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AMALGAMATION OF BUSINESS INTELLIGENCE WITH ENTERPRISE RESOURCE PLANNING SYSTEMS FOR INDUSTRY 4.0

Key words: Business Intelligence, BI, Enterprise Resource Planning, ERP, Industry 4.0., information technology, decision-making, strategic management, information management.

Abstract: Businesses today are incredibly data rich, and dealing with large amount of data, so making some inferences and conclusions, depending on the organisation size and complexity of its processes, it has been a challenge, especially that the next disruptive phase in manufacturing, i.e. Industry 4.0 (I4.0) is already underway.
Business Intelligence (BI) and Enterprise Resource Planning (ERP) have become key issues for business activities as well a necessity for further phases of the industrialisation. Their importance has been recognised especially in supporting decision making by building an analytic capability and providing a holistic framework for technical systems in production, quality management, predictive modelling and maintenance, simulation techniques, etc. The introduction of Industry 4.0 requires the digitalisation of data stored in distributed systems and organisational and technological processes. The integration allows one to facilitate the collection, integration, and analysis of data in order to affect the process of development of technical innovations and support the planning and managing in efficient and productive manner.
Therefore, the main purpose of this paper was to discuss the importance of BI and ERP amalgamation for the process of the digitalisation and maximisation of company resources stored in distributed transactional systems in the context of Industry 4.0.

Konsolidacja koncepcji Business Intelligence z systemami klasy ERP dla potrzeb przemysłu 4.0

Słowa kluczowe: Business Intelligence, BI, planowanie zasobów przedsiębiorstwa, ERP, Przemysł 4.0., podejmowanie decyzji, zarządzanie strategiczne, zarządzanie informacją.

Streszczenie: Współczesny biznes i przemysł charakteryzuje wielowymiarowość danych, duża dynamika zmian oraz konieczność podejmowania elastycznych decyzji, co stanowi także wyzwanie dla narzędzi informatycznych oraz metod zarządzania. Systemy *Business Intelligence* (BI) i *Enterprise Resource Planning* (ERP) stały się kluczowymi platformami analizy i przetwarzania danych, a także podstawą dalszych etapów zaawansowanej industrializacji. Ich znaczenie doceniono szczególnie na płaszczyźnie wspomagania decyzji poprzez budowanie zdolności analitycznych, dostarczanie *real-time* danych oraz integrację wielowymiarowych przekrojów informacyjnych.
Business Intelligence (BI) to nie tylko koncepcja, ale także zestaw technologii, które ułatwiają gromadzenie, integrację i analizę danych w celu wspomagania procesów decyzyjnych. Z drugiej strony w większości organizacji wszystkie dane potrzebne do analiz są najczęściej przechowywane w systemach planowania zasobów przedsiębiorstwa klasy ERP. Zatem głównym celem tego artykułu jest omówienie znaczenia konsolidacji systemów klasy BI i ERP dla potrzeb procesu digitalizacji i maksymalizacji zasobów informacyjnych składowych w rozproszonych systemach transakcyjnych w kontekście koncepcji Przemysłu 4.0.

Introduction

The concept of using information systems to support decision-making has been a goal of companies since the introduction of business computer technology [1]. There are numerous IT solutions facilitating various levels of management. The following are just some examples: ERP (*Enterprise Resource Planning*), BI (*Business Intelligence*), MRP (*Manufacturing Resource Planning*), DMS (*Document Management*

System), WMS (*Warehouse Management System*), CRM (*Customer Relationship Management*), and KMS (*Knowledge Management System*). These solutions offer a range of features. However, a framework of BI and ERP is the key approach to improve business operations and eventually reaching an understanding of the environment of an organisation. Industry 4.0 calls for a future of agile and affordable manufacturing fuelled by the Internet of things [1], additive manufacturing [2], cloud computing [3], big data [4], etc., and ERP or BI will become the backbone of a network of connected environment. Therefore, those were selected for further analyses paying attention a little more to ERP systems, as the BI concept was presented in [5].

1. Mutual relationship between BI and ERP

After presentation of the BI and ERP approach to data, the relationship between those two concepts is defined in this section, because they serve different functions depending on business requirements.

Business Intelligence is understood as an overarching term that definitely concerns much more than a particular piece of information or IT software. The current holistic view of BI encompasses business objectives, performance management, people, processes, analytics, reporting, online analytical processing (OLAP), and query technologies, all sitting on an information processing and management infrastructure [6]. BI is characterised as a process of analysing, transforming, and presenting structured data from multiple sources and identifying actionable business opportunities. Business Intelligence is also defined as the ability to provide meaningful information at the right time so that the decision making can be informed and fact-based [7, 8]; therefore, its main purpose is to enrich the multidimensional business environment with so far uncovered opportunities.

