Dynamic aspects of an ERP implementation project

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Abstract

The implementation of an ERP (Enterprise Resource Planning) demands the development of a complex project. On one hand, the scientific literature presents some key factors which allow the project to reach the expected objectives. However, these researches do not consider the dynamic relationships that take place among these key factors, although interrelations can benefit or stop the project development. On the other hand, there are different useful strategies for an ERP implementation that directly affect the project development. This paper develops a generic model to identify the relationships among the main key factors (best fit with current business process, resistance to change and training). The model has been validated by a company dedicated to ERP implementations in Spain. Finally, the model will also be useful to analyze the impact of the different strategies in the management of an ERP implementation project according with the project cost study.

KEYWORDS: Technology Implementation, Information System, System Dynamics, ERP

Introduction

Management applications, as ERP (Enterprise Resource Planning), SCM (Supply Chain Management) or CRM (Customer Relationships Management), should be implemented, that is to say, it is necessary to develop a project that begins with the current situation analysis and finishes with the satisfactory use of the new software.

ERPs are the most broadly implemented management applications. Companies dedicated to implement ERPs try to use the same strategy in large companies or in small and medium enterprises (SME). Normally, large companies use the ERP implementation project as a process reengineering project in order to fit the ERP best practices. While, SMEs look for an ERP that fit as much as possible with their current business processes (Everdingen et al, 2000).

Sometimes these implementations suffer delays and even are stopped. For this reason, many authors have studied these projects to discover which the key factors for their success are. Even though the key factors that drive to an ERP implementation success are analyzed in the literature review, the dynamic relationships between them have not been taken into account yet. These key factors are analyzed in next section.

System Dynamics has been used in project management (Cooper et al, 2002) and software development project (Abdel-Hemid and Madnick, 1991). ERP implementation can be considered as a particular kind of project.

For this reason, System Dynamics is a powerful tool for the study of an ERP implementation project, where the project success or failure can depend on the interaction of some key factors.

Key factors in an ERP implementation project

The authors who have studied an ERP implementation projects focus on different keys and different phases of the project. Most of them focus only in one key factor, analyzing it in an isolated way.

There are several works that classify the key factors according to the three main steps in an ERP implementation project: Setting-up, implementation and evaluation (Al-Mashari et al., 2003), (Rajagopal, 2002).

The main keys for the project success in the implementation phase are: ERP vendor selection, training on the new system, project management, cultural change control, development of system integration, and reengineering of the existing processes (Al-Mashari et al., 2003), (Bingi et al, 1999), (Amoako-Gyampah, 2004).

It is also possible to identify the same keys in some cases studies of ERP implementation developed in different field and size companies (Kumar et al., 2002), (Kumar et al., 2003), (Sarker and Lee, 2002), (Kræmmergaard and Rose 2002), (Han, 2004), (Tchokogué et al., in press), (Motwani et al., 2002).

All the studied papers include, among the main keys, the training on the new system. Even, in some researches, it is the only key factor presented (Amoako-Gyampah and Salam, 2004), (Umble et al., 2003). In fact, inadequate training has been one of the significant reasons of many ERP implementation failures (Gupta, 2000).

Besides, in all the ERP implementation projects, it is necessary to change the current company processes. Managing this cultural change is essential because half of ERP implementation projects fail because managers underestimate the effort required to achieve the cultural change (Pawlowsiki and Boudreau, 1999), (Ross and Vitale, 2000).

The resource allocation will change during the project execution, especially those resources related with the workforce required to carry out the project. The workforce management is also identified as a key factor for the ERP implementation project success (Joglekar and Ford, 2005).

It has been shown that many of the key factors are the same in the reviewed papers but, there is not any model that studies their relationships and their behavior over time. For example, on one hand, resistance to change depends on the lack of information and training on the new information system. On the other hand, if the chosen ERP fits better with the current processes, it will be necessary less reengineering and resistance to change will also be lower.

Some approaches to modeling this problem can be found in Hong and Kim (Hong and Kim, 2002) who highlight some critical factors: Fit with current business process, invisibility of ERP implementation and organizational resistance to change. These authors present a model and analyze 4 hypothesis using statistical methods. They conclude that there is a strong correlation between the implementation success and the organizational proper fit of ERP. Nevertheless it is not a dynamic model.

In summary, the research that will be presented in this paper seeks to discover, through a generic model, the relationships among the main success factors in an ERP implementation project:

- Best fit with current processes.
- Resistance to change.
- Training.

- Workforce allocation.

The proposed model and some of its variables are explained in the next section.

Proposed Model

Figure 1 represents a generic ERP implementation project. In this type of projects the current company processes are analyzed and compared with the ERP's processes. Next, the processes are classified in three groups:

- Processes that can be *directly implemented* because they match with those of the ERP.
- Processes that should be *reprogrammed* in the ERP to adapt them to the firm.
- Processes that should be adapted to the ERP through *reengineering*.

Once the correspondent task has been developed, each process waits to be implemented. Finally, the process is implemented.

