

# Selection of the ERP System with Regard to the Global 4th Industrial Revolution

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## Abstract.

**Research background:** So-called Fourth industrial revolution, triggered by the massive development of information and communication technologies and leading to the new era of manufacturing and logistics known as Industry 4.0, is definitely an important topic across the global economy. Besides their other effects, technologies of the Industry 4.0 have a significant impact on the IT landscape of organizations, including the central part of this landscape – Enterprise Resource Planning (ERP) systems. It is, therefore, important for organizations to take this fact into measure when selecting a new ERP system.

**Purpose of the article:** The aim of the presented research was to propose set of criteria, which could be used by the organization during the choice process of new ERP system in order to evaluate the readiness of every candidate for the challenges related to the Industry 4.0.

**Methods:** Development of the criteria set was based on analysis and evaluation of two main areas – firstly, the content of the Industry 4.0 and its particular technologies, and secondly the tasks which should be performed by the modern ERP system. Requirements arising from these two areas were then merged together into one set of criteria.

**Findings & Value added:** Result of the presented research is a comprehensive and easy-to-use set of criteria, which can be used as a decision-making support tool in the business practice.

**Keywords:** *ERP systems; Industry 4.0; Information systems*

**JEL Classification:** *M10; M15; M21*

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## 1 Introduction

The Enterprise Resource Planning system (hereinafter referred to as “ERP system”) is a central software element within the information and communication technology system of a company, permeating the whole company in which the basic company processes are managed and recorded. Generally, these involve at least processes in the field of accounting and warehousing (for more details see [1]); nevertheless, in case of comprehensive implementation, the current ERP systems are able to easily cover virtually any other areas, such as production planning and management, logistics, customer relationship management, etc. Even in cases where these other areas are not covered by the ERP system directly but are managed through particular single-purpose systems instead, e.g. in the form of manufacturing execution systems (MES) for production management, warehouse management systems (WMS) for warehouse management or product data management (PDM) solutions for design and technology needs, these subsystems are usually integrated with ERP so that data can be mutually exchanged. Similarly, even if there is a reporting layer over the ERP system, e.g. in the form of a management information system (MIS), the source data for its operation are usually at least partially drawn from ERP. Therefore, even in this case, the ERP system plays the role of a central node, into which relevant data are concentrated and on the basis of which fundamental decisions are made.

This unique position of ERP in business processes also means that a suitable selection of a particular ERP system is one of the key conditions for the proper functioning of the entire IT infrastructure of an enterprise. Even the process of implementing the ERP system is extremely demanding for a company, both in terms of costs and, above all, in terms of human resources. The analysis and implementation of a new system in fact requires the cooperation of employees across the company, who must in addition to their normal work provide relevant information to the implementer, participate in new system training and possibly modify selected processes so that they comply with the business logic of the new system. The particular modelling of business processes in the implemented ERP system will then fundamentally affect the operation of the whole company throughout the period when the system will be used. That is why any improper system selection at the beginning may have significant negative effects on the company operation. In extreme cases, it may even result in the company’s bankruptcy. In this context, the specialist literature in particular highlights threats to small and medium-sized companies, which, unlike large corporations, do not have the adequate financial and human resources required to cope with such a situation, see for example [2], [3]. Nevertheless, in actual business practice there are even cases of big companies that have found themselves in a critical situation due to the flawed implementation of the ERP system.

Therefore, it is not surprising that a number of expert publications have focused on designing a suitable tool to support the selection of an optimal ERP system. The specific approach by individual authors to this issue differs greatly. The proposed procedures range from relatively simple frameworks and decision making models that have their practical applicability emphasised to mathematical studies of a rather academic nature. The first group include studies based on the SMART method (Simple Multi-Attribute Rating Technique) ([4] or [3]), framework PIRCS (Prepare, Identify, Rate, Compare, Select) [3], framework Define – Evaluate – Select [5] or the SCAPE method (Selection Approach for ERP systems) [2]. Its authors usually include here a framework based on the AHP (Analytic Hierarchy Process) approach [6], although in this case it is already a more complex tool. The second group mainly includes models based on the fuzzy approach presented, for example, in [7], [8] or [9].

