Pre-Calculation of the Implementation of a Warehouse Management System, for a Specific Company

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Abstract: Companies constantly seek solutions for complex technical and economic tasks and this is especially difficult for small and medium-sized enterprises. For this, we provide an example in the barcode processing area. By looking at several versions at one company, we will show how much it costs to introduce a barcode-based warehouse management system. Our specific task was to pre-calculate the expansion of the existing ERP (Enterprise Resource Planning) system with a barcode warehouse management system. To this end, we have looked at good practices in recent years, as part of various field surveys, with several companies, across Hungary. The cost of building a barcode warehouse management system is HUF 25837559. It can be implemented on its own or with support. The barcode warehouse management system can be extended to all employees, but a version that is only extended to office employees, can also be analyzed. Accordingly, four cases were examined. In one of these cases, we set-up the theory, that in the structure of the barcode system, we extend the project management module in the expansion of the ERP system only among office employees, and thus, the investment pays off in 5 years, from existing resources. The NPV is HUF 13220000, the IRR is 43.24%, the profitability index is 1.71, DPB is 2.92 years. The logic of the calculations can be used in many other areas.

Keywords: warehouse management system; ERP; barcode; pre-calculation; NPV; DPB; IRR

1 Introduction

Providing adequate and accurate information is increasingly valued by companies. Developing the information system requires specific efforts considering local characteristics, the available technology and the business environment. Due to the large number of companies and their various activities, case studies are appropriate to explore the best practices in the field. European trends count on the increasing importance of medium-sized companies in the case of small, open economies like Hungary [1]. In the course of our work, a Hungarian company in the area of the city Szeged, was selected to present how to implement a new barcode warehouse management system, which will facilitate the day-to-day operation of the business.

Enterprise Resource Planning (ERP) systems are state-of-the-art enterprise management technologies that integrate and encompass the company's internal operational functions with high efficiency. In this way, they facilitate the support of managerial decisions and the provision of information, and at the same time lay the foundations for the development of business intelligence [2].

When asked what ERP is, the following text gives a nuanced overview: "What is the simplest ERP definition? Think about all the core processes needed to run a company: finance, HR, manufacturing, supply chain, services, procurement, and others. At its most basic level, ERP integrates these processes into a single system. But new ERP systems are anything but basic. They provide visibility, analytics, and efficiency across every aspect of a business. Using the recent technologies, ERP systems facilitate the flow of real-time information across departments, so businesses can make data-driven decisions and manage performance – live." [3].

According to this, based on the text, let's think under the definition of the simplest ERP for all the basic processes required to run a company, such as finance, HR, manufacturing, supply chain, services, procurement and others. At the simplest level, ERP integrates these processes into a single system. But new ERP systems are anything but basic. In all aspects of the company provides transparency, analysis and efficiency. The most modern technologies ERP systems facilitate the real-time flow of information between certain departments, so businesses are able to make data-centric decisions and to perform. The maturity of a company's management system is determined by how well the company can implement and use information technology in its management system. A mature company that continuously applies information technologies can use them much faster to achieve its goals and thereby increase its competitiveness [4]. Information and time become the decisive factors of production. A company can be considered successful if its business (management, executive and administrative) activities and processes are supported by information technologies, e. g., management and execution procedures and methods that require computer support at the given time level [5]. The quality information system should therefore be part of the logistics management system [6].

Nowadays, a critical competency for the successful work managers is the ability to work with large amounts of data, to know them, to draw relevant conclusions from them and to make further decisions based on them [7] Information systems help them in this activity, which fundamentally influence the way of working with data and information, as well as the ways of decision-making and communication [8]. The information system is a set of information, people, used information technologies, work organization, business management, as well as technical tools and methods for the collection, transmission, storage and further processing of data for the purpose of creating and providing information. The method tells us what we have to do in a certain stage of development or operation [9].

Information systems are currently an essential part of successful business management. When we talk about information systems for business process support and decision support, we mean business applications that are collectively known as enterprise resource planning systems – ERP.