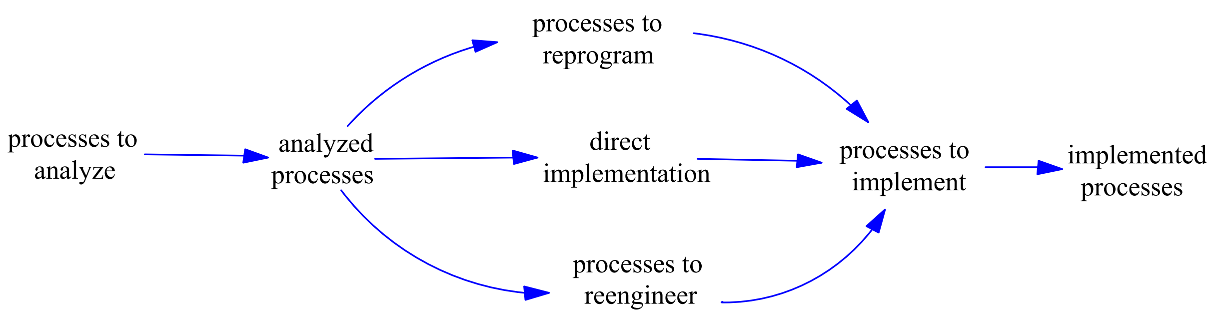

Figure 1. Generic ERP implementation project

The success in this implementing project depends on many factors: workforce's productivity, users' resistance to change, commitment to training on the new system, etc.

The project manager expects a time evolution of the project. This evolution is shown in Figure 2. The figure corresponds with the presented generic ERP implementation process. The current company processes are implemented as soon as the analysis task starts. Some of the processes will be reengineered and other group of processes will be reprogrammed in the ERP to fit the current business processes. These steps have established a deadline, when the project manager expects to be fulfilled.

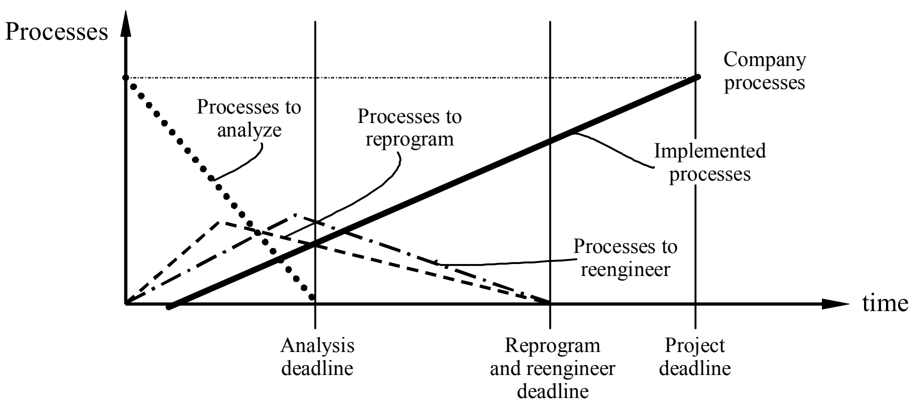

Figure 2. Expected time evolution of the project

The consultant company dedicated to the ERP implementation project will try to minimize the use of its workforce by assigning the minimum resources to achieve the implementation (Figure 3).

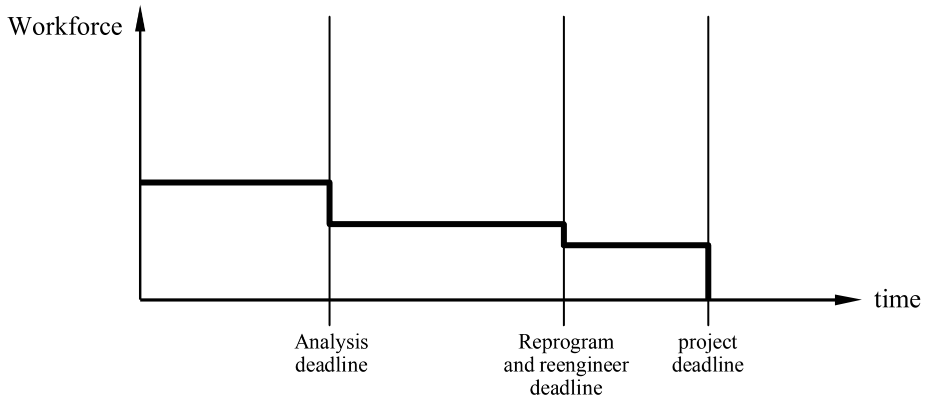

Figure 3. Expected time evolution of workforce assigment

Nevertheless there are some key factors that affect the project time behavior. These factors are interrelated each others, according to a model structure that can be summarized in the following figure (Figure 4). This model structure shows the most significant feedback loops and parameters of the implementation project (represented in boldface).

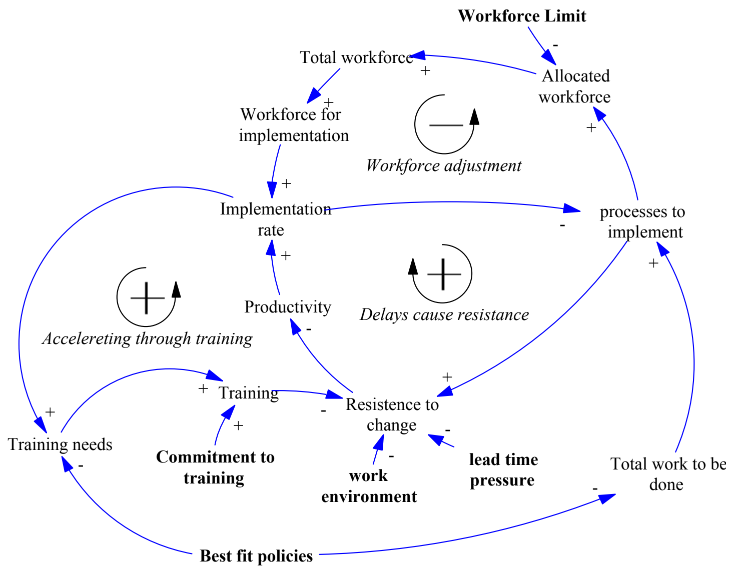

Figure 4. Model structure and feedback loops

In the figure three loops can be clearly identified:

