Theoretical Foundations of ERP Systems Under Digitization

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Abstract

Operating in the digitization and globalization of all major sectors and markets, today's companies face increasing competition, changing consumer needs and expectations and increasing power of suppliers while at the same time they are working with limited resources. In the constantly changing economic situation to support their development and provide their existence, the companies and their management need and handle increasing volumes of data and incoming information. Enterprise resource planning systems aim to accumulate, systemize and summarize the information received from all units and provide the relevant reference data needed for each level of planning.

Keywords: Digitization, Enterprise Resource Planning, ERP, Theoretical Foundations

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Introduction

The beginning of the Industrial Revolution not only marked the beginning of modern society and the consolidation of capitalism as a leading economic system globally, but also laid the foundations for a market economy and competition. Businesses are increasingly focusing their efforts on seeking competitive advantage in order to increase the efficiency of their business. This creates the need to develop specialized systems to meet the needs of enterprises and optimize their operations.

The purpose of this study is to provide a historical and theoretical overview of the nature of ERP systems in environment of fast digitalization.

In order to achieve this objective, we should solve some main tasks related to:

1. Tracing the historical development of Manufacturing planning and control (MPC) systems.
2. Clarifying the nature of ERP systems.

1. Historical development of system for manufacturing planning and control (MPC)

Manufacturing planning and control MPC systems have been known in the world of literature and practice since the beginning of the Industrial Revolution. Rondeau and Litteral (2001) and Jacobs and Weston (2007) provide historical perspectives focusing on software systems for manufacturing planning and control, discussing reorder point (ROP) systems, material requirements planning (MRP) systems, manufacturing resource planning (MRP II) systems, and enterprise resource planning (ERP) systems. As you can see, their development goes through five main stages, each stage reflecting a significant change and upgrading of the systems.

Figure 1 illustrates the deepening of planning levels from the early 1960s and the advent of computer systems to the present day, when manufacturing software is a central tool for planning, organizing, and controlling ongoing processes. The level of planning from the lowest level - the level of the production workshop, gradually covers more and more stages, processes and departments in the production enterprise, until it leaves until it moves beyond the boundaries of the enterprise in modern planning.

Each of these stages is a prerequisite for optimizing enterprise activity, reaching Enterprise Resource Planning - systems that aim not only to capture the overall activity of the enterprise and aggregate data from all units, but also to present the entire set of configured information in an accessible manner to ensure that the needs of management personnel are met. This inevitably leads to the support of the planning process at the strategic, tactical and operational level, both for the whole enterprise and for each department and activity of the company structure.

Figure 1. Evolution of planning level focus (Olhager, 2013)

The first steps to planning in manufacturing plants are directed at knowing the processes that take place in manufacturing plants. Various methods and approaches are being developed, one of the earliest examples being Frederick Taylor's Scientific Management of Labor. Scientific management (Taylor 1911) divided labor content into small pieces that could be thoroughly analyzed, leading up to methods-time-measurement (MTM), and a systematic approach to work measurement (Maynard, Stegemerten, and Schwab 1948). This method aims at breaking down the processes of individual elements that can be individually measured and analyzed, which in turn leads to the methods-time-measurement method. Some of the methods developed during this period - the 60s of the 20th century, have been accepted as basic and are still used today as economic order quantity (EOQ) - a model for making optimal decisions for the ordering of raw materials and materials, as and Gantt charts for graphically displaying and planning manufacturing orders over time and across resources, taking the production sequence of individual orders into account (Gantt 1919).

With the advent of computer systems in the late 1950s and early 1960s, it was also possible to process more and more data. Development and implementation of reorder point systems is allowed. The implementation of such a system in a large manufacturing facility could replace up to 200 white-collar employees, streamlining data entry and processing processes. Reorder point systems aim to ensure the continuity of production processes by examining historical demand data and providing statistics on the required quantities of raw materials, materials and finished products. The focus of the reorder point was on preventing items from running out of stock (Wilson 1934).

These methods and systems have been developed and aim to optimize and organize the processes in production plants, based on past periods and through the use of statistical methods.

In the 1970s, material-based planning (MRP) was introduced, which was quickly adopted and imposed on manufacturing enterprises. The use of cost standards and their implementation in planning the necessary raw materials and materials completely changes the planning processes, and it also influences the production of forecasts in production-oriented enterprises, taking into account the fact that the need for basic raw materials is the result of the forecast demand for final products.

