best representation in terms of demographic characteristics (Horváth & Mitev, 2015). A random sample would have been ideal for purposes of this study, however due to lack of information on the GVC sector it is generally not possible. Reputation-based sampling is widely regarded as the second-best option for generalizability. The investment managers were male, middle-aged and in possession of a business or finance master's degree. All were required to be proficient with business plans and company valuation. Based on interviews with other venture capital managers these demographic characteristics can be also generally observed at PVC firms, hence they are unlikely to be the source of different outcomes.

Pre-seed GVC investors tend to target startups with little information and provide a modest amount of investment. Seed GVC investors target startups that already started developing a prototype and gathering market feedback, thus generally providing higher investment levels. Expansion-stage GVC investors tend to target established startups, which have already completed prototype development and have sufficient market feedback to provide a substantial amount of investment. One aim of this study is to indicate how GVC investment preferences differ between the three types of GVC investors and across the different life-cycle stages.

Each verbal protocol interview took place over one hour during which two verbal protocol exercises were successfully completed. This resulted in 18 verbal protocol transcripts to work with. Very rich data is generated through this method but it is exceptionally time-consuming, thus the typical sample size for these studies is small. For comparison, Hall and Hofer (1993) conducted 16 verbal protocol interviews, Zacharakis and Meyer (1995) conducted 4 such interviews and Mason and Stark (2004) conducted 9 interviews with VCs. Additionally, Chiu and Shu (2010) found that the typical

sample size of verbal protocols for problem-solving studies is between 1 and 20 which also confirms that the sample size in this study is at the higher end for this type of methodology. Finally given that data captured in real-time from GVC investors is especially hard to obtain, the sample in this study contains important information on GVC investors.

Data collection procedure

Verbal protocol analysis consists of real-time observation during which researchers record the subject's thinking and decision-making processes. During the phase of observation and recording, investment managers read a business plan sent by startup entrepreneurs while articulating their critical thoughts and impressions. The procedure for conducting a verbal protocol is formed of the following stages outlined by Ericsson and Simon (1993):

1. Before the start of the experiment, it should be made clear to subjects that they must continuously articulate their thoughts explicitly during the experiment, including anything that comes to mind. If the subjects are silent for more than 30 seconds, the researcher must remind them to continue articulating their thoughts.
2. Before the start of the experiment, it is advised to conduct a test run by for example solving an easy mathematical problem. The researcher can ask the subject to perform a simple arithmetic addition task but to express every emerging thought clearly while performing the task. Hence the subject can receive some experience of the method before the start of the experiment.
3. Perform the verbal protocol experiment and audio record the narrative.
4. Transcribe the recordings to commence the analysis.

This authorship team strived to follow closely these principles. Special consideration was made in regard to business plans evaluated by the investment managers. Providing each participant with the same business plans poses various problems. For example, if an investment manager reads the business plan of a startup that doesn't fit his or her industry and life-cycle specialization, then the investment proposal will most probably be rejected outright. Another problem is that business plans provided by the researchers tend to decrease the practical validity of the research. However, if VCs are asked to read and evaluate business plans they themselves received, then these problems generally do not emerge, and the validity of the study is greatly enhanced (Zacharakis & Meyer, 1995). While being aware that giving the investors the same business plans would have increased the comparability of results, the benefits of evaluating actually received real business plans far outweigh the costs (Zacharakis & Meyer, 1995). Verbal protocol analysis is an adept tool for examining decision scenarios, provided that the following criteria are met as drawn from Ericsson and Simon (1993) and which took place in this study as outlined in Table 1.

Table 1.

The implementation of verbal protocol analysis criteria

Criteria	*Implementation in our research*
The information reported must be the focus of attention	Each interview was made in an undisturbed, silent, closed office room with only the interview subjects and researchers present.
Subjects are free from distraction	
The task is not highly routinized by habit	Real business plans from various industries were used.
There must be only a short time between performance and verbalization	Subjects continuously articulated their thoughts out loud during evaluation of the business plan and were reminded to continue articulating their thoughts after being silent for 30 seconds.
Verbalization does not require excessive encoding	The subjects articulated their own thoughts as they came to mind.
Reports are oral	Oral interviews were conducted personally
Instructions are clear	At the beginning of each interview, clear explanations were given on the method and the aim of the study.
Completeness in reporting is encouraged	Each business plan evaluation was completed