However, BI requires large amount of various data to inference and guide the business, such as technical innovation process. One of the most sophisticated information systems currently known to be able to satisfy the need for data efficiency is the Enterprise Resource Planning system (ERP) [9]. ERP is treated as one of the more common categories of business software, especially among large businesses. ERP is defined as an enterprise-wide set of management tools that balances various business activities and assures cross-functional integration between sales, supply chain, operations, marketing, manufacturing, new product development, and human resources, etc. [10]. ERP, like MRP software, manages manufacturing processes, in particular, production planning, scheduling, and inventory management. Although the full range of ERP capabilities is much more extensive and involves keeping all of workflow data in one place,

all of business processes draw data from that location to inform insights. This helps ensure data quality, since it never gets duplicated between systems and increases data accessibility [11]. A main role of the ERP system is to collect, store, and interpret data from business activities, in order to improve the performance and reduce costs through the integration and automation of the processes.

The latest ERP is often called *postmodern ERP*, because it deconstructs ERP software from one big central program into logical components and it is defined as highly modular business process management software, which is a core of an effective way of centralising information and workflow processes through data management [12].

Considering also other definitions, for example, [6, 13, 14, 15, 16, 17, 18, 19], this paper takes into account narrow understanding of ERP, and defines it as a modular computer architecture that stores and integrates data from various cross-organisational levels with no data redundancy and creates a complex picture of the entire organisation.

The literature review has shown that BI and ERP facilitate the different facets of organisation and both are needed to enhance and improve the ability of companies to decision-making at all levels of management (Fig 1), especially that stress on quick data access, sharing and exchange is fundamental for I4.0.

BI and ERP systems are incorporated within a main business process, such as development and the introduction of a technical innovation to the market, mass manufacturing, etc., Enterprise Resource Planning functions at the transactional level emphasises organisation, performance evaluation and rewards, and are task- and outcome-oriented. ERP system as a software application with a centralised database with separate modules [22] can be used to manage an entire process of the product development from the concept stage, through prototyping, introducing to the market and evaluation. A central ERP database integrates data representing different functions within the organisation. It includes the operational processes that define the primary activities that a company needs to perform in order to successfully execute its business [23]. The Industry 4.0 compatible ERP system fully integrates with manufacturing execution systems. ERP helps to put the pieces of the puzzle together and provides a single operational view of the business in order to manage and improve industrial processes.

However, to move from the data level to long term oriented strategic level, Business Intelligence is required. The most current information technology is to feed BI-based systems with data from external systems, such as ERP, that from the other hand can be an ideal tool for developing BI applications.
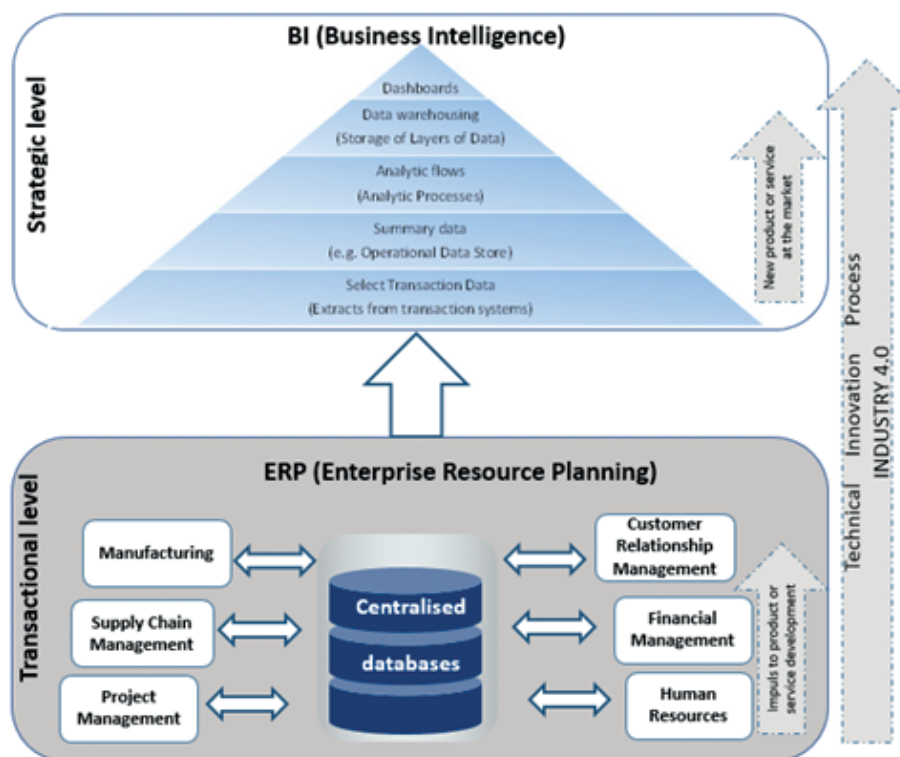
Fig. 1. The mutual relation between BI and ERP systems in a business environment
Source: The author on the basis of [20, 21]

BI uses the information and analysis from a transactional level to spur business growth and transformation innovations into market products. BI filled with ERP data allows organisations to access, analyse, and share information and knowledge about the whole process of manufacturing in order to track, understand, target, and manage business to improve its economic performance. It allows one to optimize future activities and to properly modify the organisational, financial, and technological aspects of the company's operations, so that it more effectively implements the set strategic goals. On that basis, more strategic, flexible decisions could be made with regards to future trends and patterns that influence business growth and innovation market [24].