## **2 Research Scope and Methods**

Factors that should be currently taken into account when choosing an ERP system include the fact that the economy and society as a whole are currently undergoing significant technological changes, especially in the field of ICT, which are collectively referred to as the “fourth industrial revolution” or “Revolution 4.0” (see e.g. [10] or [11]). The expected result of this transformation is the emergence of so-called “smart factories”, “Industry 4.0” or, in a broader sense, the whole “Society 4.0”, where the virtual world will be interrelated with the real world through information and communication technologies. Within the selection process of the ERP system, it should be very carefully assessed to what extent the individual evaluated systems are prepared for these technological changes. However, such an assessment requires the evaluator to have sufficient knowledge both in the field of technologies related to Industry 4.0 (at least with those that are relevant to the respective enterprise) and in the field of information systems architecture. In other words, so that an evaluator is able to assess the information system from this point of view, he/she must understand what requirements the fourth industrial revolution will place on ERP systems, and at the same time, he/she must have sufficient technical knowledge to assess, which of the offered systems can meet these requirements best.

However, looking for such an evaluator within the company may be difficult, particularly in case of small and medium-sized enterprises, which often lack sufficient capacity in the field of IT professionals. The main goal of this study is to propose a user-friendly decision support tool in the form of a set of criteria, which allows for the assessment of the ERP system in terms of its readiness for Industry 4.0 even without the detailed knowledge discussed above.

The structure of the paper is as follows - in its first section, the meaning of the term “Industry 4.0” itself is analysed, and the requirements arising from it for information systems are identified at the general level. The second section puts these demands in a specific context with ERP systems and presents a set of criteria for assessing the readiness of ERP systems for Industry 4.0, which has been proposed on a basis of this analysis. In the last section of the study, possibilities of further development of the proposed evaluation tool are discussed. Upon the creation of the evaluation tool, the method of analysis and evaluation of specialist literature related to Industry 4.0 and the subsequent synthesis and generalisation of its results with the current state of art in the field of ERP systems were used.

## **3 Results**

### **3.1 Industry 4.0 and its requirements for the information system**

One of the main problems in the analysis of the fourth industrial revolution, i.e. Industry 4.0, includes the fact that the use of these terms is now ubiquitous, but their content has not been clearly defined (see e.g. [12]). However, if the characteristics of ERP systems required for their successful integration into the environment of Industry 4.0 are to be identified, it is at first necessary to clearly define particular manifestations of this concept in the business practice.

In the specialist literature, either the Reference Architecture Model Industry 4.0 (abbreviated as RAMI 4.0) or a list of technologies contained in it are usually used for the definition of Industry 4.0 concept content [13], [14]. The RAMI 4.0 model generally describes this concept; primarily it is a structured tool aimed at grasping the principles of Industry 4.0. To analyse particular requirements Industry 4.0 imposes on information

systems, it is therefore more appropriate to use its definition through a list of particular technologies. This approach better addresses the issue as to what particular changes are about to occur in a business operation with the advent of Industry 4.0. Industry 4.0 is mainly related to the use of nine technologies, which are indicated as its “9 pillars” [14]. These are:

1. **Big data**, i.e. big (and especially rapidly growing over time) amounts of diverse data that can be stored, analysed and evaluated.
2. **Autonomous collaborative robots**, i.e. machines that are able to work largely independently, while cooperating effectively with humans at the same time.
3. **Simulation** serving both for drafting ergonomics and layout of operating areas and for the virtual development and prototyping.
4. **System integration** within the meaning of the interconnection of individual information systems within the company and across the entire supply and demand chain.
5. **Internet of things** (commonly also referred to as **IoT**) consisting in connecting everyday items to a network/Internet, and their subsequent communication both with each other and with central systems.
6. **Cyber-physical systems** (abbreviated as **CPS**), i.e. an environment where the physical reality, represented by machines, materials, products and people, will be closely connected with the virtual reality in the form of data representation of each physical object, control algorithms, artificial intelligence, etc.
7. **Cloud technologies** when an increasing amount of the information infrastructure of companies is not physically operated by them but is moved to data centres instead.
8. **Additive production**, currently mostly on the basis of 3D printing from plastic materials or metal, powder allowing for a rapid prototyping or small series production.
9. **Augmented reality** allowing for connecting the real world with the virtual one in the user's field of vision by means of smart glasses or a mobile phone (e.g. projecting schemes or work procedures directly on a respective object).