Source: own editing

Data analysis procedure

Firstly, the verbal protocol recordings were transcribed. In the transcribed text the so-called 'thought segments' were identified, which may be words, partial sentences, or complete sentences representing a coherent and distinct thought unit. To arrive at measurable results, each thought segment should be coded into a qualitative property or category, the importance of which was needed to measure investment decisions. Following rationale set out in previous studies (Hall & Hofer, 1993; Mason & Stark, 2004; Robinson, 1987; Zacharakis & Meyer, 1995, 1998), categories were drawn to answer the research question (see Table 2). The financial category mainly contains comments on the financial section of the business plan consisting of the planned revenue and cost structure, capital expenditures, and cash-flows. This financial plan is required in all three life-cycle stages. Additionally, it contains insights on the investment manager's view of exit possibilities in for example prospective buyers of a company and its possible value given that based on mental calculations company valuations are not required in such financial plans. Deductive coding was used meaning whereby the range of qualitative indicators used as categories can be increased with the discovery of thought segments which do not fit into predefined categories (Cho & Lee, 2014).

Table 2.

Qualitative properties used as categories

Management	previous entrepreneurial experience of the management team education level of the management team presence of core competencies
Product / Service	innovational value of the product or service readiness level of the product or service appearance of the product or service
Market	growth potential, scalability saturation of the market, entry barriers
Business plan	depth of the business plan level of professionalism of the business plan
Financials	financial plan (revenue and cost structure, capital expenditures, cash-flows) company value exit-opportunities
Positive externalities	job creation regional development sustainability positive social impact

Source: own editing

Each thought segment was successfully linked to one of the categories defined above. On this basis, frequency tables for results were created for each type of GVC investor (pre-seed, seed, and expansion) to identify differences between the most relevant qualities of a startup's business plan across the different life-cycle stages. The use of frequency tables is standard practice when conducting verbal protocol analysis and it is present in numerous studies examining investment preferences (for example, Hall & Hofer, 1993; Mason & Stark, 2004; Smith et al., 2010).

As with all other research methods, verbal protocol analysis has limitations. These include the possibility of frequency counts of thought units not completely representing the importance of the preference criteria because the participant may mention a particular point multiple times due to not being certain while he/she may only mention another point once when he/she is absolutely certain. Additionally, even though it is a real-time data-collection method tool the experiment-like nature of verbal protocol interviews might also distort the behavior of the subject (Mason & Stark, 2004).

Results

The frequency of qualities assessed by the GVCs in general and across the three types of investors is very revealing. Each GVC investor type (pre-seed, seed, and expansion) evaluated six different startup business plans and their thought segments were linked to six categories: financial indicators, market, product and service, management team, business plan, and positive externalities. In Table 3 frequencies of thought segments in each category in total and per life-cycle stage can be observed.

Table 3.

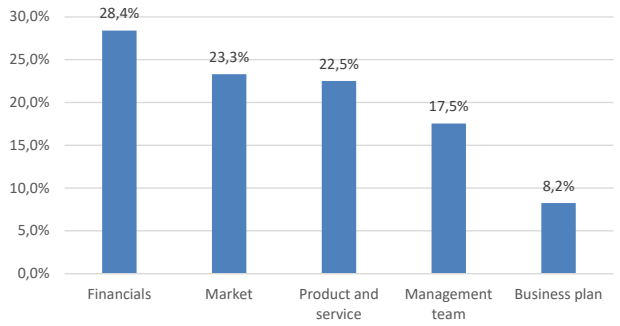
Frequency table of investment preferences based on verbal protocol analysis

Category	*Frequency (%) across the life-cycle stages*			
	Pre-seed	Seed	Expansion	**Total**
Financial indicators	25,4%	31,8%	27,5%	**28,4%**
Market	21,9%	25,8%	21,4%	**23,3%**
Product and service	21,9%	23,7%	21,4%	**22,5%**
Management team	23,7%	13,0%	15,4%	**17,5%**
Business plan	7,1%	5,7%	14,3%	**8,2%**

Source: own database

Figure 3.

