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► **To cite this version:**

Josef Basl. Penetration of Industry 4.0 Principles into ERP Vendors' Products and Services – A Central European Study. 11th International Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS), Oct 2017, Shanghai, China. pp.81-90, 10.1007/978-3-319-94845-4_8. hal-01888637

HAL Id: hal-01888637

<https://inria.hal.science/hal-01888637>

Submitted on 5 Oct 2018

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Penetration of Industry 4.0 Principles into ERP Vendors' Products and Services – A Central European Study

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Abstract. The paper deals with aspects of EIS (Enterprise Information Systems) innovation based on the development of the internet of things. The article presents the main results of a central European study dealing with the penetration of the Industry 4.0 principles into the offers of a representative sample of ERP (Enterprise Resource Planning) vendors. The results show the current strategies of ERP vendors, the integration of the new principles of Industry 4.0 into ERP applications and the position of ERP systems in the roadmap of Industry 4.0 implementation.

Keywords: ERP, ERP market, Internet of Things, IoT, Industry 4.0, 4th industrial revolution, ICT innovation

1 Introduction

Based on the growing number of conferences, seminars, workshop and articles, it seems that we are still in a growing wave of Industry 4.0. Some authors are often underlining a certain "revolutionary" character of these changes and therefore they speak about the 4th Industrial Revolution. On the other hand, it is possible to agree with those who perceive it as a further evolutionary step towards the digitizing of products and business processes based on IT as described by G. Moore in his book "Dealing with Darwin" [16]. Many publications are focused on Industry 4.0. One of them to be mentioned is "The Second Machine Age" [3]. This book describes how technology has influenced human society in recent times and deals with new business models and services that are

emerging or are emerging with new technologies. Last but not least, the concerns of human and robot collaboration are mentioned.

One of the main innovation features is related to the Internet of Things (IoT) and many national strategies of leading industrial countries are dedicated to this topic – a good example is “Made in China 2025” [15], “Industrial Internet” in the US [23], Germany [17] and Great Britain. They emphasise the national level, but there are many ways to deal with the readiness for Industry 4 in companies (www.industrie40-readiness.com, www.przemysl4.pl, www.firma4.cz).

There is no doubt that the new digitalization process is inconceivable without business software applications – ERP systems. These have played a significant role in the digitalization of companies since the 1990s. ERP systems reacted lately for example to innovations like the first internet wave, social networks, mobile devices, and even now companies believe that ERP systems are a crucial foundation stone of Industry 4.0 enterprise architecture [1].

Many analyses have been published about the readiness of companies to adopt new 4.0 principles. The perspective of the "demand" side of companies is mostly used. But the "offer" side of ERP vendors is not so often taken by researchers. This is one of the reasons why readiness of ERP vendors and their products and services were analysed in May/June 2017 in a very representative sample of a highly industrialized country in Central Europe – the Czech Republic. The following paper describes the main results of this survey.

2 Theoretical background – ERP systems and trends in IoT

2.1 ERP systems as a main long-term player in digitalization of manufacturing

Industry 4.0 is a very dynamic link between IT and manufacturing companies. It has great prospects, because these two categories are also the basic strategic technologies for the next 15 years [10]. However, many current IT trends in manufacturing companies do not have their origins today but they are being promoted over the longer term, perhaps in only a newer form with new data and in a more integrated and more user-friendly approach.

The digitalization of manufacturing had already started in the 1980s - more than 30 years ago. ERP systems have played a major role in the applied concepts and platforms since the beginning.