- **Accelerating through training**: The greater the commitment to training is, the more resources are assigned to training. As a result, resistance to change decreases. Consequently productivity increases and therefore, implementation rate increases and the training needs as well. As it has been described, an increase on training causes more training. This is known as a reinforcing feedback loop.
- **Delays cause resistance**: Delays in the lead time achieving suppose an increase of the resistance to change. Consequently, productivity decreases and implementation rate decreases as well. When diminishing this ratio, implemented processes decreases and consequently, resistance to change increases again. As it has been explained, resistance to change reinforces itself.
- **Workforce adjustment**: The maximum value of workforce and the lead time set the assigned workforce to develop the project. If there is not enough workforce (required workforce is higher than current workforce), more workforce is allocated to the project. As a result, the number of implemented processes will increase and fewer

workforce will be necessary. This loop is defined as balancing because it adjusts the workforce to the current pending activities.

We have developed a model to study the behavior of these main variables of the system. The model is composed by three different subsystems and has been validated by a consultant company dedicated to ERP implementation. The following sections describe each subsystem.

Project advance subsystem

Figure 5 represents the project advance subsystem. Some variables of this subsystem are shortly explained below.

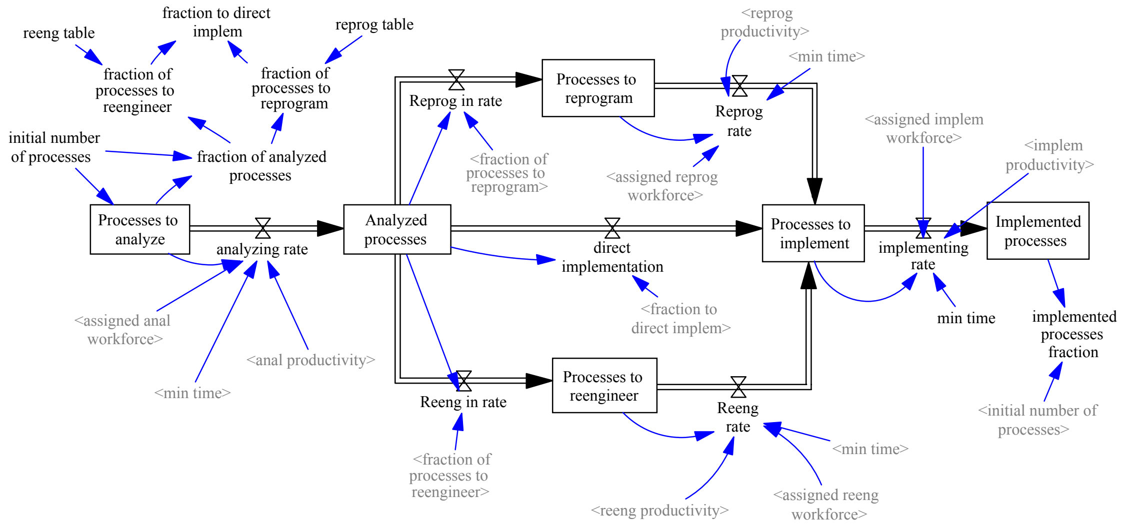

Figure 5. Project advance subsystem

The current company processes ('*processes to analyze*') are analyzed comparing them with the best practices included in the selected ERP. The analysis capacity depends on the productivity ('*anal productivity*') and also depends on the workforce dedicated to the analysis ('*assigned anal workforce*'), according to the criteria that will be explained later. The analyzed processes are classified in three groups depending on the result of the analysis: '*Processes to reprogram*', '*processes to reengineer*' and '*direct implementation*' processes.

The fraction in which the initial processes are divided in those groups depends on the fit of the selected ERP with the current processes. As a result, one of the keys presented in the literature review is represented through the charts '*reeng table*' and '*reprog table*' that will be explained later, in the experiments section.

The reengineering and reprogramming rate is the product between the *productivity* and the *assigned workforce*.

The reengineered and reprogrammed processes, together with the direct implementation processes, are stored in a level ('*processes to implement*') waiting for implementation. Again, the implementing capacity depends on the productivity (*'implem productivity'*) and on the assigned workforce (*'assigned implem workforce'*).

The ERP implementation project finishes when the '*implemented processes fraction*' is equal to 1.

In real projects, it takes a minimum time to analyze, reprogram, reengineer or implement a process. This constraint cannot be avoided allocating more resources. The variable '*min time*' has been included into the model to reproduce this behavior. This variable has been set to one week in all the cases according with the consulting company recommendations.

Workforce and cost management subsystem

The workforce assigned to each phase of the project is the minimum between the available workforce (*'workforce'*) and the workforce needs (*'required workforce'*) in each phase. Figure 6 represents the assignment of the workforce.