MRP functionality is beginning to be implemented in computer systems for operational planning. MRP systems greatly facilitate the definition of deliveries of raw materials, providing the opportunity to apply different models such as lot-for-lot, period order quantity, fixed-period

requirements. MRP systems include Capacity Requirements Planning, which also determines material flow, delivery times, delivery rates. Capacity planning also provides feedback on the implementation of the set goals, thus the need for materials can be reflected in a timely manner and the planning responds to a dynamic environment. “The use of dependent demand logic has brought about an entirely new way of planning the purchase of materials and components, sub-assemblies, etc., based on the bill of materials (BOM). This also affected the nature of forecasting in manufacturing firms, since dependent demand items did not need forecasting. Instead, the material requirements could be derived from higher-level items and end products.” (Olhager, 2013)

The 1980s brought about a fundamental change in perceptions for greater efficiency and effectiveness of operations. Just-in-time (JIT) systems and optimized production technology / theory of constraints (OPT / TOC) are emerging. The emphasis is shifting from optimizing the operating system as it is to refine the basic features of the system, such as improving quality, reducing downtime and setting up machines. Rather than optimizing operations taking the current constraints as a given, the focus shifted to improving the basic characteristics of the production system, such as quality improvements (Imai 1986) and setup time reduction (Shingo 1985).

This is where many debates start over which planning system is best. JIT and TOC take a whole new look and provide new opportunities for optimizing production processes, achieving higher profit margins, while MRP remains more suitable for production plant planning. Debates help bring together different approaches to the planning and control of production processes, units and stages, providing a much wider range of options for building plans with a higher degree of accuracy.

Behind the term MRP, more and more functions are beginning to emerge and this leads to its interpretation as manufacturing resource planning rather than the current material requirements planning. MRP II has been introduced as a term covering new system functionality. Although MRP II remains at the core of the MRP logic, the new system is significantly further upgrading with the introduction of the production program (plan). Many businesses are attracted precisely by the new concept of a complete production plan, which can be used to quickly refer to the available quantities of finished goods and the available-to-promise (ATP) concept.

MRP II is integrated into many MPC systems and is rapidly gaining popularity both in practice and in theoretical settings.

From the early 1990s to the 20th century, or more specifically in 1990, when the Gartner Group introduced the concept of ERP - enterprise resource planning. Many MRP II systems were rebranded to ERP systems in the 1990s. The functionality of the systems is increased, thus reaching a wider range of users. With the transition from MRP II to ERP, many manufacturers are upgrading their systems with new functionality that supports the so-called Sales and operations planning (S&OP), which is finding use in more and more manufacturing enterprises. “S&OP can be characterized as the long-term planning of production and sales relative to the forecasted demand and the complementary resource planning capacity” (Olhager, 2013)

With the beginning of the 21st century, an increasing number of businesses are becoming aware of the importance of globalization and the changing environment in which they operate. Competition is intensifying and markets are becoming more diverse as well as larger ones. It is no longer sufficient to study and optimize the internal environment of the enterprise alone. It needs to go beyond its boundaries. Competition changes - from competition between individual enterprises to competition between different supply chains. On the one hand are the end products that have to meet certain requirements for price and quality, and on the other hand are the suppliers of raw materials for the production of specific finished products. In this supply chain, manufacturing businesses are in the midst of and need the right tools to explore and manage inbound and supplier relationships, internal business elements and outbound flows and customer relationships.

This is where the need for ERP systems and their implementation in manufacturing enterprises also emerge.

2. Essence of ERP systems

In addition to practical applications, ERP systems are widely recognized and, as a result, subject to much research and development. But how can an ERP system be defined? Different authors also come up with different definitions for ERP systems.

According to some authors, The Enterprise Resource Planning (ERP) system is “an enterprise information system designed to integrate and optimize business processes and transactions in a corporation. ERP is an industry-driven concept and systems, and is universally accepted by the industry as a practical solution to achieve integrated enterprise information systems.” (Moon, 2007). The ERP system is considered as a complete information system designed to cover all processes in the enterprise, not specifying for the individual production enterprise, but covering all business activities. This is not only a system, but also a concept whose development is the result of the economic activity and needs of the industry, resulting in it being widely accepted as a complete solution for integrating information flows into a single system.

