Quantifying the impact of ERP malfunctioning in a manufacturing plant

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Abstract: Enterprise Resource Planning system (ERP) benefits for manufacturing companies have been praised for years and companies have become increasingly dependent on these IT tools. However, any malfunctions or temporary unavailability of the ERP can significantly affect the company business. The ERP obsolescence invokes the critical decision on whether to update, upgrade or substitute it. When these operations require significant investments, a timely evaluation of the advantages and disadvantages is needed. In this paper, we present a methodology to quantify the economic loss caused by the malfunctioning of an ERP supporting a manufacturing plant. The research took cue from a real case of a world-famous multinational company of the automotive industry. In this case, the maintenance contract supporting the previous system expired and the company experienced significant inconveniences by delaying the introduction of a new ERP. Hence, the main functional features of an ERP in a production plant processes are listed, and the potential hindrances due to the information system malfunctioning are classified in four critical macro-categories: production planning, manufacturing operations management, materials management, warehousing and inventory control. The contribution of the paper resides in classification of the main operational losses due to ERP malfunction in a generic manufacturing site, on top of proposing possible criteria for estimating the related economic losses, based on the issues faced during the real-world scenario.

Keywords: ERP, technological failure, operations management, production planning, materials management

1. Introduction to ERPs

The key role of Enterprise Resource Planning systems (ERPs) in industrial companies is well acknowledged (Tsai, et al., 2012; Černá, 2014) and recent advancements in IT, such as Web 2.0, have increased this systems' efficiency (Grabot et al., 2014). Although ERPs benefits, some drawbacks do exist. Indeed, the implementation of an ERP information system is a complex undertaking, and several studies focus on related problems: Tsai et al. (2012) state that investigations into ERP are popular especially due to the high failure rate in their implementation. A survey carried out on 141 projects in the 2004-2006 period shows that the average time for the installation of an ERP is about 16 months and that 90% of ERP implementation projects end later, when this delay is about three times longer than the original scheduled time on average (Santamaria-Sanchez et al., 2010). Mua et al. (2015) list the main reasons that lead to failures in ERP implementation. However, researchers have focused their attention mainly on the phase before or immediately after the installation of the system, highlighting difficulties and benefits. The ERP post-implementation phases seem to not be deeply explored (Ruivo, et al., 2015).

This paper focuses on the last stage of an ERP life cycle, when an updating is needed. Indeed, any temporary absence or malfunction of the ERP impacts on the companies' processes, with economic consequences. A method to quantify the losses that a manufacturing enterprise may face in case of ERP malfunctioning is here proposed: first, the main operational processes under the ERP control in a manufacturing context are recalled. Then, the eventual problems originating from its malfunctioning or absence are analysed and estimation criteria are described. Finally, an application to a leading company in automotive industry is presented.

1.1. ERP benefits

According to the main producers of ERPs, the major benefits that a company can expect are related to the increased availability of data, improved business efficiency responsiveness and flexibility (Kennerley & Neely, 2001; Holsapple & Sena, 2005). Some studies suggest that ERP can contribute in improving economies of scale (Mitra & Chaya, 1996), making business transactions efficient (Johnston & Lawrence, 1988), timely reporting information in decision-making processes (Simon, 1955) and business performance (Zmud & Apple, 1992), decreasing the maintenance cost for communication channels (Cash & Konsynski, 1985). Earl (1989) underlines how ERPs can facilitate the achievement of strategic objectives in terms of business growth, differentiation, innovation, and partnerships. Davenport (1994), McKay & Brockway (1989) and Weill & Broadbent (1998) focus on infrastructural benefits, by pointing out that the integrated architecture of ERPs can guarantee flexibility to business changes.