Although ERP systems and Business Intelligence systems are complimentary, they are distinctly different. BI is proactive, comprised of forward-thinking principles and ideas, while ERP approach occurs on either a regular, on-going basis or as needed to support HR strategy. However, ERP and BI should be integrated and function together, since they are both important to create intelligent production environment toward I4.0.

2. Synergy of BI and ERP integration

ERP and BI create an integrated platform of enterprise data systems with the Internet of things (IoT) and cloud computing required in Industry 4.0 to make better-informed business decisions and operate as efficiently as

possible. BI software can step in and take a weight off when it comes to the analysis of data stashed in the ERP system. Combining these two concepts provides a more comprehensive approach to business management and offers dynamic reporting, where companies can pinpoint lucrative business opportunities [25].

The synergy of ERP and BI appears on the software level, as the most current information technology is to load data from ERP into a data warehouse and then link to BI-based systems with BI tools (such as OLAP, data mining, query and reporting). BI software draws heavily upon the information stored in the ERP system, yet has the primary objective of analysing this information. Feeding on the information stored in the ERP software system, a BI system will take this data, analyse it, and present it back in an actionable and easy to interpret format [26]. On the organisational level, the synergy allows one to take advantage of the analytic data and proceed to strategic long-term oriented management to guide the business towards digitalisation and real-time data to increase customer value by streamlining processes, increasing quality, creating new revenue streams, and reducing production costs.

The convergence of ERP and BI systems is considered crucial, so BI is frequently tightly coupled with the ERP systems. Where ERP offers enterprise-wide data consistency and systemic integration, BI describes a set of concepts and methods to support and improve managerial decision making by using fact based support systems use-able by all levels of management [27].

Integration of ERP and BI enhances and improves the ability of companies to make decisions by leveraging the ability to manage data from the ERP system and the analytical capabilities of the BI system [28. This integration leads to optimal use of both ERP and BI systems and more specifically, the following benefits are provided [29, 30]:

- Allows one to control the recognition of corporate cash flow in real time;
- Facilitates the implementation of cooperation between departments;
- Reduces the time required to generate regular reports;
- Improves profitability by transaction data analysis and forecasting business trends;
- Enables finance staff to create financial revenue reports and expenses quickly;
- Improves accounts payable and vendor relationship management;
- Provides online access to the data, saving access time;
- Improves relations with customers through sales of in-depth data mining; and,
- Shares information with the sales department, and this allows one to make better decisions based on a macro view of the business.

Because the integration of ERP and BI systems provides a significant value for an organisation, i.e. cost and time savings, improved information and business processes, more efficient and quick decisions and market response, the next section proposes the scheme to feed the process of digitalisation of the company heading for the I4.0.

3. The ERP and BI-based framework for Industry 4.0

Traditional management methods and structures are failing to adequately respond to an overwhelming flurry of information, discontinuous change, and hyper competition in Industry 4.0 that was also the rationale for developing the ERP and BI-based framework.

The presented framework merges all levels of decision making and takes into account the following elements of strategic management [31]:

- Business environment analysis (external environment scanning and analyse, strategic resources and capabilities identification, critical points isolation and clusters identification);
- Strategy formulation (review of strategic objectives knowledge database searching, strategic options identification and selection, key issues, scenario preparation);
- Strategy implementation (organisational design: structure, culture and control, development of implementation structure, budgeting and allocation resources, discharge of functions and activities); and,
- Evaluation and control (analysis and assessment).