According to other authors, Enterprise Resource Planning (ERP) systems may be defined as the implementation of standard software modules for core business processes, usually combined with bespoke customization for competitive differentiation. The aim is to provide a breadth of integration and depth of functionality across multi-functional and often multi-national organizations.” (Skok and Legge, 2002). Therefore, ERP systems are a set of modules that optimize core business processes. In this sense, both all business processes of the enterprise and part of them can be covered. Hence the possibility of gradually adapting the ERP system to the activity of the respective economic entity. In addition to the basic modules offered by the system, the possibility of developing specialized functionalities tailored specifically to the activities of the enterprise implementing the system is also suggested. The goal of implementing the ERP system, whether it is being phased in or covering the overall activity of the enterprise, is to achieve a competitive advantage. In our view, ERP systems should ensure integrity in multifunctional and international companies. Such a function, namely the operation of the system in all units, departments and subdivisions of the enterprise, would provide consolidated information on the activity of the company, which would be used not only to evaluate the results achieved, but would also support strategic planning at all levels .

The following definition is also found in the scientific literature: “An ERP system is an integrated software solution that spans the range of business processes that enables companies to gain a holistic view of the business enterprise. It promotes one database, one application, and a unified interface across the entire enterprise.” (Ehie and Madsen, 2005) Here again, the focus is on the uniqueness of the database and the overall view of the activity. It should be noted that, according to the authors, the ERP system, even composed of different modules, is a single application, providing a common interface and operating throughout the enterprise. It follows that all employees work with one system, which greatly facilitates both operational work and communication between departments.

Other authors agree on the notion that “ERP systems integrate inventory data with financial, sales, and human resources data, allowing organizations to price their products, produce financial statements, and manage the resources of people, materials, and money.” (Markus, Tanis and van Fenema, 2000). ERP systems are considered in particular, and the activities and departments involved in the implementation of the systems are defined. It also identifies the results that could be achieved, namely pricing, financial statements and human resources management.

Based on these definitions, we could define the ERP system as an integrated system built by different modules, working individually or as a whole in a single database, covering all stages, departments and processes in a manufacturing enterprise, and aiming to provide timely, accurate and detailed information about the current state of the enterprise, as well as storing historical activity data, and thus, using set algorithms, to assist the planning, organization and control of the strategic and tactical level.

Figure 2 also provides a representation of the ERP system definitions considered above. The differences in the author's views and perceptions of ERP systems are presented.

Figure 2. Summary of the cited author's opinion on the nature of ERP systems

It should be taken into consideration that using the term system, the author goes beyond the definition of it as a set of objects and relationships between them, which are considered as a whole, but he complements it with the concept of a computer system. In view of its nature and as a result of both its own development and the progress of technologies, the ERP system is regarded as a software product or a computer system. It is the development of information technology, communication and communication technologies, including the Internet, that enables modern ERP systems to reach today's level

An overall system of its kind operating in a manufacturing enterprise has to process increasing volumes of data. And the algorithms used need technical support that cannot be provided without the help of technical development. It is the impetus for the growing pace of development of ERP systems and the development of functions integrated into these systems and implemented in a growing range of businesses and fields of activity.

The process of digitalization, namely the conversion of information into digital format, enables computer systems to cover more and more sectors of human activity, including economic activity. Digitizing the information coming from and accompanying each individual process or activity allows the formation of an information array. ERP systems, operating under the conditions of digitalization, on the one hand, are generators of digital information and generators of information arrays and users of those information arrays on the other, processing and structuring the received data, generating different outputs in the form of analyzes, forecasts, plans. and other.

Conclusion

Since its beginnings since the 1960s, Manufacturing planning and control systems have undergone significant development both in their practical orientation and in their formation as an essential part of the theoretical foundations of economic sciences. Initially, systems that support part of the business activity, with their evolution and the achievement of ERP systems, are already considered as an essential element of enterprise management.

For the 60 years of their development, MPC systems have undergone a number of changes, their functionality is growing, and the sectors of economic activity in which they are being implemented are increasing. From rules, guidelines and methods for organizing production workshops, through production planning systems, to a complete supply chain management solution, MPC systems have undergone significant changes and developments to become Enterprise Resource Planning (ERP) today.

This, combined with digitalization - the entry of computer technology into every aspect of human activity, and globalization - the operation of a growing number of businesses in international markets, confirms MPCs, and in particular ERP systems, as a key means of achieving and consolidating competitive advantages and a key tool in the management of the modern enterprise.

The combination of information technology development and economic theories creates an environment that enables the creation and validation of ERP systems as a complete solution, in the form of a software product that provides tools for managing businesses in all areas of economic activity.

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