ISSN: 0128-7680

Pertanika J. Sci. & Technol. **19 (1)**: 77 – 92 (2011)

Product Structure Initialization, the Bottleneck of ERP Implementation in Customer Driven Environments: A Case Study

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ABSTRACT

This study of the implementation of enterprise resource planning (ERP) in a customer driven environment analyzes the critical success factors throughout the initialization phase. The dynamic and stochastic nature of customer driven environments results in a massive workload of product structure configuration tasks related to new arrivals on one hand and a constant updating process on the other. Meanwhile, the development and implementation of an ERP system was studied from the very first step (i.e. the feasibly study for implementing an ERP) to the last step (i.e. testing the outputs of the implemented system) in an office furniture company for three years. The study involved analyzing of the data collected that were from a series of interviews, as well as direct observations and reviewing of the company's documents. Based on the output of the analysis phase, a top-down hierarchical analysis of goals and CSFs were carried out according to the CSF analysis method. Three top level objectives included reducing project failure risk, project cost, and project time. Analysing the primary results of the study (i.e. activity model, data flow diagram DFD of different levels, system problems and potential solutions descriptions, etc.) revealed that the critical phase of the implementation project would be product structure initialization and this should be taken into consideration as the bottleneck of production planning in customer driven environment, which dramatically reduced the ERP efficiency in this kind of environment. Moreover, initializing issues of the same process is the main obstacle to the success of the ERP implementation, as it considerably raises the project failure risk and cost. Therefore, the simplification, facilitation, and automation of the PSCM process, which lead to acceleration of this process, are the most significant success factors for the ERP implementation projects in customer driven environment.

Keywords: ERP implementation, critical success factor, make-to-order, customer driven manufacturing, product structure configuration

INTRODUCTION

Customer satisfaction is the most significant objective for all goods and services producers in the contemporary competitive market. Today, many manufacturers depend on the enterprise's product characteristics and their customer expectations in related markets to decide whether to accept a customer's orders for producing products that are not in their standard product range or whether to customize their available products to have more satisfied customers.

Received: 18 November 2009
Accepted: 30 April 2010
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Furthermore, rapid changes in customer taste and the essential need to offer proper goods to satisfy the customer's new taste have driven the manufacturers to extend their offered product list. At the same time, they must maintain the history of their previous products, which is necessary for providing customers with after-sale support and for future references. This situation leads to the creation of customer-driven manufacturing enterprises that may produce goods and services which are more compatible with customers' requirements, but their performance is seriously affected by an ever-growing volume of product information (Jianxin Jiao and Tseng, 2004; Olsen *et al.*, 1997; Hegge and Wortmann, 1991).

On the other hand, emerging manufacturing tools and techniques require continuous adjustments to be made to the present manufacturing conditions. This then forces a manufacturer to design new products so their production processes are more compatible with or to design new manufacturing equipment and adjust old products to fit the new manufacturing conditions. Therefore, managers are constantly under pressure to improve their enterprises' performance and adapt to this wide range of change and uncertainty in order to perform better than their rivals in such a volatile and competitive market.

It is important to note that responsiveness and agility are two significant competitive advantages (Koh and Simpson, 2007) that should be taken into consideration in conjunction with satisfying a customer‘s desired quality, design, and functionality. In other words, delivering a customized product according to the customers' requests within a shorter lead time is desirable (Jodlbauer, 2007).

Enterprise resource planning (ERP) systems, due to their comprehensive coverage of the vast majority of an enterprise's business processes, have attracted managers' attentions as the most effective tools to be used in increasing an enterprise's agility, particularly in production planning and control processes (Koh and Simpson, 2007).

Many surveys have revealed that despite the potential value of ERP as a business process management tool, volatile manufacturing conditions in make-to-order (MTO) environments and, consequently, heavy and unpredictable workloads, result in poorly utilized ERPs. These surveys also indicate that a production planning process (including production scheduling and material resource planning), as the heart of the system, deals with more problems than other functions (Koh and Simpson, 2007; Berglund and Karltun, 2007; Vollmann *et al.*, 1997). It is obvious that product structure information is so important that without sufficient and accurate product structure information, all kinds of planning (including material requirements, human resource requirements, scheduling and financial resource planning) are actually impossible.

Hence, product structure initialization is a mandatory prerequisite for all the other tasks in the implementation project, so it should be taken into account as a critical task (Hernandez Matias *et al.*, 2008; Koh and Simpson, 2007; Persona *et al.*, 2004). Improving the product structure configuration and modification (PSCM) process performance through simplifying, facilitating, and automating this process in possible areas is expected to pave a way for an ERP implementation project and reduce the project risk and its cost.

Considering the fact that material requirements planning (MRP) has a fundamental role for manufacturing resource planning (MRPII) and ERP, using these systems as a type of production planning and control tool leads to an identical outcome (Koh and Saad, 2003: 2002; Enns, 2001), and that the PSCM process has been located at the heart of this group (i.e. MRP, MRPII, and ERP), while all these systems can benefit from any attempt on the PSCM process improvement.

From a different angle, Berglund and Karltun (2007) surveyed a production-scheduling process in four companies and concluded that the outcome of the scheduling process was influenced by the scheduler adding human capabilities that could not be automated. This means that the improvement in the system performance will positively affect the scheduler's efficiency as a human resource, which is expected to raise the overall performance of the enterprise.