An ERP category information system can be defined as an effective tool that can cover the planning and management of the main internal business processes at all levels, from operative to strategic [10]. ERP is a packaged business software system that enables the automation and integration of most business processes and the sharing of business data within the entire company. The most important internal processes covered by ERP systems are production, internal logistics, HR and economics. The main purpose of these systems is the integration of individual business functions at the level of the entire company, i.e., the integration of various applications used in the company that ensure the information needs of individual departments and divisions into a unit working on a unified database, and thus reduces the risk [11].

The expectations of ERP systems cover flexibility, expandability and modularity. Flexibility means that the system must be able to work in harmony even when installed on different platforms, and communicate with personal computers as well as other electronic devices, such as robotic arms on production lines or automated material handling equipment in warehouses. Within extensibility, we can distinguish between vertical and horizontal growth, in both cases the expectation is that the system is able to continue to function even in the event of increasing product volume or widening product range, and to be able to perform its tasks even during the introduction of new processes [12].

As a result of integration, the efficiency of the internal operating system of companies is improved, the time spent on work processes is reduced, thus their costs and risks are reduced and customer satisfaction is significantly improved.

The concept of lean management has been in focus for recent years. It aims to learn the sources of various losses inherent in operational processes and eliminate them [13]. Undoubtedly, the benefits are available if related data is adequately managed. An advantage of standard corporate management information systems

over custom-designed integrated corporate management systems is that they are ready to purchase and a much more cost-effective solution [14].

The lean approach is based on the triple unity of purpose, process and respect for people. Its main question is how to produce the highest value for the customer using the least possible resources, time, energy and effort [15]. A lean organization recognizes what value means to its customers and strives to constantly increase it in key processes [16]. The ultimate goal is to provide perfect value to the customer through a perfect value-creating process, in which the rate of loss is zero. In order to achieve this, the lean approach shifts the focus of management from the optimization of isolated technologies, devices and departments to the optimization of the flow of products and services, whose value processes flow through technologies, devices and departments all the way to customers. The power inherent in people is one of the driving forces behind lean. It builds on the employees and their ideas, which is why this is also its critical point [17]. How do we get them to do it in a society where it is not natural to "idea" at the level of operators [18] [19]?

Beyond the great opportunities of developing a corporate information system, some limitations must be considered. A remarkable issue is that standard systems are built according to a general corporate structure, and as a result, they cannot be adapted to each company so easily. In this case, we need to rethink whether we are adapting the system itself to the business or the business to the system. In both cases, these appear as a cost factor in the company's budget.

Another disadvantageous issue may be the burden placed on the employees to learn the new system. Initially, employees may be afraid to use the new system. As the learning phase can take many months, this is also a cost in the budget. Moreover, the data migration from a predecessor system to the new architecture can be difficult or impossible. As a result, a source of error arises during the transfer of data, and in some cases functional achievements and outages may occur between the two structures.

2 The Case of a Specific Corporate Management Information System

2.1 The Corporate and the Corporate Management Information System of company called "P@rtner"

The company was founded 30 years ago in the Szeged area. Currently, 14 people work at the company. They are produced special vehicles and machines based on individual customer requirements. For example, "smart" fertilizer spreader with

GPS communication, snow plow, special trailers. The purpose of our research is to plan a financial pre-calculation for the company regarding the purchase of the new barcode warehouse management system. After that, the company's managers decide whether to buy it or not. If they bought the warehouse management system, what would be the payback period for the investment? We are looking for answers to these questions.

We present the most important information related to product identification after the presentation of the specific corporate management system. We present the barcode identification method most suitable for the company. We are also described the parameters of the selected barcode data collector and barcode printer. Then we will make the economic calculation of these. The process of our research can be seen in the Figure 1.