Overall investment preference hierarchy based on verbal protocol analysis

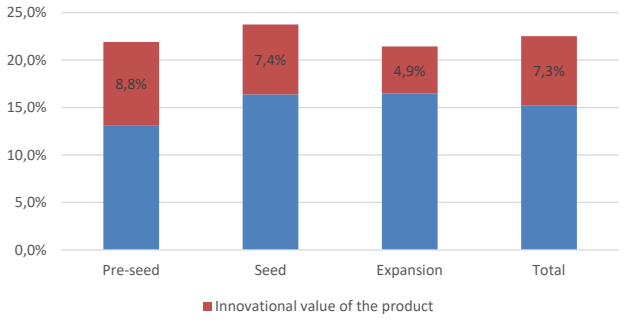


Source: own database

Overall examination of results reveals that GVC investors valued financial indicators of the company most highly (28,4%), followed by the market (23,3%). This is completely opposite to preferences of PVC investors, who generally mostly value the market followed by financial indicatorss (Zacharakis & Shepherd, 2005; Mason & Stark, 2004; Shepherd, 1999). This result does not support hypothesis H1a stating that GVC investors mostly overall value the market followed by the financial indicators of the target company. The reason behind this can be in very strict state oversight which GVCs operate under, thereby requiring them to closely follow financial guidelines when selecting target companies. The market and product/service are almost equally important in the evaluation process. The high ranking of the product/service category is interesting because there is evidence in the literature that VCs do not value this factor highly. For example, Mason and Stark (2004) found it to be one of the least valued characteristics. A possible reason behind this coalesces with hypothesis H1b: "*Overall GVC investors value the innovational value of the product highly within the product/service category*". It emerged that the contribution of observations on the innovational value of the product form a large portion of the total observations on the product, as seen in the Figure 4.

Figure 4.

Share of innovation-related observations within the product and service category based on verbal protocol analysis



Source: own database

It is also notable that the GVCs discuss the innovational value of the product relative to all product-related observations mostly in the pre-seed phase (40% share), and less in the later phases (seed: 31% share, expansion: 23% share). This may be due to less market validation information available about the company in the earliest phases which places more responsibility on the VC to determine if there are innovational properties in the product or not. Innovation is already market-tested in expansion stage companies, thus there is less need for analysis. Overall, this outcome supports hypothesis H1b. Combining the two findings that (1) the GVC places a large emphasis on the quality of the product/service and (2) within the product/service category, analysis of the innovational value makes up a large portion. It is therefore found that the GVC investor values the innovational value of the product most highly.

In terms of overall ranking, quality of the business plan (8,2%) attains the lowest level of importance. Thus, startup entrepreneurs seeking state investment should be aware that their companies should have very good financial prospects to receive funding. In the following sections, the results of the three investment phases are analyzed, where some variation may arise.

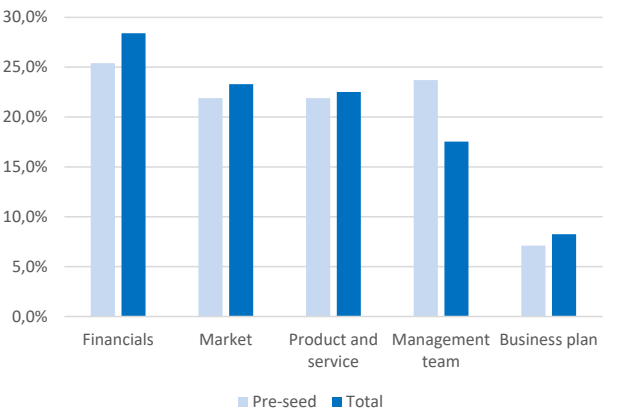
Pre-seed

To identify qualities sought by GVC investors in pre-seed ventures results of pre-seed GVC verbal protocols are examined. Surprisingly, the most discussed criterion of the pre-seed GVC investors was again found in financial characteristics of the company (25,4%), closely followed by the management team (23,7%). However, management was the most discussed factor by pre-seed GVC investors when compared with others (seed: 13%, expansion: 15,4%) (Figure 5.).