Table 1: Key role of ERP in digitization of manufacturing companies

	80's	90's	2000	2010	2015+
Main concept	CIM FMS	ERP CAD/CAM	ERP + CRM+ SCM PLM	ERP + MES + APS	ERP in Industry 4.0 concept Smart factory Digital Twins
Main technology driver	Relational database	Relational database	Internet Portal role of ERP (.com)	Mobile applications	IoT Apps
Main integration area	Product and production systems	Customer order	Horizontal chain from suppliers to clients Product Lifecycle	Vertical connection from all plans to realization of production and logistics flow	Sensors Machine-machine communication Man-machine communication
Main data role	Product and production system data integration	Customer data integration	BI (Business Intelligence) Analytics of internal data	CI (Competitive Intelligence) Analytics of external data	AI (Artificial Intelligence) Big Data Analytics

Table 1 presents all the main concepts, technology drivers and integration areas of IT penetration in manufacturing over the last 35 years. It is unfortunately not possible to describe all these aspects and relations in proper detail in this paper.

The most important feature is that the ERP systems followed the implementation stages of CIM (Computer Integrated Manufacturing) [21] and FMS (Flexible Manufacturing Systems) [25] concepts. All these concepts were based on relational databases. The digital factory and digital enterprise information systems based on ERP systems represent the next steps, followed by integration with CRM and SCM, MES and APS and BI finally in the following decades. The last step is an ERP system in Industry 4.0 aimed at smart factories [24] and digital twins.

2.2 IoT as one of the key trends in ERP development

Many significant consultancy companies such as Gartner Group [9], BCG [2] or Deloitte [6] present their typologies of what the current trend towards Industry 4.0 should include. Mostly the following trends are mentioned:

- cloud
- big data
- internet of things
- extended reality
- simulation, digitization
- digital twinning, various autonomous solutions, human and robot collaboration
- a wide range of sensors and their evaluation leading to artificial intelligence

The cloud solution and big data are now already relatively widely used and exploited and they are something like a key enabler of current changes. But the real symbol of the new trends is the internet of thing (IoT). The increasing availability of Internet connectivity, declining Internet connection costs, and a growing number of devices that include Wi-Fi technology and other sensors are perfect for creating IoT.

The integration of ERP and IoT is important globally too. For example the world ERP leaders like SAP, Microsoft and Oracle are today also in the top ten of IoT leaders. (Microsoft in 3rd position, SAP in 8th position and Oracle in 10th position (IoT report, 2015)

It is clear that the concept of Industry 4.0 is based on industrial integration mediated by information technology. This integration involves real-time or near-real-time data sharing, information sharing, and continuous communication. This is also a potential for the further development of ERP.

3 Methodology – formulation of aim and research questions

This paper deals with a survey of the penetration of Industry 4.0 principles into ERP companies, their products and services. The important questions concern the role of selected IT trends and enterprise information system software applications within Industry 4.0 now and in the near future (the next 2 and 5 years). An important question is also the preparation of ERP companies for this new trend in their strategies.

The motivation for this survey was not only the current technological trends but the published manufacturing study oriented towards Industry 4.0 penetration at the global level (Infosys, 2015) and on the national level in Germany [7] and Perspective [18]. These surveys were the motivation for our own survey in the Czech Republic of certain companies [1]. The results of this survey from last year confirmed the key role of ERP systems (65.2%) in the integration of plans of companies during the preparation for Industry 4.0. The next most important package was MES applications (43.5%).

Another reason for the survey described in this paper is to obtain a more detailed view of current ICT trends that are somehow connected with ICT, such as mobile devices, clouds and big data on the one hand, and ERP, MES, APS and BI applications on the

other. Last but not least, trends like robots, smart logistics and flexible production planning are also analysed.

The main research questions in this survey are:

- 1) Have ERP vendors already integrated the new principles of Industry 4.0 in their products?
- 2) Do ERP systems still play a major role in enterprise architecture which should be implemented in Industry 4.0 strategy?
- 3) Are the main Industry 4.0 trends already integrated in current ERP vendor products and services or are they planned in the following 2 or 5 years?
- 4) Do ERP vendors already have their own Industry 4.0 strategy?

4 Sample description and data collection

The subtitle of the article is “a central European study” because the survey was carried out in the Czech Republic. This country provides a good example of ERP trends. It has the highest proportion of industrial production in the economy as a whole from the European Union, namely 47.3%. This is more than the most industrialized EU countries such as Germany (40.2% with EU share 27%), the United Kingdom (41.7% with the EU share 12.7%) or Italy (37.9% with EU share 12.1%). The penetration of ERP in the Czech Republic is also very high, reaching 21.4% for small companies, 57.8% for medium sized companies and 81.8% for large companies [5].