Though the benefits of ERP are often described, it is not easy to assess and quantify how these are translated into tangible and economic advantages. According to O'Leary (2000) savings are mainly due to the integration among managerial functions and the increase in information availability. Kennerley & Neely (2001) indicate a general distributed savings on overheads. Davenport (1998) and Shang & Seddon (2000) point out productivity, quality and process yield increase. De Masi et al. (2006) highlight the savings from the increase of internal process accuracy. Rockart & DeLong (1988) focus on analytical capabilities. Poston & Grabski (2001) argue that benefits are expected

to arise mainly by reduction in employees' costs.

1.2. ERP in Operational process

The paper focuses on manufacturing enterprises and specifically on production plants; in this context, the operational processes mostly dependent on the ERP are production planning, manufacturing operations management, materials management, warehousing and inventory control processes. Indeed, most of the ERPs implemented in medium-large manufacturing plants include the modules dedicated to the automatic execution of these specific processes. Therefore, the processes that may be impacted the most by malfunctioning or absence of a ERP have been selected. Focusing on manufacturing sites, those processes performed at company level (e.g. sales planning, distribution, forecasting, etc.) have been excluded from the analysis, as well as those processes not falling within the scope of operations management (e.g. controlling, financial accounting, etc.)

1.2.1. Production planning and manufacturing operations management (MOM) processes

Within these processes, an ERP typically executes master production scheduling and shop floor control. Here, ERPs increase the efficiency by integrating processes and effectively sharing information (Sadrzadehrafiei, et al., 2013). That allows to assess the feasibility in executing the master production plan. Moreover, thanks to scheduling optimization, the system positively impacts the allocation of resources, reduces production downtime and supports logistics and inventory management (Weill & Broadbent, 1998, Rai & Hornyak, 2013).

Hence, the absence of the system makes it difficult to punctually evaluate the available production capacity and, therefore being able to efficiently fulfil the order requests. Moreover, the system lacks forces to manually execute the processes and therefore, increases occurrences of errors. To overcome these disadvantages, the employees' workload in production planning may intensify and eventually the number of allocated staff may increase.

1.2.2. Material Management process

Material management in manufacturing can be approached according to look-ahead or look-back logics. Look-ahead logic is commonly used in automotive industry and its typical implementation in ERPs is through the Material Requirements Planning (MRP) algorithm (Boersma & Kingma, 2005, Berchet & Habchi, 2005). Analogously, MRP is the common name for the ERP module which computes the net material requirements and define production and sourcing plans. It considers customer orders, the Bill of Materials (BoM) - the list of all components, sub-assemblies, semi-finished products and raw materials needed for each product - the inventory levels, and production and purchase lead time. The MRP module has been recognised to reduce product cost, helping in inventory reduction by improving the processes of releasing supplying and production orders, aligning the incoming and outgoing flows (Kennerly & Neely, 2001, Poston & Grabski, 2001). The ERP improves communication and integration among the suppliers, customers and operators involved in material management processes (Davenport, 2002). In addition, an ERP, by avoiding errors, delays, omissions and misunderstandings can increase the customer service level and satisfaction (Wieder & Davis, 2003)

The absence of a system able to properly support the procurement process result in manual execution of its activities and may intensify the employees' workload and the inaccuracies. Therefore, any bug in the MRP process can cause significant economic damages.

1.2.3. Warehousing and inventory control process

Within these processes, the ERP can take care of managing warehouse storage locations and monitoring the goods inventory level, eventually triggering re-orders to suppliers. Thus, it integrates the procurement processes (purchase, production, sales, inventory management and accounting) and provides transparency by allowing better inventory tracking and monitoring. Therefore, it reduces the consumables materials cost as well as the cost of subcontracting personnel, purchasing cost, and finally the warehouse cost. On top of this, raw material, parts and components supply processes managed with look-back logic are also triggered by the inventory control feature. Matolcsy, et al., 2005, analysed the economic benefits of implementing an ERP and emphasizes the impact on operations by measuring the increase in inventory turn and the improvement in logistics, distribution and supply processes. The upstream and downstream production processes integration minimizes the working capital and, hence, it reduces the possibility of stocking obsolete materials (Rizzi & Zamboni, 1999, Davenport et al, 2002; Shang and Seddon, 2000).