Hypothesis 2a proposes that in the pre-seed phase GVCs mostly value qualities of the management team, similarly to angel investors. This hypothesis is partly supported since the management team formed the highest valued characteristic compared to other investment phases, but it was not the most absolutely highest category valued in the pre-seed phase. The issue of planned equity shares of key players is also relevant in the life-cycle stage. The importance of the financial indicators suggests that GVCs place strong emphasis on profitability and return potential of a startup even in infancy stage. Within this category, GVCs gave special attention to the composition of the equity holders. The GVCs placed equal emphasis on the market and the product consideration (21,9% in both cases). These are still relatively high weights, and several business plans were criticized for lack of diligent market analysis, especially regarding the identification of competitors. In some cases, the gathering of market feedback was strongly appreciated. In terms of the product, GVCs seemed to focus most on the innovational value, as in "*we are looking for something that hasn't been done a million times before*". Innovativeness was also shown to be a key driver of entrepreneurial growth by Czyżewska et al. (2016).

Figure 5.

Pre-seed stage and overall investment preference hierarchy based on verbal protocol analysis



Source: own database

Evidence of pre-seed GVC investment managers operating according to an entirely different preference structure than PVC investors was also noted. Financial indicators of the company are seen as the most important quality in a startup application for funding followed closely by that of the management team. The importance of the management team in this phase resembles the investment preference of angel investors (Hsu et al., 2014; Mason & Stark, 2004). This is most likely because in the pre-seed phase where angel investors are also active, investors should base their decision on the perceived capabilities of the management, as in this very early phase there is little verifiable information available about a given project thus leading to informational asymmetry. This renders the importance GVCs place on the financial indicators of the company in the pre-seed phase as even more surprising, thus hypothesis H2b "*In the pre-seed phase, the financial indicators of the company are among the least valued characteristics by the GVC investor*" is not supported. Hence the prior explanation that GVC investors spend the resources of the state is strengthened in that their accountability is elevated and their investment decision

is supported by the estimated financial indicators of the business plans. This finding is common to all three life-cycle stages.

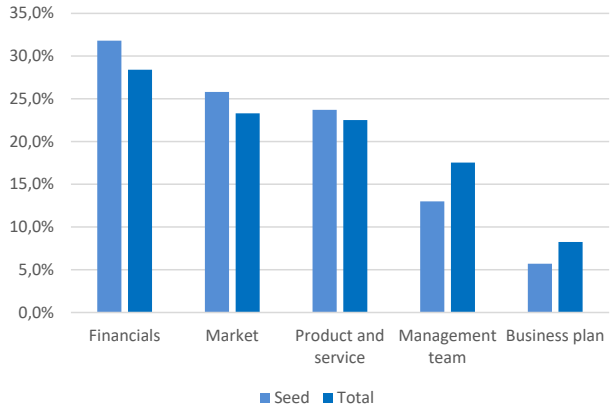
The qualities attached to the structure and flow of the business plan were under minimal scrutiny in the pre-seed category (7,1%), thus strong support for hypothesis h2c proposing that in the pre-seed phase the quality of the business plan is one of the least valued characteristics was evident. This is understandable since at this early stage, the length of the required plan tends to be much shorter than in later stages.

Seed

Qualities sought in seed ventures by GVC investors are examined in this section. The most scrutinized factor is once again clearly that of the financial indicators (31,8%). The financial plan, especially in terms of the price and cost structure is the subject of most criticism (Figure 6.).

Figure 6.

Seed stage and overall investment preference hierarchy based on verbal protocol analysis



Source: own database

Since financial criteria of the seed stage startup phase tend to be more valuable than in the pre-seed stage it is understandable that a detailed financial plan for the near future becomes a more significant criterion. However, it is still very hard to forecast because of a lack of substantial historical data. The other two main factors in the seed investments consisted of the market (25,8%) and the product (23,7%) with the management team (13%) and business plan (5,9%) forming the least important categories. It was very interesting to note the management team factor achieving such low importance in the seed stage. This resembles findings of prior verbal protocol studies (for example Hall & Hofer, 1993; Zacharakis & Meyer, 1995; Mason & Stark, 2004) on VC investment preference indicators given it is also suggested to be in stark contrast to previous post-hoc studies by Tyebjee and Bruno (1984), Macmillan et al., (1987), Robinson (1987) and Khan (1987). However, hypothesis 3a, proposing that GVC investors mostly value the market followed by financial indicators in the seed stage can not be supported. This hypothesis was formed by assuming GVCs follow the investment preference structure of PVCs in the seed and expansion stage but also place a higher emphasis on the business plan than PVC investors. In contrast, results in this study indicate that GVCs value financial indicators the most, followed by the market which further confirms high regard given to financial indicators by GVCs, suggesting the need to follow a strict financial evaluation process in selecting target companies, in order to comply with state regulations. Quality of the business plan was the least valued characteristic (5,9%), therefore hypothesis H3b proposing that the business plan is in the top three characteristics in the seed phase can not be supported. This essentially implies that GVCs are free to place more emphasis on the factors that are important in regard to the business and there is little need to scrutinize the business plan structure, which is also very consistent with the manners in which PVCs tend to value this characteristic. Hence it can be concluded that the state-controlled nature of GVCs materializes in their focus on the financial prospects of the business plan and not upon the structure and general quality of the business plan. This is another finding that startup entrepreneurs might bear in mind when applying for GVC financing.