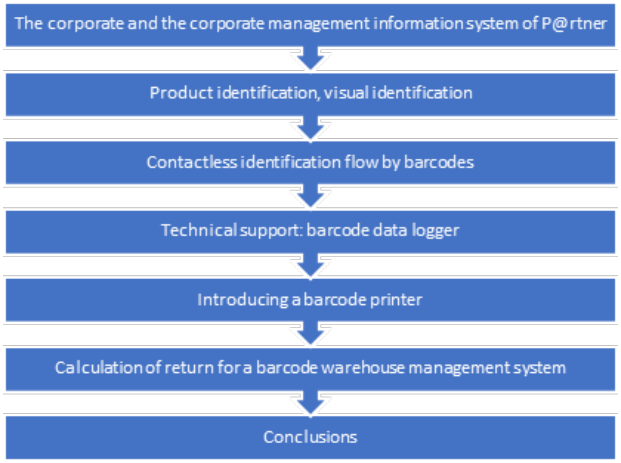

Figure1
The process of our research

The corporate management information system of P@rtner. ERP is the standard corporate management system designed by Rose Software Kft., The predecessor system of which is the Helix corporate management information system is still operating at the examined company. The standard corporate management information system is a modular architecture built around a framework. Table 1 shows the modules of the P@rtner corporate management system.

Table 1
P@rtner. ERP corporate management information system modules

Framework	
Trading module	Tangible asset
Manufacture	Wages and labor
CRM	Stock registry

Project management	Controlling, Business intelligence
Document management	Vehicle and implement registration module
Process management	EKÁER module
Web portal, ERP on the web	mobile.P@RTNER
Web shop	mobile.sales (PDA)
Banking relationship	Additional features

2.2 Product Identification, Visual Identification

We present the important things about product identification and visual identification, as we alluded to in the previous chapter. Most industrial companies, including tourism [20] [21] and food supply companies [22], have realized that it is essential to use product identification and tracking systems, but at the same time, the implementation of the system requires joint work of technical, business and legal expertise. Beyond a logistic approach, management researchers and economists also are dealing with the problem [23]. The inclusion of information from customers and clients in the system is becoming more and more important in order to improve logistics processes. Competitiveness requires cost-effective production and services from businesses, the key to which can be the proper identification and tracking of products [24].

A highlighted task within the supply chain is product identification and tracking [25]. Visual identification, which requires a person, does not meet today's logistical requirements, due to its excessive slowness and high error rate [26].

By using product identification systems, products can be tracked, process control and inventory management can be improved. In the long run, this allows for automatic product identification and traceability, thus improving supply chain strategies. It increases the overall redesignability of the entire supply chain by removing a number of barriers that limit the structure of the supply chain [27].

Today, science and technology have become very dominant, with human knowledge and skills as the primary resource [10]. Within this, project management [28] is of increasing importance, including the inclusion of information in the system, which may come from customers and clients, possibly in the field of logistics [29].

Several categories of identification are known, the best known of which is automatic identification. This identification includes the procedures and technologies that make it possible to obtain information about an object without human intervention and transform it for further use [30]. Automatic product identification systems can provide companies with a lot of information about different operations in the supply chain. However, it is important to collect reliable information continuously. The ultimate goal is to find the appropriate data collection technology [31].

In the increasing corporate competition, the cost-effective production of products and the provision of services, warehousing [32], special storage and transport are important, the key to which may be the appropriate identification. In practical life, we can encounter two types of product identification. These are the two types of tactile and non-tactile identification. One identifies the product using tactile (mechanical) holes and cams. Unlike contactless forms of identification, there is a physical contact here. For non-contact identification systems, four types can be distinguished. The chip card or RFID chip the electronic one uses to carry the data. In the optical solution, products are identified using a barcode. In the case of magnetic identification, you can track the products with the help of a magnetic stripe, while on a satellite-based GPS, you can track the products using an on-board computer.

2.3 Contactless Identification Flow by Barcodes

A simple but widely effective optical solution for product identification and checking product flow is a barcode system. A barcode is a square or rectangular shape that contains analog black lines with white spaces of various sizes. The black lines and spaces in a barcode represent a machine-readable code in the form of numbers and characters. It follows that a barcode is the way to encode information into a pictographic pattern, that can then be read, by a machine [33].

A barcode is an identifier consisting of a combination of numbers and letters, which is a coded form that can be read without any touch by machines. A barcode is just an identifier, a reference number that points to a specific element in a database. All other information is stored in the current database.

There are two main types: one-dimensional and two-dimensional barcodes. A one-dimensional barcode is a defined alternation of vertical dark lines and light gaps of different thicknesses that provide information to the reader. In contrast, two-dimensional barcodes can carry much more information than their 1D counterparts. Two-dimensional identifiers use different geometric shapes for identification.