In sum, the conclusion drawn from reviewing the literature of ERP employment in MTO manufacturing environments (Hernandez Matias *et al.*, 2008, Berglund and Karltun, 2007; Koh and Simpson, 2007; Beheshti, 2006; Persona *et al.*, 2004, etc.) implies that this kind of environment is mainly facing problems related to product structures in two separate phases, as follows:

- Product structure database initialization
- PSCM process throughout ERP utilization

Meanwhile, problems in the initialization phase are related to processing a massive volume of information on product structures that must be entered into the database quickly and under the pressure of a constant and heavy flow of new arrivals. The difficulties in this particular phase considerably raise the implementation failure risk and its cost. In addition, problems in the utilization phase also originated from this heavy workload as well as a modification workload arising from internal elements that aggravated the pressure on the PSCM process and created a bottleneck in the production planning process. This bottleneck increases the delivery lead time, which is the most significant performance indicator for customer driven enterprises and paralyzes the scheduler as a human resource.

The expected results of simplifying, facilitating, and automating the PSCM process are as follows:

- Implementation failure risk and cost reduction
- Delivery lead-time reduction
- Increased scheduler performance and enhanced system reliability through a reduction of the amount of inaccurate and defective information
- Enhanced system reliability through a reduction of the amount of information that is not reflected in the system

This paper focuses on the ERP problems in connection with the PSCM process through the initialization phase. In addition, an analysis of the potential destinies of the implementation project and the risks and success factors, which are expected to reduce the failure risk and cost of the project, will also be given.

MATERIALS AND METHODS

Method

Manufacturing systems in the wood industry are some of the finest types of systems to track and investigate business management tool issues and customer driven manufacturing systems. This is due to the complexity of production processes, as they deal with products with many variants (e.g. colour, material, options, dimensions, etc.) and they have a make-to-order attitude. Many other studies have already chosen the wood industry to test their hypotheses (e.g. Hernandez Matias *et al.*, 2008; Carlson and Yao, 2008; Berglund and Karltun, 2007).

The development and implementation of an ERP system were studied from very first step (i.e. the feasibly study for implementing an ERP) to the last step (i.e. testing the outputs of the implemented system) in an office furniture company for three years. The case company was one of the pioneer office furniture manufacturers in Iran. When its Board of Directors decided to considerably extend their offered product list and accept the newly-designed customer orders, a measure was taken to defeat their rivals in the market, and they were no longer able to use only the Excel spreadsheets in their production planning process.

After a comprehensive feasibly study, the company came to the conclusion to invest in a tailored ERP. This was because none of available ERPs on the market could match the company's requirements within its budget. The first author had participated in the ERP development as a system analyst and consultant through system development and different stages of the implementation. This direct engagement with the related issues provided the author with a comprehensive overview of the problems and the success factors in this scope. As the development project was carried out according to the structured systems analysis and the design method (SSADM V4), the outputs of the analysis and modelling phase provided the authors with all critical success factors (CSFs) analysis requirements.

A brief review of the analysis phase may provide a better perception of references on CSF analysis. According to the SSADM method, the analysis phase includes analyzing the current situation to find out how the current system works and to diagnose the current problems (Weaver *et al.*, 1998). This process involves analyzing the data collected from a series of interviews and direct observations and reviewing of the company's documents. The following steps are parts of this stage:

- Develop a business activity model: A model of the business activity is built, while business events and rules are investigated as inputs to the specification of the new automated system.
- Investigate and define requirements: The objective of this step is to identify problems associated with the current environment that are to be resolved by the new system. It also aims to identify the additional services to be provided by the new system and users of the new system.
- Investigate the current processing: The information flow associated with the services currently provided is investigated and described in the form of a data flow model. At this point, the data flow model represents the current services with all their deficiencies.
- Investigate the current data: This step is to identify and describe the structure of the system data independently of the way the data are currently held and organized. It produces a model of data that supports the current services.
- Derive a logical view of current services: The objective of this step is to develop a logical view of the current system that can be used to understand problems with the current system.

Based on the output of the analysis phase, a top-down hierarchical analysis of the goals and CSFs were carried out according to the CSF analysis method. The mission statement was "implementing the developed ERP within one year and with a determined budget." Thus, three top level objectives were defined (i.e. reducing project failure risk, project cost, and project time). Having in-depth system specifications (i.e. activity model, data flow diagram DFD of different levels, system problems, and potential solutions descriptions, etc.) showed that the critical phase of the implementation project would be product structure initialization. A detailed analysis revealed that simplifying, facilitating, and automating this process in the ERP could directly satisfy the top-level objectives. This was shown later in practice through the implementation project. The sequence of the methodology is clearly illustrated in *Fig. 1*.