Expansion

Figure 7.

Expansion stage and overall investment preference hierarchy based on verbal protocol analysis

Source: own database

Qualities GVC investors seek in expansion-stage ventures are examined forthwith. Results of expansion stage evaluations resemble those of the seed stage in the sense that the financial indicators of the company are deemed the most important (27,5%), followed by the market (21,4%). However in this case the product or service holds the same importance as the market (21,4%) (Figure 7.).

Similarly to previous results, this finding does not support hypothesis 4a, proposing that GVC investors mostly value the market followed by the financial indicators of the target company in the expansion stage. However, construction of the business plan (14,3%) has much higher importance in this phase compared to other phases which can be attributed to the business plans being the longest

at this life-cycle stage. Hence there is more opportunity to criticize their structure and flow, but hypothesis H4b is not supported since the business plan is not in the top three most valued characteristics. Thus, entrepreneurs applying for expansion stage GVC financing should devote more resources to competent construction of the business plan compared to the earlier stages. However they still can expect to receive relatively little criticism related to the quality of the business plan. The Table 4. contains results associated with the hypotheses.

tendencies of the market, the market share and pricing power of market participants, and the plan to capture a targeted share of the market. The business plan should follow a coherent structure and style and should be as concise, factual and straightforward as possible and preferably present data through graphical means. Use of 'buzzwords' should be avoided. Ideally, the plan should follow the structure laid out in the executive summary. Additionally, pre-seed startup plans should also contain references to support their major propositions.

Table 4.

Result table for hypotheses

	Hypothesis	Supported	Partly supported	Not supported
	Overall, GVC investors value the market the most followed by financial indicators of target companies.			X
H1b	Overall GVC investors value the innovational value of the product highly within the product/service category.	X		
H2a	In the pre-seed phase, the management of the target company is among the most valued characteristics by the GVC investor.		X	
H2b	In the pre-seed phase, the financial indicators of the company are among the least valued characteristics by the GVC investor.			X
H2c	In the pre-seed phase, the business plan of the company is among the least valued characteristics by the GVC investor.	X		
H3a	In the seed phase, the GVC investor values the market the most followed by the financial indicators of the target company.			X
H3b	In the seed phase, the GVC investor values the business plan of the target company among the top three characteristics.			X
H4a	In the expansion phase, the GVC investor values the market the most followed by the financial indicators of the target company.			X
H4b	In the expansion phase, the GVC investor values the business plan of the target company among the top three characteristics.			X

Source: own database

Demonstration of the main criticisms of investment managers on the product, market, management team, financial indicators, and business plan structure of startup companies and formulation of advice on how to better write a business plan is another significant contribution of this paper. Based on observations of investment managers, it is advised that introduction to the product or service should begin with identification of the main market based problem to be addressed for which the product or service proposes a solution. Entrepreneurs should also double-check to ensure their product does hold innovational value, or merely imitates that of competitors. Finally by entrepreneurs only revealing positive aspects of their products or services investment managers can be significantly deterred. Hence attention to the shortcomings of products or services is essential.

The business plan should indicate that there is market demand for the product or service of the startup company verified by market data and by user feedback. This aspect is generally required even in pre-seed business plans but is greatly emphasized in the seed and expansion stages. In the latter two stages, additional information is required for the market study which should be mostly based on publicly available data related to the size and

The management team should contain essential core competencies required for the success of a startup company. Furthermore, team members in possession of core competencies should be significant shareholders of the firm. The aim should be to avoid larger competitors luring away key employees to notionally guarantee that key players of a startup company will support the success of the business in the long run. For this reason, founders should carefully consider the distribution of equity between key management team members. Furthermore, startup management teams should show "*great passion and enthusiasm*" for their project and should be able to dedicate the majority of their time to it.