Any inaccurate assessment of the inventory levels has a potential economic impact. The lack of a system that precisely monitors the inventory level can reasonably generate an inappropriate increase in stock or stock-out events. If the warehouse management process is manually executed, it may be particularly long and a risk of error is present.

2. Method for quantifying the impact of ERP malfunction in a manufacturing plant

In this section, the method to asses and quantify the main economic losses due to the lack of the ERP is detailed. First, the general assessment to be performed in a company that aims at identifying the economic losses is introduced. Then the loss quantification is described according to the four main operational processes and their difficulties. Clearly, a percental factor to consider only the influence of ERP on the loss must be appropriately estimated.

In order to quantify the economic loss, a company should first identify the time reference period. The analysis must be constrained to the period which is defined by the time the system started working improperly till the moment it was fully available to be used again. The existing problems in the reference period must be identified and the evidences and reports must be gathered. The personnel involved in the four main operational processes must be interviewed to determine the difficulties and inefficiencies faced by the company. Lastly a drawbacks/benefits gap analysis must be carried out. Indeed, the way the ERP

managed the processes when it perfectly worked and the way the processes were managed without the system must be compared. Finally, data and evidences must be gathered in order to quantify the identified problems. Some hypothesis or assumptions may be needed if all the data is not available.

2.1. Quantifying the economic impact

Most authors dealing with the impact of ERP on operations efficiency focused on the possible advantages originating from its installation. No specific contributions seem to be present in literature listing the eventual drawbacks deriving from its malfunctioning. The following table lists the major contribution on the first side, clustered according to the four operational process activities previously identified.

Table 1: Main operational advantaged from ERP support

C1 Production planning process
Better production plan and schedule (Sadrzadehrafiei, et al., 2013)
Improves in resources allocation (Weill & Broadbent, 1998; Sadrzadehrafiei, et al., 2013).
Decrease in delays/errors in fulfilling orders. Increase in 'available to promise' capability (Chand et al., 2005)
C2 MOM process
Reduction of production cycle time (Weill & Broadbent, 1998; Rai & Hornyak, 2013)
Reduction of lead time and quality costs. Increase in operations efficiency, reduction in maintenance downtime (Sadrzadehrafiei, et al., 2013)
C3 Material management process
Improvements in on-time delivery, reduction in work stoppages caused by lack of parts (Chand et al., 2005)
Improvements in communication and integration among the suppliers, customers and operators (Davenport, 2002)
Improvements in logistics, distribution and supply processes (Matolcsy, et al., 2005)
C4 Warehousing and inventory control process
Increase in inventory turns (Matolcsy, et al., 2005)
Reduction in working capital and in obsolete materials inventory levels (Rizzi & Zamboni, 1999, Davenport et al, 2002; Shang and Seddon, 2000).
Reduction in inventory carrying costs and stock-outs, increase inventory availability rates (Chand et al., 2005)
Reduction of inventory level and improvements in inventory management (Sadrzadehrafiei, et al., 2013, Weill & Broadbent, 1998; Rai & Hornyak, 2013).

Based on this literature review and on the analysis of the specific industrial case, a list of potential economic losses deriving from ERP malfunctioning was generated and it is showed in the following table. In order to point out the entity of the economic loss, each macro-process has been further divided into a sub set of causes.