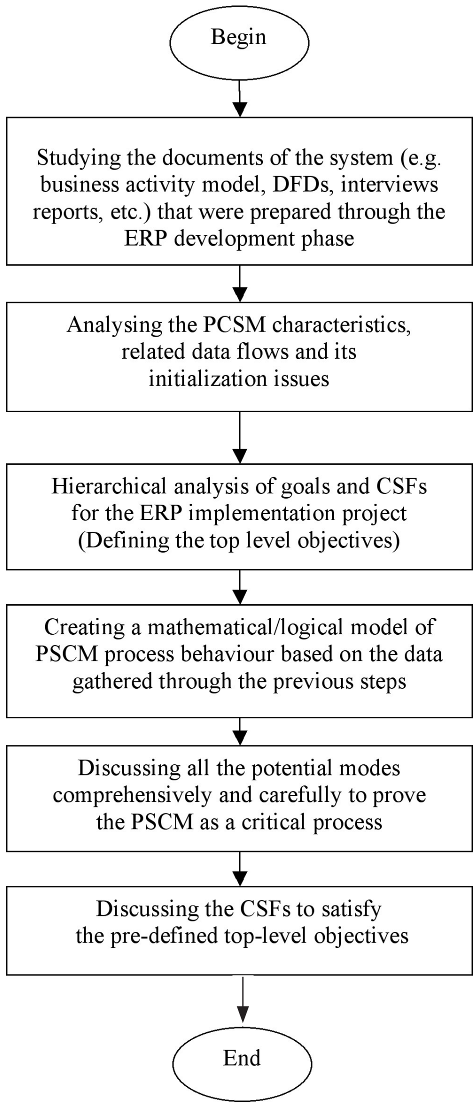

Fig. 1: The flowchart of the methodology

Company's Description

In this section, the case study company is briefly described, including a brief history of the company's improvements in connection to its information systems. The case company is one of the pioneer office furniture manufacturers in Iran which was founded in 1996. The development of the company was quicker than expected because of the special attention paid by its founders to exploiting modern managerial tools and methods.

The company attained the ISO 9001 certificate in fall 2002, as a result of practicing the standard requirements throughout the company. Two years later, the company was granted "the best product quality manufacturer" and was given a crystal statue by the HOFEX council during the Annual Office and Home Furniture Fair in 2004.

The company offered a range of computer and printer desks and a limited range of office furniture at that time. The production planning process was manipulated by three workers (the scheduler, his assistant, and the production planning supervisor) using several MS Excel spreadsheets.

The fair in 2004 was a critical point in company's history, in which the Board of Directors had decided to extend the range of products offered to compete against other companies. They did this by adding more office furniture models and office partitions.

In addition, the company also accepted all the new design requests and big furnishing projects (including purpose-designed products). This main competitive policy led to a substantial increase in production planning workload. A backlash was expected at this time because the workload was no longer manageable with the available resources.

Apart from the effects of the above strategic decision, the normal increase in production planning workload caused new problems in this process, originating primarily from its major sub-process (i.e. PSCM). Increasing the workload on the PSCM process partially paralyzed the spreadsheet-based production planning system. Eventually, the Board of Directors decided to conduct a feasibility study to implement an ERP system as a way of addressing the situation. Thus, a six-month analysis was carried out on the company's workflow and its production planning characteristics, as well as the requirements and an evaluation of available ERP systems on the market which revealed that none of the available alternatives could cover all of the company's requirements. This was particularly true in the PSCM process and the Board of Directors came to the conclusion in early 2005 that they should invest in developing a tailor-made ERP system.

At that time, the company already had approximately one hundred employees, of which twenty were white-collared. The company also had approximately 50 basic products, excluding different colours (i.e. each item was available in five colours on average), and out of which five were available in two different dimensions, which made the total 300 distinctive products. In addition, the same products might be available with different options in terms of functionality and some of them were available in two different materials (i.e. chipboards and medium-density fibreboards or MDF). This further increased the total number of variants to 450 distinctive items in terms of their model, colour, material, options, and dimensions.

Although many of components were used in several products, the available system did not allow the production planning team to re-use them in several structures. This meant that one product structure per variant was to be filed and thus, there was an archive of one hundred thousand data records, considering the fact that each product underwent 220 production processes on average.

Obviously, dealing with such a large volume of data was too demanding and caused many mistakes, which further spread to other parts of the system in spite of the hard efforts on the part of the production planning team. This massive amount of data, all of which needed to be entered into the new ERP database, were the main obstacles to implementing the available ERPs.

The trends in the company's performance indicators were not desirable, and putting more pressure on the system would have caused them to become even more negative. From the annual inspection reports of ISO9001, one could see that the promised delivery time, a main key performance indicator (KPI) of the company, was seven working days during this era (including one day for taking orders, five days for production planning, out of which, four days were used for product structure configuration and one day was used for the final assembling and delivery). This length of time caused them to be overdue in 42% of the cases, out of which 33% were due to issues related to product structure configuration. As product structure information was a mandatory prerequisite for any planning activity, utilizing the ERP was impossible prior to the launching of the PSCM process, so product structure initialization was apparently and undeniably a critical task.

Beyond the company's performance indicators, delays statistics and overall workflow diagrams suggested that the PSCM was the main bottleneck of the business processes and its performance directly affected the company's overall performance. This situation drove us towards paying particular attention to analyzing the PSCM issues and their essential role in the success of ERP implementation.

RESULTS AND DISCUSSION

The PSCM Process Characteristics

The term "product structure" in the case company is a collection of all the required resource information for producing a specified product, including the related production process characteristics that are presented in a hierarchical manner with defined process priorities.

The product structure was documented in a tree format, where every non-leaf node was representative of a production process (e.g. E, I, F, etc. in *Fig. 2*) related to a corresponding workstation and had a specified duration. In this format, the result of any production process comes out as part of its direct parent. The nodes located in the lowest level in any branch (i.e. leaf nodes) of this structure are raw materials (e.g. L, M, N, K, C in *Fig. 2*) and this provided the production planner with the information required for material resource planning. Parent-child relationships define process priorities that located at the different levels of the structure.