A complete list of all ERP systems and their vendors is available at the portal systemonline.cz. There are 88 ERP products from 75 ERP vendors. All these vendors were addressed by the survey. A special questionnaire form was created with the formulated research questions and it was made available for ERP companies on a website. Data collection was carried out from the online survey in May/June 2017.

Fifteen ERP companies answered the survey, meaning that the survey had a 22.7% response rate. It is important that the sample of companies reflects the profile of the whole Czech economy. In addition, the main market share belongs to SAP and Microsoft applications and these two companies also responded to the survey. It means that even though the response rate was not so high, the results gained from the survey are representative. Furthermore, some other reactions were gained from the survey. There were also answers from companies who only sent an email informing us that they were not able to complete it because they were not yet considering Industry 4.0 principles. They also admitted that receiving the survey form was an inspiration for them. There were five such companies.

5 Research results

Generally, the majority of companies that participated in the survey declared that they have dealt with Industry 4.0 for either more than three years (60%) or more than one

year (20%). There were no companies delivering ERP products on the Czech market that said “that they know this new trend but they do not want to implement it” or declared “that they have not met the Industry 4.0 so far”.

5.1 Integration of 4.0 principles in enterprise applications

The results for the first research question “Have ERP vendors already integrated new principles of Industry 4.0 in their products” confirm the key role of ERP systems in integration plans of ERP vendors during their preparation for Industry 4.0.

Table 2: Integration of 4.0 principles in enterprise applications

Integration of 4.0 principles in enterprise applications	Already integrated	Integration in plan	No plan to integrate
ERP (Enterprise Resource Planning)	80%	13%	7%
MES (Manufacturing Execution System)	53%	27%	20%
APS (Advanced Planning and Scheduling)	53%	27%	20%
WMS (Warehouse Management System)	53%	27%	20%
PLM (Product Lifecycle Management)	47%	20%	33%
CRM (Customer Relationship Management)	53%	27%	20%
BI (Business Intelligence)	40%	20%	40%
BPM/BPMS (Business Process Management Suites)	33%	20%	47%
Apps	20%	27%	53%

80 percent of ERP systems declare that the principles of 4.0 are integrated. The following most integrated are MES and APS applications. CRM with PLM applications are also applications with a high integration rate. In terms of smaller or not planned integration, APPS, but also BMP and BI are positioned on the opposite side of the application spectrum with a very low level even in the future.

5.2 Key role of ERP in implementation of Industry 4.0 strategy

The second research question “Do ERP systems still play a major role in enterprise architecture which should be implemented in “Industry 4.0” strategy” was oriented towards the sequence of implementation of main enterprise software applications.

The results show possible sequences that are very diverse (see the examples below). Anyhow, the answers to proper “implementation order” can be divided into the following three types:

The first type of implementation order uses ERP systems as the first step of gradual Industry 4.0 implementation followed by MES application:

ERP then MES then APS then WMS

ERP+MES+WMS+PLM (together) then APS then CRM

In the second type ERP systems are associated with CRM, when CRM was also nominated as the first application:

ERP+CRM then APS then WMS+MES+BI+PLM

CRM then ERP then WMS then BI

The third type applied MES in the first position and ERP was one of the last steps:

MES then APS then PLM then WMS then CRM then ERP then BI

The survey confirms the key role of ERP as the first and the most important foundation stone of Industry 4.0 architecture. ERP was mostly in first place.

5.3 Industry 4.0 trends applied in the ERP offer

The third research question was: Are the main Industry 4.0 trends already integrated in the current ERP vendor products and services or are they planned in the following 2 or 5 years?

The results show that all the selected topics are already being applied today. Cloud computing and mobile devices are in first position, big data is in second and the industrial internet of things is in third position.