The most common barcode is EAN13 (GTIN-13), but in the database of the examined company, the corporate management information system generates a barcode from the item numbers, although in some cases this has to be overwritten, but it is very useful. Article numbers consist of numeric and alphanumeric characters. Therefore, the most appropriate encoding is Code 128.

Code 128 is a rapidly expanding barcode system. The Code 128 barcode has 11 module-wide characters, each consisting of three lines and three spaces. This barcode system includes 2 types of verification codes for increased security. The main features of this barcode type are: it can display high information densities and alphanumeric character sets, it can be continuous and self-checking, and it can be of variable length and its various uses are standardized.

The scanning itself is done by barcode scanners. Sensors must be able to read black and white lines on products quickly and efficiently. At the same time, they must transmit the acquired information to a computer or terminal, which can immediately identify them with the help of the built-in product database [34].

2.4 Technical Support: Barcode Data Logger

The company needs to purchase data loggers and a barcode printer for barcode product identification. We will calculate the return on these. We describe the properties of the specific barcode data logger. The acquisition of 4 barcode data loggers is required during the investment. In the selection process, we aimed to provide the company with a data collector that is very powerful and, last but not least, industrial.

For this purpose, we proposed two types of terminals, the first of which is a Honeywell EDA61K mobile barcode data acquisition terminal, and the second is the newest member of the MC3000 series made by Zebra Symbol. In terms of value for money, the two products fall into almost the same category.

During the selection, the Zebra MC3300 was chosen by the investor. The Zebra MC3300 barcode mobile handheld data collection terminal is part of Zebra's highly successful MC3000 series, which dates back 15 years. The Zebra MC3300 barcode data logger runs on the Android operating system and is also equipped with a huge 4-inch color touch screen. Developed for warehousing and manufacturing environments with the following parameters (Table 2).

Table 2

Developed for warehousing and manufacturing environments with the following parameters

Component	Parameters
CPU type	Qualcomm 8056 1.8 Ghz hexa-core 64 bit
RAM	2GB, 16GB Flash (Standard)
Operating system	Android 7.0 Nougat AOSP GMS operating system
Keyboard	29-key keyboard
Screen	WVGA 4-inch color touch screen (480 × 800 pixels)
Roaming, Bluetooth	IEEE 802.11 a / b / g / n / ac / d / h / l / k / r / w fast roaming, Bluetooth 4.1, 2.1 + EDR
IP	IP54, -20 ° C to + 50 ° C, can be dropped from 1.5 meters
Barcode scanner	1D laser imager barcode scanner, normal distance

2.5 Introducing a Barcode Printer

The third pillar of the system is the barcode printer, with which the barcodes generated by the ERP system can be converted into physical form. The label

printer is also a device designed and manufactured by Zebra Symbol that listens to the ZD220. Its predecessor is the Zebra GC420 label printer.

The Zebra ZD220 is an entry-level model among 4" printers. More specific parameters are (Table 3):

Table 3
More specific parameters

Component	Specific parameters
Type of printing	Direct thermal or thermal transfer printing
Resolution	203 dpi / 8 dots per mm
Print speed	102mm / sec
Memory	256 MB Flash; 128 MB SDRAM
Program language support	EPL, ZPL
Maximum print width	4.09 in. / 104 mm
Firmware (basic software)	ZPL II; EPL 2; XML

3 Calculation of Return for a Barcode Warehouse Management System

Besides the technical and technological evaluation, the implementation of the idea requires financial approval. The return on the investment may influence the selected solution or the services added to the system. The cost of setting up a barcode warehouse management system is HUF 25837559 (data based on 2023). It can be implemented only on its own or with the help of support. The barcode warehouse management system can be extended to all employees, but a version that is only extended to office employees can also be analyzed. Accordingly, four cases were examined. In case of A, we make the cost calculation for a barcode warehouse system paid for with our own capital, in which the project management module is built for the entire workforce.

In case of B, in addition to our own capital, we pay the costs from refundable state support, in which we want to expand the project management module to the full number of employees.