Table 2: Main operational losses due to ERP malfunction

C1 Production planning process	
C1.1	Losses due to imprecise assessment of the available production capacity
C1.1.1	*Losses due to missed production opportunities caused by of underestimation of production capacity*
C1.1.2	*Losses related to overtime work hours caused by overestimation of production capacity*
C1.1.3	*Losses related to production lines inefficiency caused by undesired rescheduling*
C1.1.4	*Losses due to unaccomplished production orders*
C.1.2	Losses related to increase in the employees' work time generated by manual activities
C2 MOM process	
C2.1	Losses due to issues in production execution
C2.1.1	*Losses related to reworks*
C2.1.2	*Losses related to slowdown and micro-stops*
C2.1.3	*Losses related to production rescheduling and consequent delays*
C3 Material management process	
C3.1	Losses related to increase in the employees' work time generated by manual activities
C3.2	Losses related to missing or obsolete parts
C3.2.1	*Losses related to obsolete codes substitution*
C3.2.2	*Losses related to obsolete codes destruction*
C3.2.3	*Losses related to unplanned transportations caused by delivery delays and scraps*
C4 Warehousing and inventory control process	
C4.1	Losses related to increase in inventory levels
C4.1.1	*Losses related to increase in storage space*
C4.1.2	*Losses related to increase in stockholding costs*

2.1.1. Losses in production planning process

The economic losses to be quantified in production planning process are mainly connected to the imprecise timely assessment of the available production capacity and to the increase in employees' effort. The first losses can be detailed by considering four main causes. Firstly, the decrease in produced volumes due to the underestimation of production capacity (C1.1.1) must be considered. Excluding the possibility to resort to subcontracting or backlogged orders, this can be estimated by comparing the requested volumes with the agreed and defined volumes in delivery plans. The identified gap can be valued by considering a contribution margin of each specific product. Then, the increase in production cost due to the overestimation of production capacity (C1.1.2) can be computed using the overtime work hours. Moreover, the efficiency of production lines may be reduced due to the frequent modification in plans, and therefore, the production cost (C1.1.3) may increase. This cost can be estimated by considering an incremental value of inefficiency in production lines on the base of modification frequency in production rate. The inefficiency must be valued at the production standard cost, that is the processing cost, excluding the materials and components cost and the overtime cost, already taken into account. Then, the expected reduction in profit due to unaccomplished production orders (C1.1.4) can be computed by comparing the scheduled and the actual production plans. The unaccomplished orders must be valued considering the contribution margin per product. Finally, the increase in employees' effort for production planning activities (C1.2.1) can be quantified by considering the increase in the resources involved in those activities.

2.1.2. Losses in manufacturing operations management (MOM) process

According to the identified problems in production management process the main economic impacts to be quantified are the ones caused by the missing components. Among these, ERP malfunctions may lead to cost for reprogramming the production schedule and the consequent delay in completing finished products (C2.1.3), due to slowdown and micro-stops (C2.1.2), and due to reworking products (C2.1.1) are the most relevant to be taken into account. Indeed, note that slow-downs, micro-stops and reworks are among the big losses of the Overall Equipment Effectiveness manufacturing operations key performance indicator (Nakajima, 1988).

2.1.3. Losses in material management process

Considering the problems identified in material management process, the main economic losses to be quantified can be synthesized in the greater efforts asked to employees assigned to the execution of the process, and the generation of obsolete and missing codes. The first cost can be easily computed, as indicated above for the same category but by considering the material management process (C3.1.1). The generation of obsolete codes may lead to an increase in supplying cost (C3.2.1). Moreover, the cost of destruction or dismissing (C3.2.2) obsolete codes must be considered. Finally, a stock-out cost (C3.2.3) connected to the delays caused by missing components may be incurred.

2.1.4. Losses in warehousing (WHS) and inventory control process

The main economic losses to be quantified in warehouse management process linked to the used storage space and the misalignment between the physical inventory and accounting inventory were analysed. Both the economic losses are due to the increase in stock levels and can be easily computed by the use of scientific literature. In fact, the literature estimates an advantage of using management software in terms of stock reduction as an average ratio of 30% (De Masi, et al., 2007). A higher stock level can increase the stocking used space and may consequently lead to an increase in the warehousing cost (C3.1.1). In addition, the immobilized working capital in materials and components increases. The cost (C3.1.2) can be computed by multiplying the same estimated coefficient by the economic value of the average working capital. Therefore, these costs don't need the estimated percental factor.