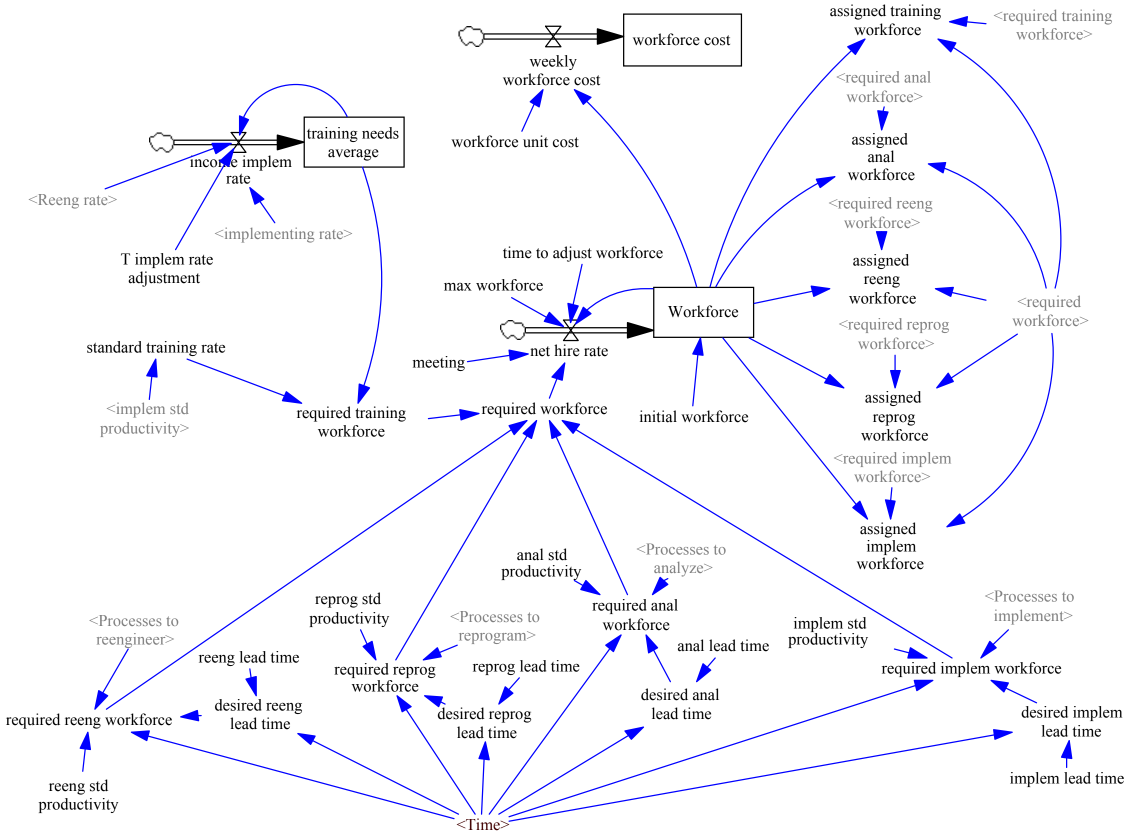

Figure 6. Workforce and cost management subsystem

Each project phase (analysis, reengineering, reprogramming, and implementation) has its particular *lead time*, that will be established in the experiments section. The *'required workforce'* is determined by taking into account the rest time until the *lead time* and the *standard productivity* in each activity in a monthly meeting. In order to represent a monthly meeting, a "pulse train" variable (activated each four weeks) called *'meeting'* has been added to the model.

The model includes the training needed time. This time will be based on the implemented processes and on the reengineered processes. An exponential adjustment of the needed training (*'training needs average'*) is carried out in the model because the answer to the training needs can not be considered immediate.

The addition of all the workforce requirements in each time step constitutes the *'required workforce'*. Besides, it is possible to establish a *'maximum workforce'* level. Taking into account the *'current workforce'* and the *'maximum workforce'* levels, in man-hour units, the needed workforce will be allocated or reduced. It is assumed that the free consulting company's workforce can be assigned to other projects and, if it is not necessary, it can be reduced from the ERP implementation.

By comparing the current workforce and the required workforce, it is possible to *assign the current workforce* to each project activity. If the current workforce is higher or equal to the required workforce, the model assigns the required workforce to each activity. If the current workforce is lower than the required one, the model assigns it proportionally to each activity.

It is important to point out that the pressure to complete the lead time is taken into account when the needed workforce is calculated.

This subsystem also includes the accumulated '*workforce cost'* in each project phase. In this case, the cost is calculated keeping in mind the workforce level in each time step.

Effects on productivity subsystem

The model analyzes the impact of the *resistance to change* and the *lead time pressure* in the *productivity* rate (Figure 7). The standard productivity is 1.

Resistance to change is based on the ignorance about the use of the new ERP and it increases as a consequence of the lack of training or a bad workplace climate.

Resistance to change effect is calculated, through the '*effect of resistance to change on productivity table',* comparing a mean value of the assigned training workforce with the required training workforce. Later, this table will be explained and modified, in the experiments section.

The value 0 for resistance to change means that all the users recognize the value added by the new system, and show enthusiasm. The value 1 implies that all the users are against the new system and obstruct its implementation. Intermediate values measure the mean value of the users' enthusiasm/opposition.

The model represents another factor that affects the productivity: the burnout due to the delay over the project lead time. Comparing the lead time of each project phase, a value of the '*accomplished fraction'* is obtained and it is compared with the expected one.

The effect on productivity is not based on an immediate value of the accomplished fraction. The effect is based on the mean value obtained by the exponential adjustment of this variable; its effect on productivity can be obtained through the '*effect of lead time pressure on productivity table'*. This table will also be explained and modified in the experiments section.