In case C, we pay with own capital, in which the project management module is extended only to office workers. In case of D, we are combined C and B.

A summary of our results is shown in Table 4. The economic evaluation of the investment is checked by some indicators [35], including:

NPV: Net Present Value [36]

IRR: Internal Rate of Return [37]

PI: Profitability Index

DPB: Discounted Payback Period [38] [39]

Table 4
Summary of our calculation results

	Case A	**Case B**	**Case C**	**Case D**
NPV (HUF)	5991000	2886000	13220000	10115000
IRR (%)	18.05	11.49	43.24	32.56
PI	1.23	1.11	1.71	1.54
DPB (year)	4.06	4.50	2.92	3.24

Based on the results obtained:

Case A, with the introduction of the barcode warehouse management information system, will show a return within 5 years, using only the company's own resources. The net present value (NPV) received is HUF 5991000, which is higher than HUF 0, so the investment is expected to increase the value of the company [40] and result in a positive net income in the 5-year period under review. The calculated internal rate of return is 18.05%, which is higher than the expected return of 6%. The profitability index was 1.23 in the calculation, which is greater than 1. The discounted payback period is 4.06 years, based on which the project will pay for itself in year 5. As the calculated and expected values are the same, this indicator also meets the expectations. Overall, Alternative A can be accepted.

Case B assumes that the introduction of the barcode warehouse management information system would return within 5 years by involving equity and repayable state support. The net present value obtained during the investigation was positive, 2886 HUF; therefore, an investment is expected to increase the value of the company. As a second indicator, we examined the internal rate of return, which was 11.49%. As this value is higher than the expected return of 6%, this indicator is also considered acceptable. Next, we examined the profitability index, which is 1.11. As greater than 1, it is considered acceptable. Finally, we calculated the discounted payback period, resulting in 4.50 years. The return on investment is also expected within the expected 5 years. In summary, option B is also acceptable for all indicators.

Case C assumed that we will extend the project management module in the expansion of the ERP system only among office employees in the structure of the barcode system, and thus the investment will return in 5 years. NPV for the case is HUF 13220000. This value is greater than zero and is therefore considered acceptable. The internal rate of return was 43.24%. The present result shows a higher return than the expected 6%. The profitability index was 1.71, which is higher than 1. The last time the discounted payback period was calculated, and the result was 2.92 years, which means that the investment pays off in the third year. The project must therefore be approved. In the case of C, all the calculated values

deviated in the positive direction compared to the set one, so we can accept this alternative as well.

Case D assumed that with the extended project management for office staff, the barcode warehouse management system would return in 5 years, financed from its own and repayable state support. The first indicator was the net present value (NPV), for which we received HUF 10115000. We then examined the internal rate of return, which gave a value of 32.56%. This result is higher than the expected 6% yield, so we also accept this final result. The profitability index is calculated at 1.54, which is greater than 1. The discounted payback period is 3.24 years. In summary, in the case of D as well, all indicators showed a corresponding value.

Conclusions

The case example showed that the problem must be dealt with in a complex manner. We know that there exist more modern technologies and there are many possibilities within them, but integration into the system is more important than the device. That is why we chose the tool described above. We made economic calculations for four investment alternatives. As the four investment alternatives met the exam requirements. However, one needs to choose the one that is best for ones' company.

Comparing all the indicators, we can see that Case C, provides the highest net present value, profitability index and internal rate of return. In addition, the return on the investment is the best in this case compared to the others. So, this alternative is best suited for a business that consists of nothing more than the introduction of a barcode warehouse management system with an extended project management module for office employees involving only equity.

But if we also take into account the subjective factor, that this system does not yet fully cover the possibilities of an integrated corporate management information system, e.g., a record of the working time associated with the bar code system to be introduced at a later date. Then, in that case, the best solution would be the first, Case A, which does not bring as much revenue to the business as Case C, but provides a more promising opportunity for further development for the company.

According to the research question, as to whether it is worth implementing the warehouse management system, the case studies of this paper provides confirmation. The return on the investment is within four years, which can be considered positive. This case study can serve as a sample for similar projects, including any evaluation methods.

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