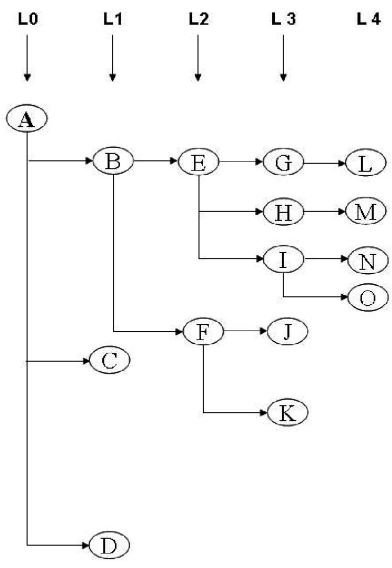

Fig. 2: A conceptual scheme of the product structure in the case company

Each node was recorded as a row in the company's Excel spreadsheets, bearing its specifications, including the process code, the work station, the process time, the parent node code, the consumption rate, the outcome component code for non-leaf nodes, as well as the raw material code for the leaf nodes, and a descriptive data field in some cases. The parent code of each node established a hierarchical relationship among the nodes, which was interpretable in a tree structure manner (see *Fig. 2*).

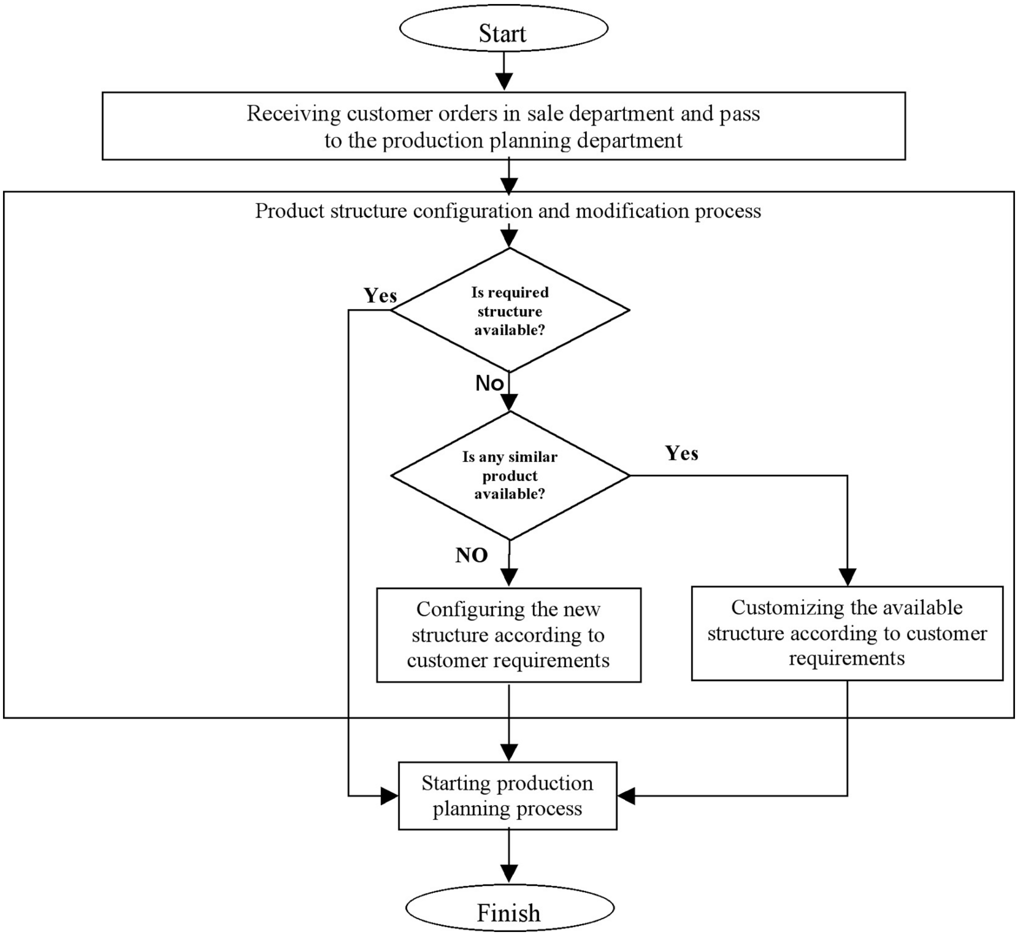

Fig. 3: Routine workflow of the PSCM in the case company

The number of nodes varied from approximately one hundred (for some plain computer desks) to more than four hundred (for some of more complicated models of office furniture), depending on the complexity of the products. The average number of rows per product was 220, as previously reported. The structure information of the products was independently archived in separate worksheets, despite the fact that there were many identical components in the different products which could have been summarized. *Fig. 3* illustrates the PSCM routine workflow in the company.

As illustrated in *Fig. 3*, the PSCM process includes technically comparing customers' requirements with available products to find an identical or similar product. Meanwhile, minor or major modification or a complete configuration might be required, depending on the differences of the volume.

Configuration of a new product comprised of a range of decision making tasks based on the information available that is scattered among several worksheets and the personal experience of the production planning team members. The output of the process included in-depth manufacturing specifications for a given product. These specifications comprised of the required materials, production processes, production priorities, input and output of each process, consumption rates, and basic materials.