Table3: Industry 4.0 trends applied in ERP offer

Industry 4.0 trends applied in enterprise applications	Used now	Planned to be used in following 2 years	Planned to be used in following 5 years	No plan for usage
Mobile devices	73%	0%	20%	7%
Cloud computing	73%	0%	0%	27%
Big data	60%	7%	20%	13%
Industrial Internet of Thing)	47%	13%	33%	7%

Digital Production	40%	0%	20%	40%
Additive Manufacturing	40%	0%	13%	57%
Cyber Security of Data	33%	0%	33%	33%
Wearables (glasses, watches,..)	27%	7%	27%	53%
BYOD concept (bring your own device)	20%	13%	20%	47%
Voice Control	27%	20%	20%	33%

Trends such as Digital production, Additive manufacturing (known also as 3D printing) and Cyber Security have less positive answers for using today but they have higher potential for the future.

The second group of answers could be called “further industry 4.0 trends”. This second group shows the lower level applied trends today and at the same time the very high level of answers that they will not be in plan even in the future. Trends like augmented reality, digital modelling and new sensors and their relations to the ERP could be an idea for a separate survey.

Table4: Further Industry 4.0 trends applied in ERP offer

Further Industry 4.0 trends	Used now	Planned to be used in following 2 years	Planned to be used in following 5 years	No plan for usage
Machine Learning	20%	7%	33%	40%
Artificial intelligence	13%	7%	53%	27%
Augmented Reality	13%	7%	33%	47%
Digital Modelling	13%	7%	27%	53%
Energy Harvesting	13%	13%	13%	60%
Autonomous Robots	13%	7%	33%	47%
Virtual Assistants	7%	7%	47%	40%
Human-robot interaction	7%	7%	33%	53%
New sensors, incl. biosensors	7%	13%	33%	47%
Quantum Computing	0%	20%	33%	47%
Brain Interfaces	0%	7%	33%	60%

5.4 Existence of Industry 4.0 strategy

The fourth research question was: Do ERP vendors already have their own Industry 4.0 strategy?

A high percentage of ERP vendors (60%) have already a strategy for Industry 4.0 and some vendors still do not have a strategy but they are working on preparing it (13%). And finally still 27% of ERP vendors do not have a strategy for Industry 4.0. The results show that more ERP vendors have own Industry 4.0 strategy than companies using their products. The similar survey from the last year (Basl, 2016) showed that a high percentage of Czech enterprises (39.1%) did not have a strategy for Industry 4.0. Nearly the same percentage of enterprises was preparing such strategy (30.4%). And finally, nearly 25%, it means each fourth company, already had a strategy for Industry 4.0.

Table 5: Industry 4.0 trends applied in enterprise applications

Strategy for Industry 4.0	Ratio
We do not have a strategy for Industry 4.0	27 %
We do not have a strategy for Industry 4.0 now but we are preparing it	13 %
We have a strategy for Industry 4.0 and it is a part of business strategy	60 %
We have a strategy for Industry 4.0 but it is not a part of business strategy	0 %

It is very similar to the answers from firms in the global survey (Infosys, 2015). The reason for this could be that companies have to intensively care about the Industry 4.0.

6 Conclusion

Industry 4.0 seems to be a topic with high potential, especially at a time when the digitalization of production is growing. The survey results indicate many similarities between Industry 4.0 penetration in ERP systems in the Czech Republic and leading developed countries.

The survey identified a big potential for further analyses and surveys of the obstacles why Industry 4.0 is not applied more widely. The main reason for ERP companies is high costs connected with Industry 4.0 implementations (53%) and then little awareness of the issues of Industry 4.0 (47%). The low rate of usage of Industry 4.0 in companies (27%) and not so clear business effects (7%) were also mentioned as the obstacles.

The survey results also show that companies perceive the level of penetration to be higher than the level in companies that expressed the need for the existence of the proper methodologies and road maps for Industry 4.0 implementation so far. These aspects are again possible areas for research in the future.

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