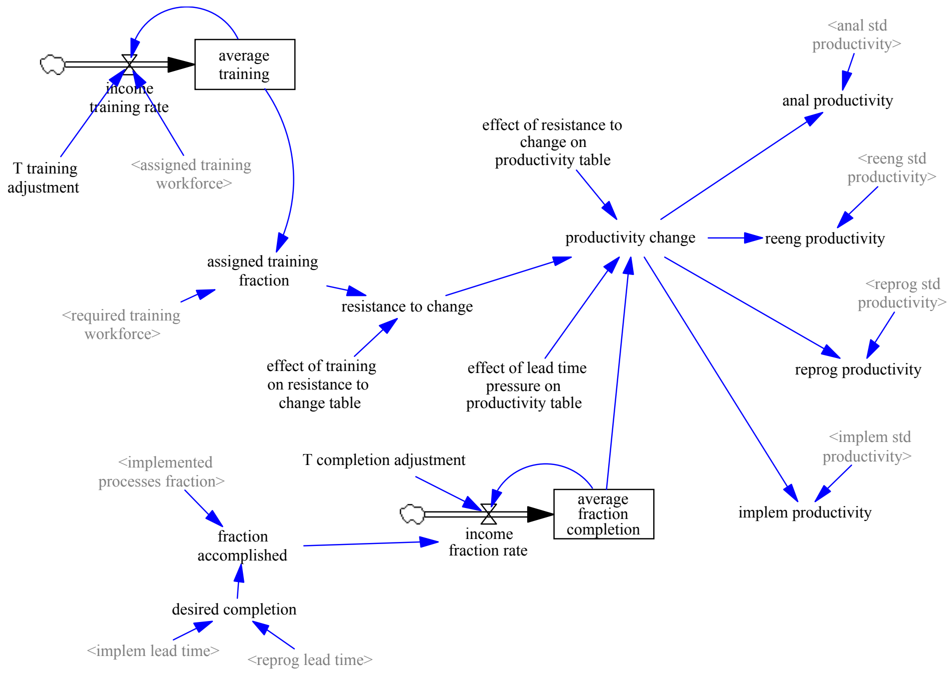

Figure 7. Effects on productivity subsystem

These described effects reduce or increase the real productivities in the analysis, reprogramming, reengineering and implementation activities.

Performed experiments

The experiments carried out with the model seek to discover the behavior of the fundamental keys highlighted by all the reviewed authors: Resistance to change; an efficient project management represented by workforce allocation; the importance of the training plans; and the effect of the best fit of the ERP with the current processes.

Some of the variables maintain their value in most of the outlined scenarios. The value of these variables has been validated by a consultant company located in Spain. This company has a broad experience in this topic with more than 40 ERP implementation projects in SMEs throughout the country.

Even if a bigger sample of ERP projects must be necessary to completely validate the model, the experiences of the consultant company allow carrying out an initial calibration.

The consultant company has collaborated to define the next initial values for some variables of the model:

- The ERP should be implemented in a generic company with 100 business processes.
- The lead time of the main activities is established in a generic project (referenced to the start time): Analysis (10 weeks), reprogramming (40 weeks), reengineering (40 weeks) and one year for implementation (52 weeks). These lead times will be changed in some scenarios.
- The workforce initially assigned to the project is 5 people, who work 40 hours weekly (200 man-hours/week). This workforce can be increased to 280 by eventually adding two more workers to the project.
- 20 man-hours are needed to analyze one process; 80 man-hours to reprogram one process; 80 man-hours for its reengineering; and 50 to implement the process (including trials and reworks).
- The training needed for each implemented process is calculated as 10% from the needed man-hours for its implementation. This value is based on the recommended training time in an ERP implementation project (Umble et al., 2003).

Model behavior under expected conditions

This section describes the outlined scenario to show the ERP implementation process and the expected time behavior under the following conditions, considered as “standard conditions”:

- The ERP has been chosen without taking into account the best fit with the business processes, regular practice ratified by several authors (Mabert et al, 2003). As a consequence, an important number of processes will be reengineered or reprogrammed (Figure 8). The figure represents the fraction of processes that must be reengineered or reprogrammed according to the fraction of analyzed processes.

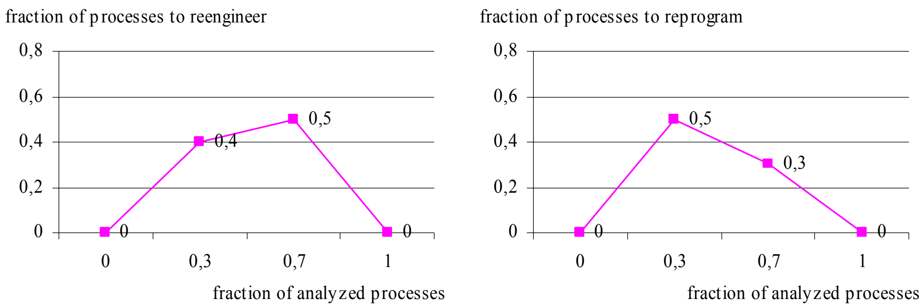

Figure 8. Reengineering and reprogramming fraction of processes

- It is possible to allocate or reduce the required workforce. The studied consulting company is able to react to a project workforce demand reassigning its workforce each month (4 weeks). The maximum workforce that can be applied is 280 hours.
- The assigned training workforce corresponds to the required training workforce.
- The effect of resistance to change on productivity follows the relationship shown in Figure 9. There are not any empirical studies that ratify the values shown in the figure. However, the relationship among the variables must be reflected since, otherwise it would suppose that their value is constant (e.g. productivity and resistance to change would be constant over time). So, some experience based values have been used to allow studying the behavior of the whole system.