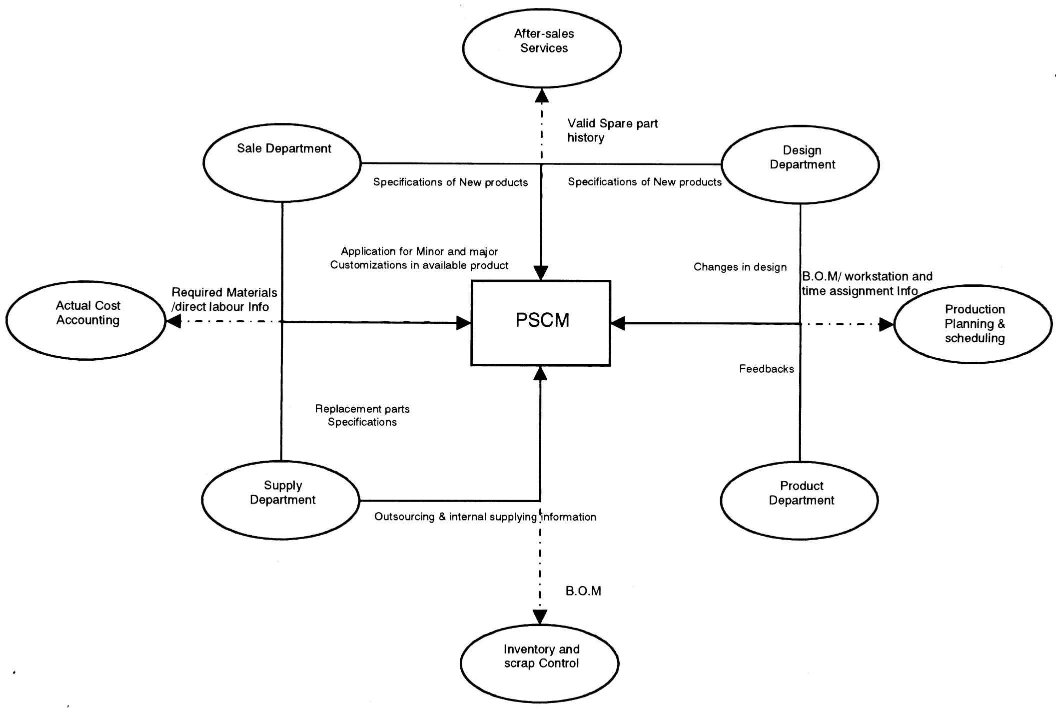

Fig. 4: Context-level data flow diagram (DFD) related to the PSCM process

According to the concept of the customer-driven manufacturing, the customer is the most significant source of data for the product structure configuration and modification (PSCM) process. Unlike make-to-stock environments or mass production, the production planning department in the make-to-order environment is dealing with a continuous flow of customer requests that may lead to specifying a completely new product structure, as well as minor or major customizations in the structures of the available products.

As stated earlier, the company's competitive strategy entails offering new, designed products to the customers and improving available products according to the market feedbacks. This means that the Design Department has to send additional internal workflow towards the PSCM process. Moreover, the Design Department also increases the workflow because of the extensive modifications to the available product structures that are necessary because of the changes in technology, new machinery, modern production methods, and new components and raw materials.

In practice, the Supply Department also triggered a workflow due to the problems in providing the manufacturing process with desirable resources. In many cases, it was not possible to find compatible resources with enterprise standards due to the supplier's market constraints. In these cases, similar parts were used instead. It is obvious that without reflecting these changes in the information systems, tracing the valid product structure to provide the customers with proper after-sale services and analyzing the supplier's market was impossible. In addition, the avoidance of reflecting minor changes in the system gradually undermined the reliability of the system. Therefore, an additional workload would develop to track these kinds of changes in the system.

The last mentionable workflow towards the PSCM process was the change in the system which was caused by decision making in relation to outsourcing a component or producing a component which was once obtained from the supplier. Despite the strict supervision done to ensure the accuracy of the provided product structure information, on many occasions, the product department were still facing deficient and inaccurate product information. This could include items missing in the bill of the material (B.O.M), dedicating the wrong raw material, an incorrect consumption rate, an incorrect workstation, etc. These deficiencies triggered a reverse workflow of revision requests targeted to the PSCM process. The context-level DFD in *Fig. 4* illustrates all the data flowing towards the PSCM process.

However, the modification of a component might affect several product structures. The impact of the modification depends on the number of products that contained the component in their structure. The communal modification should be reflected in many worksheets. This was a demanding and time consuming task that sometimes caused information incompatibility.

Potential Modes Analysis

The normal functionality of the PSCM (i.e. serving all of the above-mentioned workflows) could not stop for a long period of time before initializing the new system or the routine workload interfered with the initialization process and reduced its rate of progress.

Once a product structure has been initialized, it should be frequently updated during the project in both the new and the old systems to achieve desirable level of system reliability at the end of the project. This intervening updating process would make the project progress rate dwindle while the initialization phase was progressing. The more project proceeds, the more often information should be updated so that the proceeding velocity will reduce along the time vector and this reduction begins shortly after the start of the initialization process (see *Fig. 5*). The resulting nominal rate turns into the actual rate, as follows:

Actual Progression Rate = Nominal Progression Rate - Intervening Processes Increment

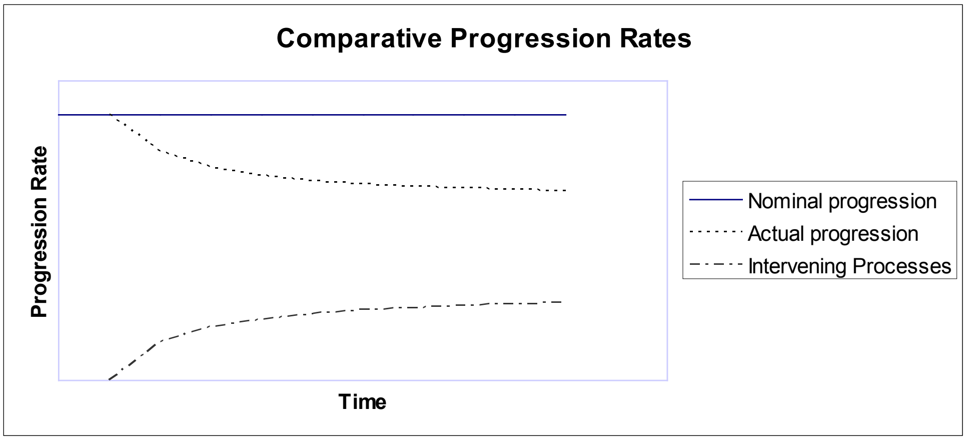

Fig. 5: Intervening task's effect on project progression rate

On the other hand, the initialization process deals with a growing stockpile of product structures which should be entered to the new system. Thus, the project progression velocity should be discussed as a relative element instead of an absolute one. The equations below describe the 'nominal relative progression rate' and the 'actual relative progression rate'.