The most important financial requirement is that of 'scalability'. If a startup company is not scalable, then the VC is typically unable to make a subsequent profitable exit because growth of the business is limited. For this reason, it is generally much harder for companies with a physical product to convince the VC to invest, while technological startups tend to be favored for VC financing. However, even technological startups tend not to receive VC financing if for example advertising revenues are their sole form of planned income. In either regard, startup companies should carefully design the part of the financial plan relating to sales growth. This should

be based on publicly available data in order to convince VCs that startups are indeed capable of achieving targeted sales growth or capturing the targeted market share in the timeframe specified. Listing parties potentially interested in future acquisition of a startup can help indicate to VCs the potential exit possibilities, thus 'sweetening the deal'.

Conclusions

This article has examined differences in investment preferences across three distinct investment categories of Hungarian GVC investors in the pre-seed, seed, and expansion life-cycle stages by conducting three verbal protocol interviews in each resulting in 18 interviews in total. All investment managers evaluated two business plans from their portfolio consisting of the best and the worst. Each interview lasted for one hour and took place in undisturbed circumstances. Regarding selection of investment managers, a quota sampling method was used combined with reputation-based sampling to achieve maximum generalizability in each life-cycle stage. Through the use of verbal protocol analysis the actual investment screening procedure of the GVC in real-time could be captured. This eliminates recall bias associated with earlier post-hoc studies, which essentially based conclusions on VCs' potentially flawed recollection of their previous investment choices. Another issue related to such studies is that of post-hoc rationalization thereby causing individuals to produce reasons to justify their prior decisions. Although verbal protocol analysis has its own inherent limitations, most prominently in the relatively low number of verbal protocols that can be reasonably conducted, it is still widely used compared with conjoint analysis to examine VC investment decisions.

It was found that in overall terms GVCs mostly valued the financial indicators of the company. This was followed by the market and the product criteria in the seed and expansion stages. Generally in the literature, PVC investors value the market above financial indicators in direct contradiction to findings in this study. This is due to considerable state oversight placed on GVC investors required to follow statutory financial requirements when choosing investments. In the seed and expansion stages, the management team was not considered as an essential aspect of evaluations, but was more important than construction of the business plan. Management accorded a relatively low priority indicates resemblance to findings of previous real-time studies on PVC investment decisions (Hall & Hofer, 1993; Zacharakis & Meyer, 1995; Mason & Stark, 2004). In the pre-seed stage, the situation is starkly different in that the most important aspects of examined startup companies were still the financial indicators closely followed by that of the management team. High importance of the management team can be attributed to a lack of operational history. Investment managers should therefore base decisions more on the capabilities of management rather than the business idea or financial data when a business plan is relatively short. Ultimately in the early stage, the management should convince the VC that they can fully realize potential of the startup venture. Essentially in this stage, the GVC also adopts some characteristics of angel investors particularly a preference for a credible management team (Hsu et al., 2014; Mason & Stark, 2004), while maintaining the highest regard for financial indicators of the company, which is the most important quality that GVCs seek in every life-cycle stage. Quality of the business plan formed the least important quality in all three life-cycle stages, which is consistent with the value PVCs place on it (Hall & Hofer, 1993; Zacharakis & Meyer, 1995; Mason & Stark, 2004). It was also found that GVCs place great emphasis on the innovational value of the product or service of the target company which is greatest in the pre-seed phase. This is consistent with the aims of the governmental program that contributed funds for GVCs to invest in.

This article has presented information on the investment preferences of governmental venture capital investment managers in three different life-cycle stage specialization categories. Startup companies seeking funding will moreover be able to locate information on what to do and what to avoid in formation of the business plan. The main limitation of this study lies in focus on the Hungarian venture capital market. Other researchers should be encouraged to also use verbal protocol analysis to examine governmental venture capitalists in their country of origin. This would assist in identifying geographical and temporal characteristics in a still a relatively under-researched field. Additional possible research questions may include addressing evaluation of pitch presentations by GVC investors, and the type of support entrepreneurs may expect from GVC investment other than financial support on the basis of metrics which GVC investors use to evaluate success of their investments.

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