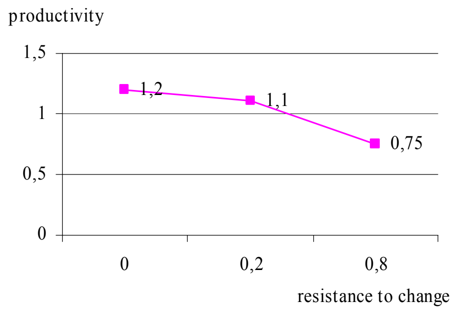

Figure 9. Effect of Resistance to change on productivity

Under these conditions, the following graph (Figure 10) represents the process and workforce time evolution under standard conditions.

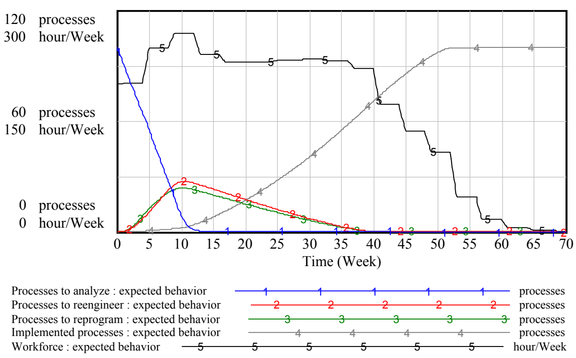

Figure 10. Process and workforce time evolution under standard conditions

The lead time of each phase is fulfilled and the workforce changes every 4 weeks if it is necessary. In fact, it is observed that more workforce is demanded at the end of analysis phase, due to the lead time pressure. In the 52th week all the processes have been implemented.

Effect of resistance to change

Resistance to change can be understood as the employees' opposition to the installation of the new ERP. As consequence of this resistance, productivity will decrease and it will take more time to carry out the expected work.

There have been taken into account three main factors that affect to the resistance to change: Work environment, commitment to training and pressure to fulfill the project lead time. (Figure 4):

- In any company, when the work environment is not good, it is more difficult to carry out changes. An ERP implementation project is a strong change in the way the company works.
- The training needs are due to the new way of working derived from the reengineering process or from the new ERP's procedures. The lack of training causes resistance to change. Besides, if current business processes are not modified, training needs will be lower and, as a result, resistance to change will decrease.
- Finally, resistance to change will decrease if the assigned workforce corresponds with the required workforce because this way, the lead time of each phase is fulfilled.

The following experiments will show the influence of the work environment and the commitment to training on the resistance to change.

Work environment effect

The goal of this scenario is to reflect this situation through two simulations. In the first one (*bad workplace climate*), the work environment is worse than in the standard case and, therefore, the influence of resistance to change is higher. In the second simulation (*good workplace climate*), the work environment is better than in the "standard conditions" case and the effect of resistance to change is lower. This way, resistance to change effect on productivity follows Figure 11.

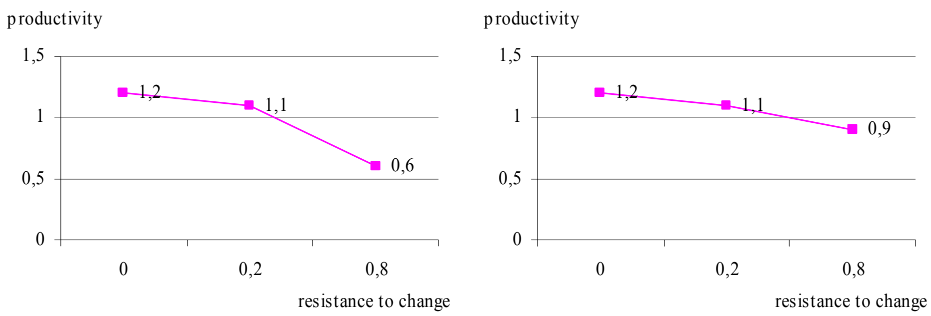

Figure 11. Bad and good climate and its effect on productivity

The next graphs (Figure 12) represent the evolution of the processes in these scenarios. The graph on the left represents the situation of higher resistance to change and the figure on the right shows the situation of lower resistance to change.

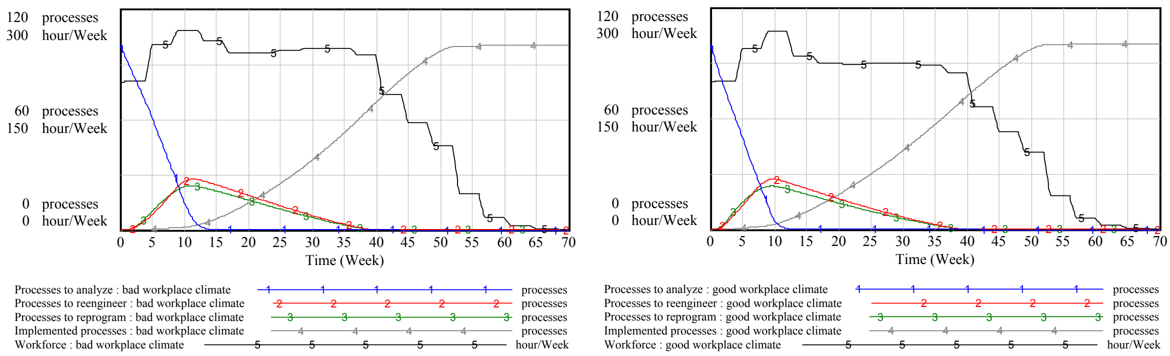

Figure 12. Process and workforce time evolution under higher and lower resistance to change

Due to the fact that there is no constraint in the allocated workforce (and the required workforce do not up to the maximum workforce) it is possible to finish each phase of the project in the specified lead time.