Nominal Relative Progression Rate = Nominal Progression Rate - Input Rate

and

Actual Relative Progression Rate = Nominal Relative Progression Rate - Intervening Process Growth

Meanwhile, *Fig. 6* depicts how the input rate affects the nominal and the actual progression rates, as well as how it shifts them to a lower level (i.e. nominal relative and actual relative progression rates).

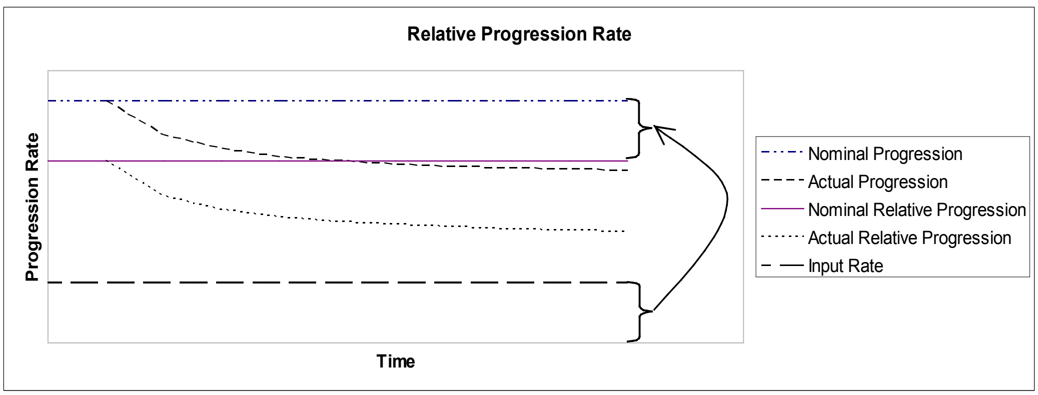

Fig. 6: Absolute and relative project progression rates

The "actual relative progression rate" is the final form of the project proceeding curve that has been affected by almost all of the typical factors and it gives a good representation of the actual project proceeding velocity. The shape and slope of the curve are apparently dependent on many unpredictable factors. Nonetheless, they could be ignored in this context or case because they do not affect the analysis in this scope. Similarly, the input rate and the nominal progression rate have been assumed to be constant rates, but they are not constant in the real world practices.

Some factors have been ignored, such as the changes in the volume of customer demands, changes in the working calendar (i.e. the number of working hours in different days or number of holidays in different months), seasonal changes in demand, the complexity of the products ordered during different periods, human resource availability, software bugs, problems occurring during the data entry process, hardware breakdowns, intervening activities (e.g. receiving a phone call, attending meetings, etc.) that are not part of the scheduler's official job description. Including these factors would make the situation more complicated, and it is unnecessary because this simplified curve is able to cover all of the required aspects of the initialization phase and to analyze all the possible destinies of the project. Regardless of the shape and slope of the curves, the following equation is valid based on the concept of integrals in calculus (Apostol, 1967):

$$\int_0^t h(t) = \int_0^t f(t)\,dt - Area_A$$

As it is obvious, the surface of area A is equal to the surface of area B (see *Fig. 7*), while, $Area_B = \int_0^t g(t)\,dt$ so the original form of the equation can be modified as follows:

$$\int_0^t h(t) = \int_0^t f(t)dt - \int_0^t g(t)dt$$

In which:

f(t) = Nominal Relative Progression Rate
g(t) = Intervening Process Growth
h(t) = Actual Relative Progression Rate

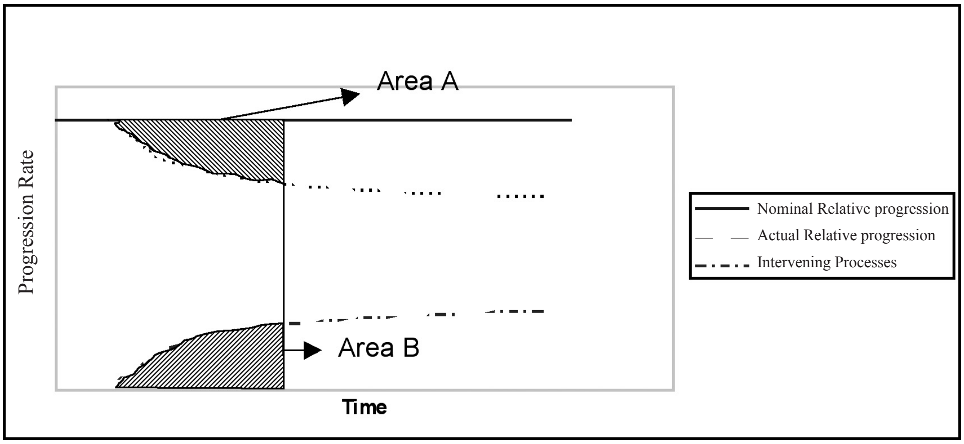

Fig. 7: Equal surfaces

At the theoretical finish line of the project, where $t = t_f$ in the above equation, the finish line would be equal to the first stockpile (FS) (i.e. the amount of data that should be entered into database at the beginning of the initialization phase) and the equation would therefore change, as follows:

$$\int_0^{t_f} h(t) = \int_0^{t_f} f(t)dt - \int_0^{t_f} g(t)dt = FS$$

Fig. 8 illustrates a typical project progression model of an initialization phase, whereby two different modes can be assumed, in which the destiny of the project should be separately analyzed, as follows:

1. The 'intervening process growth' curve goes along the 'nominal relative progression rate' curve and they never meet. In this condition, regardless of the shape of the curves and their relative distance, the initialization phase can theoretically finish at point "t_f", in which:

   $$\int_0^{t_f} f(t)dt - \int_0^{t_f} g(t)dt = FS$$

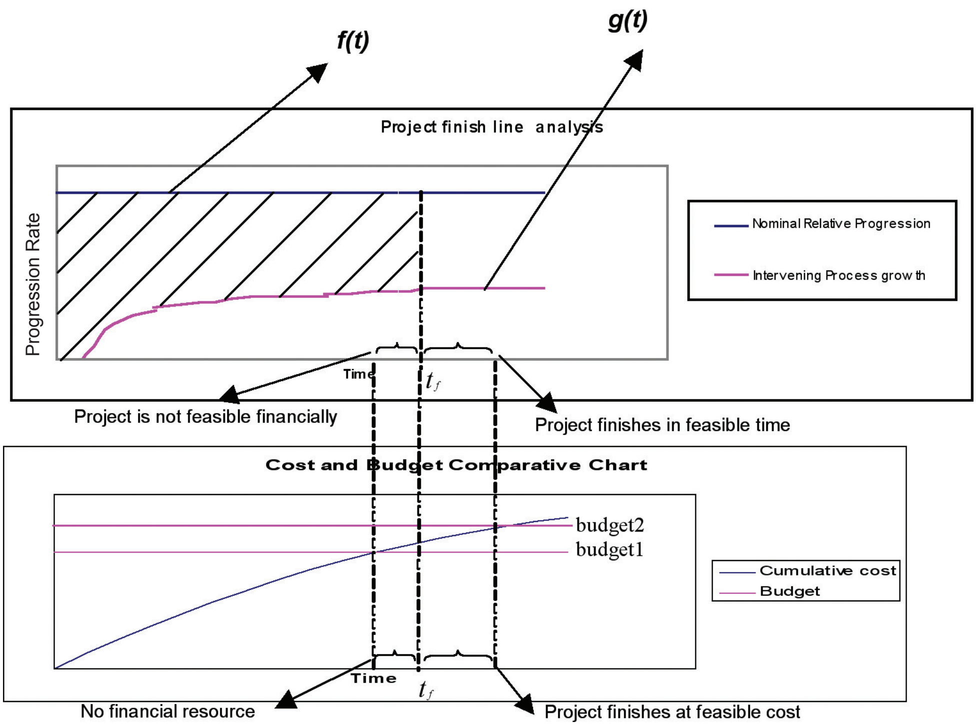

Fig. 8: Technical and financial analysis of the project finish line

In this mode, a cost and budget analysis helps to predict the feasibility of the project.

- If the cost of the initialization phase exceeds the budget at point "t_f" (i.e. the theoretical finish point), it can be inferred that the project is technically feasible, but it is financially infeasible at the same time.
- If the initialization phase finishes before its cost exceeds the budget, the project is taken as both technically and financially feasible.

Even if a project is feasible from a theoretical point of view, the overall feasibility is dependent upon the project budget and cost scheme. Instead of moving the theoretical finish point forward and backward to analyze the situation, two different budget lines (i.e. budget1, budget2) are illustrated in *Fig. 8* to have both modes in a single figure, though the project budget scheme is fixed in practice.

2. The 'intervening process growth' curve crosses the 'nominal relative proceeding rate curve'. The project destiny should be discussed by taking three significant aspects into account, as follows:
   - The project theoretical finish line, t_f;
   - The project budget scheme;
   - The critical point (i.e. *cp*) in which the project progression rate becomes negative.