3. Case study

In the below subsections, first, an introduction to the target company and to the context is presented. Then, the economic losses are identified according to the proposed method. The name of the company as well as the economic results are not mentioned due to a confidentiality agreement.

3.1. The context

The proposed method was applied to a production site of a leading company in the automotive industry. The company has operations worldwide and several production sites. The reference period started when the service contract between the target company and its ERP supplier ended. The company was already informed about the need to upgrade or replace the ERP in the previous period, as starting from the expiring date the supplier wouldn't provide any maintenance. However, the target company delayed the introduction of the new system. The selection of a new supplier, the design of the new system and its full implementation took months longer than what the company expected. During the reference period, the ERP didn't properly support the company business and many inefficiencies arose. The company was therefore interested in determining the economic loss it was suffering due to the lack of a proper working ERP.

3.2. The methodology

The proposed methodology was applied:

1) Analysis of the ERP processes map, i.e. the processes under the ERP control and the type of support provided by the systems;
2) Interviews with each of the process owners, to list the problems experienced by the company during the identified reference period;
3) Design of an operational losses framework and of cost attribution models, collection of data and evidences;
4) Losses quantification based on a gap analysis comparing how the system managed the processes when it was perfectly working and when it was totally or partially unavailable;
5) Validation of the methodology and of the final results with the company's top management.

The data was gathered from company database extractions and from managerial accounting internal reports. The analysis considers the costs on an annual basis. In case of data partially missing or incomplete, some hypotheses were needed and data was prudentially inferred and shared with the company management. The panel of interviewed people in the company included: the managers of the Warehouse, Purchasing, Logistic, Finance and HR department, the Business and Cost Controllers, and a software engineer, being unavailable the Production Planner and the Site Manager.

3.2.1. Production planning process

The first cause analysed was the decrease in produced volumes due to underestimation of capacity. Unfortunately, negotiations between the factory and the headquarter for generating plans were carried out in an unstructured way, and historical information to determine the deviations from the requested production was not available. The frequency of deviation was confirmed by the respondents, but the lack of evidence didn't allow to precisely quantify or roughly estimate the loss.

Then, as the production capacity was overestimated, the cost due to overtime work hours, was considered. The documentation reported the incurred overtime cost during the period. By observing the irregularly produced volumes per month, the overtime costs should have been fully recognized as inefficient. But the casual factor related to this specific issue and process was prudentially estimated as 50%, meaning that a properly functioning information system to support the production planning process would have reduced the need for overtime work by 50%.

$$C_{1.1.2} = \text{average overtime cost per year} \cdot 50\%$$

Then, the loss due to frequent changes in production plans was investigated. The changes in production plan, was indicated by respondents to be a spread practice during the reference period. But, as timely reports were missing, assumptions based on available data were needed to quantify the loss. Considering a monthly average, the production rate was modified, to make the production compliant with the delivery plan for 10.2% of the total time. The incremental inefficiency value of the production lines was considered no less than 10%, based on the specific industry characteristics. The transformation cost was provided by the company for the reference period as an average amount per year. The annual overtime cost was then excluded by this cost, as it is already considered in C1.1.2. The interviewed personnel reported that at least 60% of the changes in the production plan was due to malfunctioning of the information system

$$C_{1.1.3} = \text{net transformation cost per year} \cdot \left(1 - \frac{1}{1+10\%*10,2}\right) \cdot 60\%$$

The margin reduction due unaccomplished production orders were computed according with the following assumptions and the available data. On average 300 vehicles were removed from the production plan every year. The profit margin of each vehicle was declared between a maximum and minimum value. But, punctual evaluation was not possible, then the minimum value was conservatively selected. No more than 10% of the excerpts were judged to not be related to ERP malfunctioning. Therefore, the percental factor was set to 90%,

$$C_{1.1.4} = \text{margin per vehicle} * \text{average numb of vehicles per year} \cdot 90\%$$