However, it can be observed (Figure 13) that the required workforce increases if the resistance to change is higher, and that it decreases if it is lower. The costs, comparing with the standard case, turn out to be 4,4% higher in the first case and 2,9% lower in the second one.

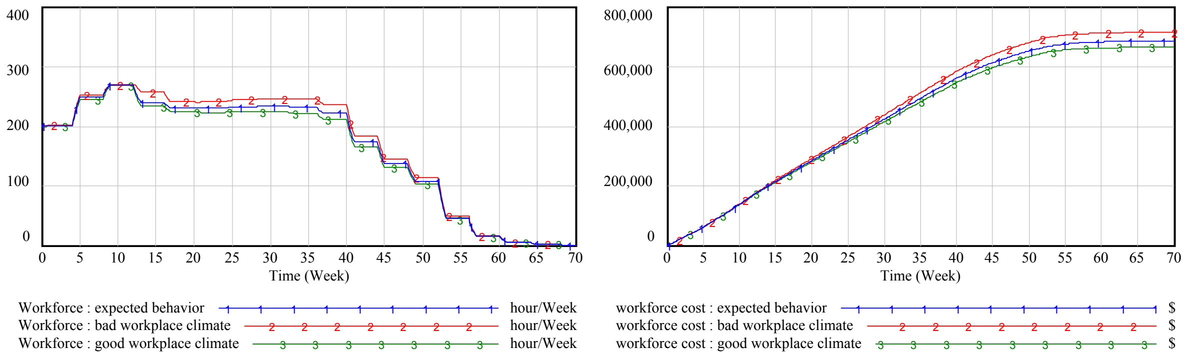

Figure 13. Workforce and cost differences between expected behavior and resistance to change variations

Training effect

Resistance to change can be compensated through training. If assigned training is equal to requested training, employees will accept better the new ERP and the new processes.. Two opposed cases can be analyzed:

- Assign less man-hours to training (half of the required man-hours) than the required ones in the standard scenario.
- Assign more man-hours (twice as much as needed in the model) than the required ones in the standard scenario.

The following graphs (Figure 14) show this situation. It can be observed that if managers assign less hours than the required ones, resistance to change decreases productivity and more workforce is needed. Due to the fact that required workforce do not up to the maximum workforce, in both cases the project ends on time.

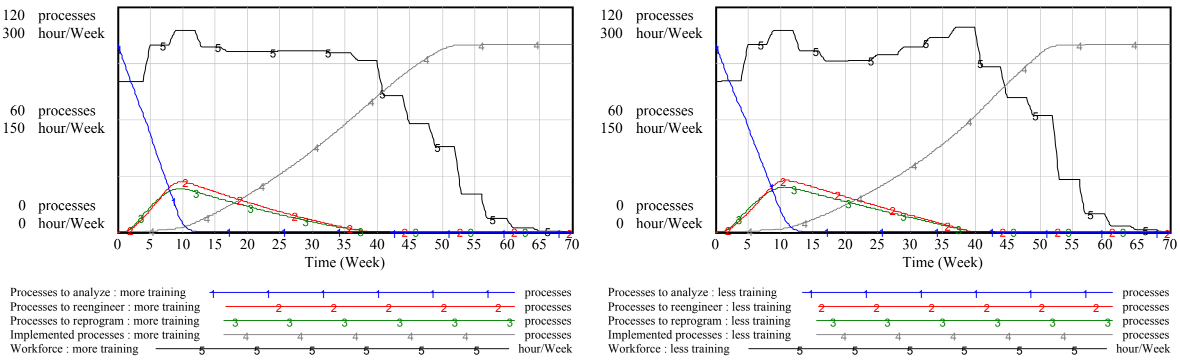

Figure 14. Process and workforce time evolution under training changes

However, increasing the training above the required level, supposes a cost increase estimated in 3% of the standard cost. The reason of this increase is supported by the increase in the required workforce. If the training is lower, the cost is increased until 8,8% because the increase in resistance to change and the subsequent productivity lose.

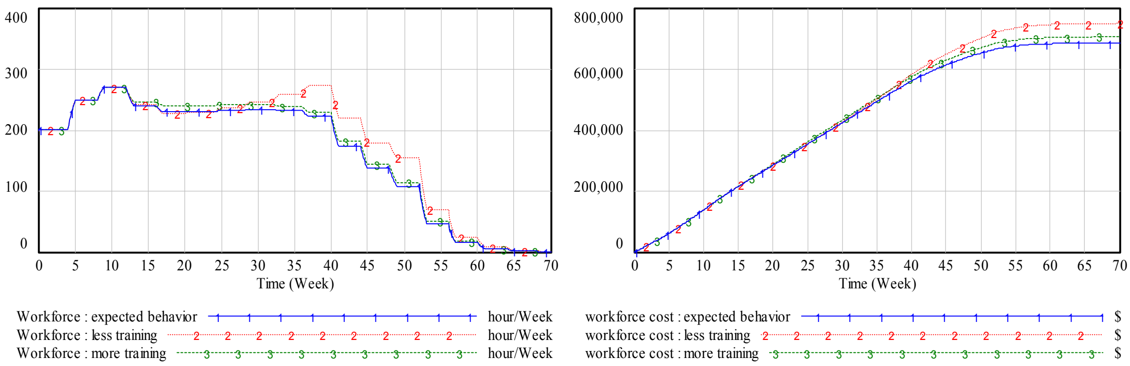

Figure 15. Workforce and cost differences between expected behavior and training changes

Best fit effect

Most of the studied papers conclude that one of the key factors in an ERP implementation, in a SME company, is the best fit with current business processes. In order to discover if the selected ERP properly adjusts to the company processes, it is necessary to carry out a previous study of the company processes using specific methodologies (Santos and Sarriegi, 2004). This study will increase the project cost. As a result, the experience demonstrates that companies do not usually carry out a previous analysis and that the ERP that offers a smaller budgeted implementation cost is chosen.