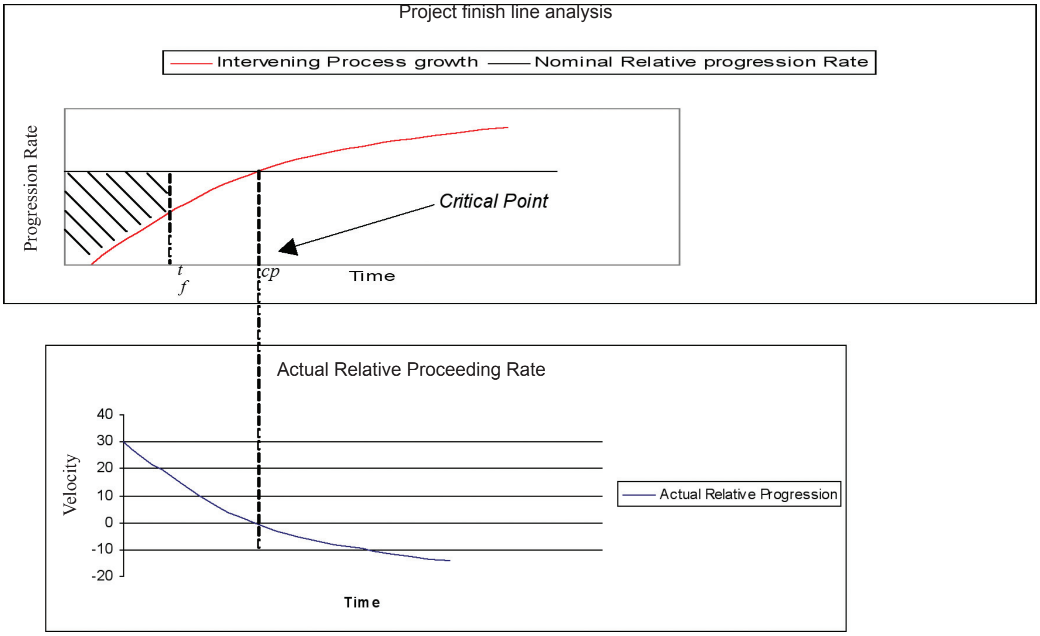

Fig. 9: Critical point analysis

Thus, three different situations can be assumed in this mode when all of the above-mentioned aspects are included:

$$\int_{0}^{cp} f(t)\,dt - \int_{0}^{cp} g(t)\,dt < FS \qquad (2.1)$$

As shown in *Fig. 9*, the project will be never actually finish because in passing the critical point, the progression rate will turn into a negative rate. Therefore, the more time passes, the more the stockpile of the un-entered data grows.

$$\int_{0}^{cp} f(t)\,dt - \int_{0}^{cp} g(t)\,dt > FS \qquad (2.2)$$

In this condition, everything is dependent upon the position of the theoretical finish point of the project, which is located somewhere before '*cp*' in relation to the financial finish point. This is similar to the first mode and two different destinies can be derived in this condition, namely:

- If the cost of the initialization phase exceeds the budget at this point, it can be inferred that the project is theoretically feasible, but it is financially infeasible.
- If the initialization phase finishes before its cost exceeds the budget project, it is accepted as both theoretically and financially feasible.

$$\int_{0}^{cp} f(t)\,dt - \int_{0}^{cp} g(t)\,dt = FS \qquad (2.3)$$

The final situation is where the critical point is the final line of the project at the same time. In other words, $cp = t_f$. A financial analysis can again shed light on the destiny of the project. If the project cost does not exceed the budget at the '*cp*' point, the project is therefore feasible. Otherwise, it is not feasible from a financial perspective despite the fact that the project is theoretically feasible.

Meanwhile, finding solutions for raising the proceeding velocity and reducing the effects of intervening processes on the progression rate can result in moving the theoretical end of project backward. Moving this point backward when the project budget is fixed can lead to a change in the project destiny, i.e. from infeasible to feasible or simply to finishing the project at a lower cost, depending on the project condition. Considering the fact that the PSCM process initialization is a mandatory prerequisite for all the other tasks in an ERP implementation project, particularly in customer driven environments, moving the theoretical finish point of this phase backward will reduce project failure risk by changing the destiny of previously infeasible modes to feasible and reducing the overall project cost and duration.

As such, enhancement of the proceeding velocity is possible through simplifying and facilitating the PSCM process, while data accuracy will be guaranteed through reduction of the manual data entry and the embedding of strict constraints within graphical user interface (GUI).

CONCLUSIONS

The simplification, facilitation, and automation of the PSCM process, which lead to the acceleration of this process, are significant factors that can reduce the failure risks and cost of ERP implementation in the customer-driven environment. Moreover, it can be expected that improving the performance of this process can lead to an enhancement in the overall company's performance as the empirical results of the case company also admit this claim as the PSCM process is the bottleneck of production planning in these kinds of environments.

The production planning process was manipulated by three workers (the scheduler, his assistant, and the production planning supervisor) using several Excel spreadsheets before implementing the ERP in the case company. From the annual inspection reports of ISO 9001, one could see that the promised delivery time, a main key performance indicator (KPI) of the company, was seven working days during this time (including one day for taking orders, five days for production planning, out of which four days were used for product structure configuration, and one day was used for the final assembly and delivery). The difficult and high-pressure production planning process caused the product to be overdue in 42% of cases, of which 33% were due to product structure configuration issues.

More importantly, the ability in implementing the framework for the PSCM to reuse the available components was found to reduce the total number of product structure data records from one hundred thousand in the previous system to merely eleven thousand in the new system. In addition, the case company's annual inspection report after the ERP implementation project also revealed significant improvements in the company's performance indicators. The promised delivery time was reduced to four working days, of which one day was for taking the orders and transferring related data to the production planning department, another day for the final assembly and delivery, and only two days were required for the whole production planning process. Overdue delivery due to product structure configuration issues was also reduced to 16%, as a result of controlling the negative effects of uncertainties on delivery by utilizing the new system's capabilities in the area of production planning. The implemented ERP also had a visible effect on human resource use all over the enterprise, particularly in production planning, as the new production planning process could be conducted by a single employee, and more efficiently than it was in the past.

The characteristics of the ERP, as they are related to the PSCM process, should be taken into consideration as the three critical success factors for the ERP implementation in the customer driven environment. Meanwhile, a further analysis on this critical process in both the initialization and utilization phases may lead to a diagnosis of more factors which affect the ERP performance in the customer driven environment. Taking into account the above-mentioned CSFs in designing ERP software and focusing on PSCM process issues can lead to developing ERPs that are more compatible with the customer driven environment and one which can play a significant role as a business process management tool.

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