On the basis of the analysis presented in the publication [15], we believe a tenth technology should be added to these 9 pillars, which play an important role in current business practice, in particular in the field of logistics and asset tracking in general. Automatic Identification and Data Collection (AIDC) is this tenth technology. Collectively, this term is used to indicate technologies enabling unambiguous identification of objects and subsequent automated collecting data about them. Currently, various methods are used for these purposes; they are either operated on the basis of marking the monitored object with a unique machine-readable identifier (e.g. QR code or RFID chip) and subsequent automatic reading of this identifier, or on the principle of machine image or sound recognition.

Therefore, from a practical point of view, the fourth industrial revolution mainly consists in the massive spread of the above-mentioned technologies both in individual companies and in society as a whole. Now, we can identify particular demands to be imposed by the routine use of these technologies on information systems. We have based this definition on the publication by Leyh et al. [16], who define the following key requirements that an information system operated in an Industry 4.0 environment should meet:

- A. It must be ready for **horizontal system integration**, i.e. the interconnection with other information systems within a company. In the case of an ERP system, it is mainly about the data exchange with specifically focused systems such as MES,

WMS, supply chain management systems (SCM), product lifecycle management systems (PLM) or MIS.

- B. It must be ready for **vertical system integration**, i.e. the data exchange with information systems of business partners (or also other stakeholders, as the case may be) across the supply chain. Leyh et al. [16] stress that this should be a fully automated integration.
- C. It must allow for **digital continuity** for every single product. The life cycle of a product must be completely captured by respective information systems, whereas all particular product information must be available at all times to all interested parties.
- D. It must be erected on the **service-oriented architecture (SOA)**. Thus, the information system in the environment of Industry 4.0 should not be a monolithic structure; on the contrary, it should be possible to use its individual components separately, even from interconnected information systems.
- E. It must be able to be operated in **the cloud**. Therefore, the system should not be limited to the infrastructure of the particular company.
- F. It must allow for the **information aggregation and processing**, which means an ability to obtain data from various inputs (including other information systems in the company using the horizontal integration) and evaluate them effectively, e.g. through clustering, correlation analysis, etc.
- G. It must comply with the principles of the **cyber security**. First of all, the system must primarily guarantee the protection of data and their availability only to authorised users.

### **3.2 Expanding requirements for information systems within the conditions of Industry 4.0**

On a basis of the analysis of the particular above-mentioned Industry 4.0 technologies, we consider it appropriate to add some more requirements:

- H. It must allow for the **fast and customised processing of big data volumes**. Big data in Industry 4.0 environment are generated both in the field of production, where individual production machines connected to the data network are able to send detailed information about the course of each individual production operation to the central repository, and in the field of production and business logistics, where it is possible to monitor the precise position (or even the route) by means of the Internet of Things combined with the AIDC technology not only of each warehouseman, reach truck or vehicle, but in extreme cases also of each individual material or product. The information system prepared for Industry 4.0 should therefore be able to process these extreme volumes of data efficiently, either for the purposes of productivity evaluation or predictive maintenance (in case of data from production facilities). Effective processing of these data is subject both to the system ability to perform various analyses adapted to particular needs of a company and a sufficient rate of these analyses implementation. This feature is essential for the full use of benefits the big data, the Internet of Things, cyber-physical systems and AIDC technologies offer.
- I. It must be able to **collaborate with various platforms including mobile ones**. The use of the information system should not be strictly limited to one operating

system running just on one type of device (usually a PC with Windows OS). Instead, it should also be possible to interact with it via mobile devices (both in the form of portable industrial terminals and mobile phones), tablets, stationary industrial terminals, etc. A multiplatform system can only be used to the full in a smart factory environment, where these mobile and stationary terminals are routinely used.