Finally, the interviewed staff revealed that during the reference period, the management of production planning activities was assigned to a minimum of two full-time employees. The causal contribution of the absence of an adequate information system on the commitment of human resources for the management of production planning management activities was estimated as 50%.

$$C_{1.2.1} = \text{employee cost per year} \cdot \text{number of employees} \cdot 50\%$$

3.2.2. Manufacturing operations management process

Information about anomalies due to missing components was provided for the entire reference period. For each year, the average rework time needed in minutes, the missing component that generated the need for a specific rework and the number of occurrences of such failure is shown in the document.

The production lead time increased as the parts had to wait for being offline reworked due to missing components. The collected data reported the value of average waiting time per year. By considering the average hourly cost of a production operator, the average annual cost of off-line rework due to the lack of parts was computed. The amount of reworks resulted in 14% of the average annual production. 5% was estimated to be physiological (percentage of pending rework in a production plant in the same sector) while 9% is connect to problems in the ERP. Therefore, 64% of the total cost was estimated to be due to the absence of a properly working ERP software

$$C_{2.1.1} = \text{average waiting time per year} * \text{employee cost per time unit} \cdot 64\%$$

The costs due to slowdown and micro-stops, and the cost for reprogramming the production schedule due to the consequent delay could not be estimated as precise and timely data reports were missing.

3.2.3. Material Management process

The raw material and component supplying process was impacted by inefficiency and inadequacy of the installed MRP module. Therefore, the use of the MRP module during the reference period was minimized, and, accordingly, the most critical part of the process execution was manually carried out. The activities were usually performed twice: the orders were manually computed on an Excel spreadsheet and the obtained results were loaded on the ERP information system to check for any discrepancies with the orders generated by the MRP module. The described process took much longer than the automatic process performed by MRP module and inevitably inaccuracies were spread.

Respondents reported that during the reference period, two operators were fully dedicated in defining supply orders through the spreadsheet. The absence of an adequate system on the commitment of human resources for the management of production planning management activities was estimated to contribute 50%.

$$C_{3.1.1} = \text{employee cost per year} \cdot \text{number of employees} \cdot 50\%$$

The economic loss related to the supplying of obsolete codes was estimated only through the respondents' answers, as there were no recorded evidences. The economic loss due to the release of supply orders for components already declared obsolete, due to the lack of adequate updated procedure in the ERP, was quantified by respondents and clearly, the absence contributes completely in generating obsolete codes.

$$C_{3.2.1} = \text{obsolete codes supplying cost} \cdot 100\%$$

The economic loss related to destruction of the obsolete codes during the reference period was provided. The percentage that reflects the contribution of the absence of an appropriate information system in generating production excerpt, was estimated to be at least 10% meaning that almost 90% of the causes of obsolescence are due to factors not related to the lack of an adequate information system

$$C_{3.2.2} = \text{obsolete codes destruction cost} \cdot 10\%$$

Finally, the increase in transportation cost due to components stock-out was analysed. The documents related to the transport has been provided for the entire reference period. The average total cost per year was computed. Considering the specific process, a percental causal factor of 90% was brought back to ERP malfunctioning.

$$C_{3.2.3} = \text{unplanned transportation cost} \cdot 90\%$$

3.2.4. WHS and inventory control process

The company used an external warehouse for storing materials and components and it paid only for the used space. The increase in storage levels can be directly

computed by multiplying the annual cost incurred for the storage service by the 30%. Therefore, the financial loss due to the larger occupied space caused by the lack of adequate support system to the warehouse management process, can be computed considering the monthly fees for the used square meter and the used space, multiplied by 12 months.

$C_{4.1.1}$ = *warehouse monthly rent per sqm· sqm·12 months·30%*

Finally, the average immobilized working capital in materials and components inventory was estimated by interviewing the personnel. Multiplying the value by the average weighted cost of capital, and by the 30% factor estimated according to literature, the increase in the working capital was computed.