The conceptual framework identifies the Enterprise Resource Planning and Business Intelligence characteristics and their competencies in the strategic management for requirements of Industry 4.0 (Fig. 2).
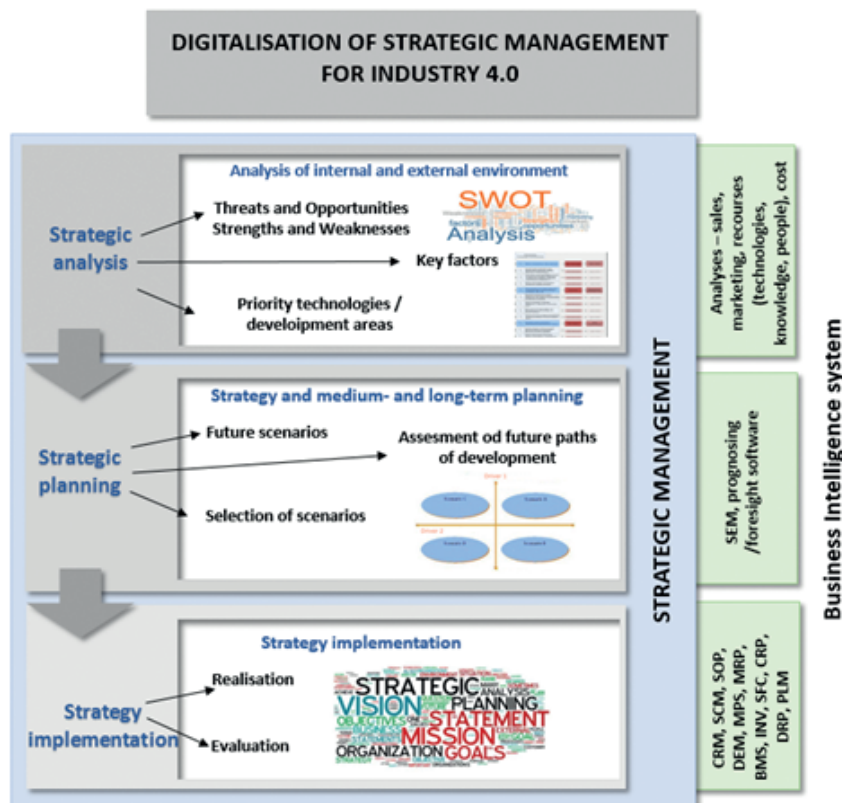

Fig. 2. The framework of ERP and BI-based digitalisation for Industry 4.0 requirements

The developed framework based on the strategic management process within Industry 4.0 proposes the use of BI and ERP class computer systems to support and automate individual business processes, and it aligns strategic tasks with ERP and BI competencies. Operational processes generate transactional data stored in the ERP system, and BI sources data from the ERP via extraction and provides the transformation and consolidation diverse data into meaningful performance indicators.

At the stage of strategic analysis, the proposed framework includes procedures, databases and computer systems to analyse the following: financial results, costs, indicators, financial flows, sales plans vs. results, profitability, marketing, production costs, efficiency and quality at all stages of the process. The strategic planning phase considers advanced software packages performing complex, sophisticated analyses and comparisons of human resources, human capital, order completion, inventory status, quality and performance assessment, as well as software for forecasting, foresight, and strategic planning (SEM). At the implementation stage, the proposed methodology includes IT tools for *Customer Relationship Management* (CRM), *Supply Chain Management Systems* (SCM), *Sales and Operations Planning* (SOP), *Demand Management* (DEM), *Master Production Schedule* (MPS), *Materials Resource Planning* (MRP), *Product structure subsystem* (BMS), *Material Transaction Subsystem* (INV), *Production control* (SFC), *Capacity Requirements Planning* (CRP), *Distribution Planning* (DRP), *Product Lifecycle Management* (PLM), etc.

The integration allows companies to take advantage of ERP data using BI reporting capabilities as Business Intelligence developed on the top of the ERP system and takes advantage of simplified data acquisition drawn from a homogenous source. The strategic management on each level (strategic analyses, planning and strategy implementation) sifts through large amounts of data in order to focus their resources more effectively and efficiently with the use of computer systems. BI provides refined information that could be used for advances Industry 4.0 requirements on the context of the data digitalisation. Created in that way, the data platform gives access to timely accurate data that processes large amounts of data and provides support for tactical, operational, and strategic decision making within the I4.0.

The framework that aggregates Business Intelligence and the ERP information system within Industry 4.0 and should become more and more integrated with organisational processes, bringing more productivity and better control to those processes.

Conclusions

The introduction of Industry 4.0 requires not only a shift to the digitalisation in manufacturing systems that connects physical assets and digital networks, but also predictive analysis tools for production and maintenance. The growth in an Industry 4.0 environment will be intrinsically linked with a business's ERP and BI systems that should be in a better position to meet the fast-paced and connected requirements of Industry 4.0. To be ready for digital transformation, ERP and BI software should provide business with a common platform, allow for central master data management, and offer real-time data processing, enabling all stakeholders in the business to have access to the latest, and most accurate data in real-time.

The paper presented the scheme for the amalgamation of ERP and BI systems within company introducing I4.0. On the basis of literature review, the mutual relationship between ERP and BI was more attentively explored. This indicated needs for BI and ERP integration, and simultaneously drew a synergic process. Only the synergy derived of the combination of strategic management techniques, information technology systems (for instance ERP and BI) and human resources management enhances organisational performance and improves the ability of companies to evidence-based decision-making, and brings a real I4.0.

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