- J. **To adhere to industry standards both in the field of software and in the field of a communication with hardware.** Fundamental manifestations of Industry 4.0 include is the extensive integration both between individual information systems and between the real and virtual world. Which is why an information system ready for Industry 4.0 should be able to interact with other products through standardised communication protocols or, in the event of a codified protocol absence, at least in accordance with generally accepted good practice examples. On the other hand, the system should not be operated on proprietary technologies and non-standard procedures.
- K. To allow for the **utmost modularity and customisation levels** so that it can be adapted to the particular needs of each company, not only during implementation, but also for the rest of its life cycle. One has to in fact assume that on one hand the development of the existing technologies of Industry 4.0 will continue and on the other hand completely new technologies will be invented; in connection with this development, business processes will also develop and change. A system ready for Industry 4.0 therefore cannot be static and rigid; it must be able to keep up with these requirements instead.

### **3.3 Draft evaluation tool for assessment of the readiness of the ERP system for Industry 4.0**

The 11 requirements defined above were subsequently analysed in relation to the current state of art in the field of ERP systems, both in terms of their technologies and in terms of the processes ERP systems currently have to meet. In this analysis, we relied both on the specialist literature and the experience of one of the authors of the article, who has long been active in the development and implementation of ERP systems and is therefore experienced in terms of technical issues that are usually addressed during the ERP system selection and implementation.

The objective was to propose a set of criteria that would not place with regard to the evaluation high demands on the evaluator in the field of detailed knowledge of information systems architecture or particular technologies of Industry 4.0. A general knowledge of information technologies should be sufficient for their assessment. Criteria are therefore clearly defined. In some cases they even contain some examples of products that are most widespread in the business practice. Furthermore, the criteria deliberately do not contain complicated rating scales that would determine the degree of compliance with the requirements of a given criterion, as the need for an arbitrary assessment of the degree of compliance with the criterion would again increase requirements placed on an evaluator. Instead, the criteria wording allows for evaluating the compliance of each of them by “Yes” - “No” conditions. This results in an easily evaluable checklist, the completion of which (both by the evaluators themselves and suppliers of individual applicant systems) should provide evaluators with an initial view of the readiness of individual ERP systems for Industry 4.0 – the more criteria are answered “Yes”, the better. The created draft set of criteria, including their links to particular requirements defined in the previous subchapters, is demonstrated in the Table 1.

**Table 1.** Criteria for assessment of the readiness of the ERP system for Industry 4.0

| <b>Criterion number</b> | <b>Link to requirements</b> | <b>Criterion definition</b>  |
|-------------------------|-----------------------------|--|
| 1                       | A, B, J                     | The system has an API layer allowing for communication by means of the REST architecture, allowing for the full system control.  |
| 2                       | A, B, J                     | The system has an API layer allowing for communication by means of the SOAP protocol, allowing for the full system control.  |
| 3                       | A, B, J                     | The system has an API layer allowing for communication by means of the integration database or, rather, integration database objects, allowing for the full system control.  |
| 4                       | A, B, J                     | The system allows for the automatic export/import of data files in a standard format (e.g. csv) to/from the determined repository.   |
| 5                       | A, B, J                     | The system supports standard EDI protocols relevant for the field of the enterprise activity (e.g. VDA in the automotive environment).   |
| 6                       | C                           | The system allows for saving documents with each product, both directly and in the form of the repository link. At the same time, it is able to open these links or to start the program, which is able to open them, if available.                                |
| 7                       | C                           | The system has the standard functionalities of the PDM/PLM system (registration of all product data, change management, registration of technological procedures, drawings, etc.) or offers, as the case may be, a native connection to the corresponding product. |
| 8                       | D, J                        | The architecture of the system is service-based, respecting the standard contract mechanism and using one of the standard data transfer formats (XML or JSON).   |
| 9                       | E                           | All system functionalities can be controlled via the web client. If this is not thus possible and a local client is required, the system must run smoothly in the remote desktop mode so that the client does not need to be installed on workstations.            |
| 10                      | D, E, H                     | Individual services can be distributed to multiple servers, both in the sense of application servers (if used) and in the sense of machines (physical or virtual). Multiple instances of one service can be created for higher performance.                        |
| 11                      | F, H                        | The system has Business Intelligence tools or, as the case may be, supports the native connection to a specialised tool for Business Intelligence.   |