$C_{4.1.2}$= *average immobilized working capital · cost of capital ·30%*

3.3. Economic impact of ERP absence

The quantification of the economic damage related to each activity caused by the lack of ERP modernization was carried out on an annual basis. It relied both on scientific and technical considerations, and on evidence provided by the company and interviews. Once the economic loss was determined for each activity, it was possible to compute the loss caused by the lack of the ERP in each operational process and, hence, the total economic damage suffered by delaying the implementation of the new ERP.

Therefore, the economic damage related to the lack of the information system updating in the selected company in the reference period was computed by summing the identified costs. The total industrial cost, sustained by the target company in the year before the ERP started working improperly, was compared with the computed annual average cost during the reference period. In the following table, the percental increasing (Δ‰) in cost is reported. Hence, it shows the potential saving the company could have gained by the use of an ERP

Table 3: Economic impact of ERP malfunction

Cost Category		Δ‰
TOTAL COST		2,5‰
C1 Production planning process		**0,84**‰
C1.1	Losses due to imprecise assessment of the available production capacity	0,77‰
C1.1.1	*Losses due to missed production opportunities caused by of underestimation of production capacity*	N.A.
C1.1.2	*Losses related to overtime work hours caused by overestimation of production capacity*	0,29‰
C1.1.3	*Losses related to production lines inefficiency caused by undesired rescheduling*	0,34‰
C1.1.4	*Losses due to unaccomplished production orders*	0,14‰
C.1.2	Losses related to increase in the employees' work time generated by manual activities	0,80‰
C2 MOM process		**0,05**‰
C2.1	Losses due to issues in production execution	0,05‰
C2.1.1	*Losses related to reworks*	0,05‰
C2.1.2	*Losses related to slowdown and micro-stops*	N.A.
C2.1.3	*Losses related to production rescheduling and consequent delays*	N.A.
C3 Material management process		1,23‰
C3.1	Losses related to increase in the employees' work time generated by manual activities	0,08‰
C3.2	Losses related to missing or obsolete parts	1,15‰
C3.2.1	*Losses related to obsolete codes substitution*	*0,33‰*
C3.2.2	*Losses related to obsolete codes destruction*	*0,10‰*
C3.2.3	*Losses related to unplanned transportations caused by delivery delays and scraps*	*0,72‰*
C4 WHS and inventory control process		**0,38%**
C4.1	Losses related to increase in inventory levels	0,38‰
C4.1.1	*Losses related to increase in storage space*	*0,20‰*
C4.1.2	*Losses related to increase in stockholding costs*	*0,18‰*

4. Conclusion and Discussion

ERPs are essential for efficiently managing a manufacturing site. Hence, their temporary lack or malfunction, impacts the proper manufacturing operation. The quantification of the loss due to the system absence is challenging and the problem doesn't seem to be widely described in literature.

In this paper, we proposed a method to determine the economic damage a company operating a manufacturing site may face if its ERP is not available or partially working. The method is based on consequential steps where the manufacturing process is first split into the main operational processes and then in main activities impacted by ERP. The method considers scientific reflections and hypothesis as well as specific considerations about the company subject to the analysis. The proposed methodology was then applied to a manufacturing site of a leading company in the automotive industry. The company didn't punctually plan the new ERP implementation and spent a period running the production processes without a fully operating system. Many activities performed automatically by the ERP were manually executed during the reference period. Consequently, the effectiveness and efficiency decreased and the generated errors propagated through the process.

This method helped the company in quantifying the economic losses per year. The percental factors determined and the cost computed are specific for the company the method was applied to. Hence, the reported values can't be considered significant even in the same industry; however, the analytical approach based on the categorization of the main losses that the method uses, is general and may be applied in all the companies facing ERP malfunctioning in a target period that are interested in quantifying the economic damaged suffered.

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