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|----|---------|--|
| 12 | F, H    | For the requirements of the Business Intelligence, the systems allows for using the OLAP access.   |
| 13 | E, F, H | The system allows for performing the Business Intelligence analysis in the specialised data centre environment.  |
| 14 | F, H, K | The system allows for filling in customised analytical procedures in the Business Intelligence tool.   |
| 15 | G       | Logging in the system allows for using the single sign on.   |
| 16 | G       | The communication between individual services and between individual application levels is encrypted.  |
| 17 | G       | The system allows for the access and right control up to the level of individual events and columns in the database.   |
| 18 | G       | The system allows for the retrospective audit of used events and monitored data for each user.   |
| 19 | G       | The application layer accesses the database layer under a dedicated account, not directly through individual user accounts. Therefore, users accounts do not have direct rights to the database layer.   |
| 20 | H       | The system supports the in memory processing for working with online data.   |
| 21 | I       | The system has the web client executable in standard browsers (Chrome, Firefox, Opera, Safari, Edge). The client allows for the complete system control.   |
| 22 | I       | The system has a mobile client executable on both standard platforms (both IOS and Android). The client allows for the complete system control.  |
| 23 | I       | The system has clients executable on industrial terminals, which perform the functions of MES (records of production operations, material consumption, reporting of breaks, produced scraps and deviations, viewing of production documentation). Or it offers a native connection to the product itself with these functions. |
| 24 | I       | The system has clients executable on mobile terminals, which meet the WMS functions (warehousing, picking from the warehouse and booking material or goods, viewing the warehouse map, routing within the warehouse). Or it offers a native connection to the product itself with these functions.                             |
| 25 | J       | The system is based on standard technologies in the field of databases. It uses some of the standard SQL distributions (e.g. MSSQL, Oracle, DB2, MySQL, MariaDB, PostgreSQL). It does not require the proprietary SQL distribution.  |
| 26 | J       | If the system uses the application servers, it may work without further adaptations on standard servers (e.g. Apache Tomcat, WildFly, Oracle WebLogic or .NET Application server). It does not require any proprietary application server.   |
| 27 | J       | If the system uses web servers, it may work without further adaptations on standard servers (e.g. Apache, NGINX or IIS). It does not require a proprietary web server.   |

|  |   |   |
|--|---|---|
| 28   | K | The system allows columns to be filled in the database, both data and defined by a calculation.   |
| 29   | K | The system allows for the creation of new tables including editors for working over these tables and links between these tables and the rest of the system.   |
| 30   | K | The system allows for the creation of new events in the system. The event functionality is defined by some of the standard script languages, e.g. JavaScript, Python or Visual Basic. It does not require the exclusive use of a proprietary language.  |
| The legend of less known terms used in the table |   | <p><b>API</b> (Application Programming Interface) – an interface enabling the communication with the software from outside</p> <p><b>REST</b> (Representational State Transfer) – a widely used interface architecture</p> <p><b>SOAP</b> (Simple Object Access Protocol) – data exchange protocol frequently used within the API interface</p> <p><b>XML</b> (eXtensible Markup Language) – a markup language used for the creation of structured files suitable for the data exchange</p> <p><b>JSON</b> (JavaScript Object Notation) – a way of data notation used for the creation of structured files suitable for the data exchange</p> <p><b>OLAP</b> (OnLine Analytical Processing) – the technology of data storage in the database suitable for working with big data volumes</p> |

Source: own elaboration

### 3 Discussion and conclusion

The previous chapter presented a simple set of criteria, using which persons responsible for the selection of the information system can quickly assess the architectural and functional readiness of individual ERP systems for the challenges associated with Industry 4.0. This is therefore a decision supporting tool, which can help evaluators, especially in the initial stages of selection allowing for to exclude from further selection ERP systems, which are completely unsuitable for the environment of Industry 4.0, and on the other hand to identify those systems that are leaders in this area. Systems selected in this way can be subjected to a more complicated analysis, e.g. on the basis of provided demo versions, reference visits, etc.

Nevertheless, in the presented form, it only is an initial proposal of the tool, which should be further developed. The first possible direction of further development is the creation of a system of weights that would more accurately assess the importance of individual criteria. The system of weights is also related to the second intended direction of development, which is the adaptation of the proposed checklist for the needs of individual sectors, at least at the level of the weights of individual criteria. However, a partial reformulation or the addition or removal of selected criteria depending on their importance for a particular sector also is possible. Both of these directions could be examined by means of a questionnaire or expert interviews with persons responsible for the selection of information systems and with the owners of individual main processes in companies. These surveys will be subject of the further work of authors of the article.

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## References

1. Gu, Y., Qi, L., Wang, J. (2018). Breaking The Monolith: Strategy, Variety, and Performance of Enterprise Information Systems. *Journal of Systems Science and Systems Engineering*, 27(6), 727-770.
2. Alpers., S., Becker, Ch., Eryilmaz, E., Schuster, T. (2014). A Systematic Approach for Evaluation and Selection of ERP Systems. In S. Wrycza (Eds.), *SIGSAND/PLAIS 2014* (pp. 36–48). Gdansk: Springer.
3. Olson, D.L., Johansson, B., Atem de Carvalho, R. (2012). A Combined Method for Evaluating Criteria When Selecting ERP Systems. In Ch. Moeller, S. Chaudhry (Eds.), *Re-conceptualizing Enterprise Information Systems* (pp. 64-74). Aalborg: Springer.
4. Haddara, M. (2014). ERP Selection: The SMART Way. *Procedia Technology*, 16, 394-403.
5. Alaskari, O., Pinedo-Cuenca, R., Ahmad, M.M (2019). Framework for Selection of ERP System: Case Study. *Procedia Manufacturing*, 38, 69-75.
6. Wei, Ch., Chien, Ch., Wang., M.J. (2005). An AHP-based approach to ERP system selection. *International Journal of Production Economics*, 96(1), 47-62.
7. Kilic, H.S., Zaim, S., Delen, D. (2014). Development of a hybrid methodology for ERP system selection: The case of Turkish Airlines. *Decision Support Systems*, 66, 82-92.
8. Karsak, E.E., Ozogul, C.O. (2009). An integrated decision making approach for ERP system selection. *Expert Systems with Applications*, 36(1), 660-667.
9. Efe, B. (2016). An integrated fuzzy multi criteria group decision making approach for ERP system selection. *Applied Soft Computing*, 38, 106-117.
10. Vacek, J., Dvorakova, L., Cerna, M., Horak, J., Caha, Z., & Machova, V. (2019). *Identifikace, analyza a hodnoceni principu, postupu, metod a nastroju pro adaptaci sektoru sluzeb na technicke, ekonomicke, socialni a environmentalni podminky Spolecnosti 4.0.*
11. Hofmann, E., Rusch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry*, 89, 23-34.
12. Inkermann, D., Schneider, D., Martin, N.L., Lembeck, H., Zhang, J., Thiede, S. (2019). A framework to classify Industry 4.0 technologies across production and product development. *Procedia CIRP*, 84, 973-978.
13. Rojko, A. (2017). Industry 4.0 Concept: Background and Overview. *International Journal of Interactive Mobile Technologies*, 11(5), 77-90.
14. Vaidya, S., Ambad, P., Bhosle, S. (2018). Industry 4.0 – A Glimpse. *Procedia Manufacturing*, 20, 233-238.
15. Polivka, M., Dvorakova, L. (2019). Vyuziti automaticke identifikace a sberu dat prostrednictvim radiofrekvencnich technologii v prostredi Prumyslu 4.0. *Trendy v podnikani*, 9(2), 53-61.
16. Leyh, Ch., Schaffer, T., Bley, K., Forstenhausler, S. (2017). Assessing the IT and Software Landscapes of Industry 4.0-Enterprises: The Maturity Model SIMMI 4.0. In E. Ziemba (Ed.), *Information technology for management: new ideas and real solutions*. Cham: Springer, 277, 103-119.