The development of this scenario seeks to analyze the importance of the "best fit with current processes" strategy in the selection of an ERP. If one ERP adjustment is better than another, the number of processes that must be reengineered or reprogrammed decreases, according to the following table (Figure 16). These values are based on consultant company experiences:

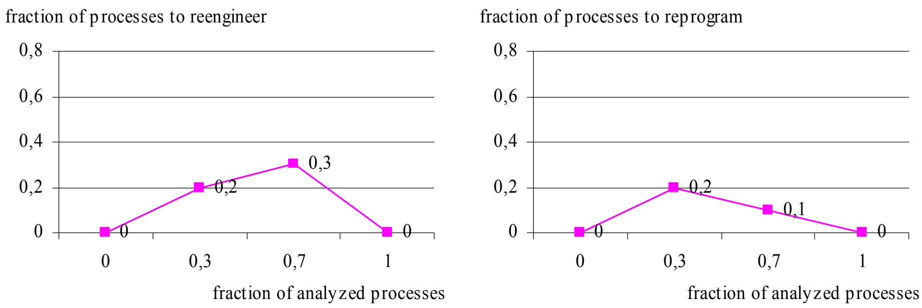

Figure 16. Reengineering and reprogramming fraction of processes in a better fit scenario

The model allows studying the case of an ERP that adjusts very poorly to the company processes as it is shown in Figure 17.

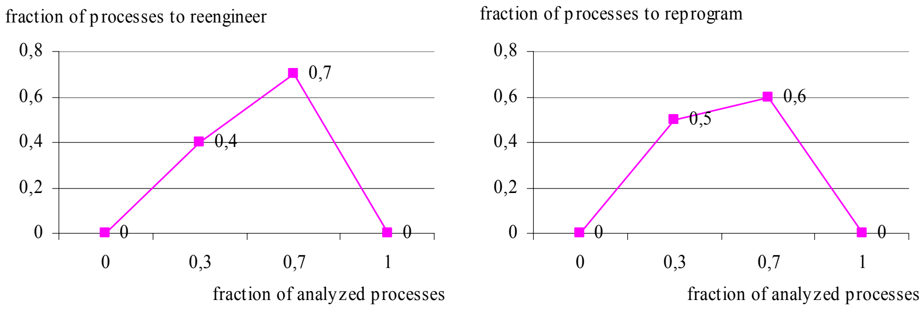

Figure 17. Reengineering and reprogramming fraction of processes in a worse fit scenario

The simulations of these scenarios are compared in Figure 18. A higher number of workforce requirements can be observed in the second case.

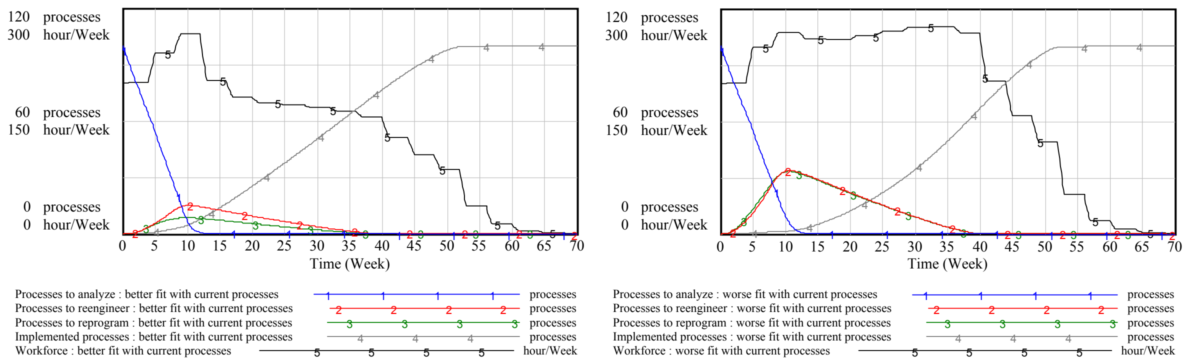

Figure 18. Process and workforce time evolution under better and poor fit scenarios

This result is evident since the number of processes to reprogram and to reengineer decreases when the ERP adjusts better to the firm processes.

However, the model offers an important result: The cost associated in the case of a best adjustment reflects a reduction of 22,6%. Therefore, whenever the previous study to the selection of the ERP does not overcome this value, it will be profitable to carry out it.

The cost increment if the ERP adjusts poorly to the current processes is about 11,6% comparing it with the standard cost.

Combined experiments

The model allows combining two or more scenarios to analyze the relative weight of each factor in the success or failure of an ERP implementation project. Several combined scenarios have been analyzed but only two of them will be presented. Both include the worst conditions of the studied scenarios but, the case of the best fit with current processes has been proven, that is to say:

- High resistance to change.
- Assignment of 50% of the required training workforce.
- Better fit and worse fit with current processes.

The obtained results are interesting (Figure 19). Lead time of the project is fulfilled only in the left case. In the worse condition experiment, the project suffers one month delay. Besides, the needed workforce changes importantly.

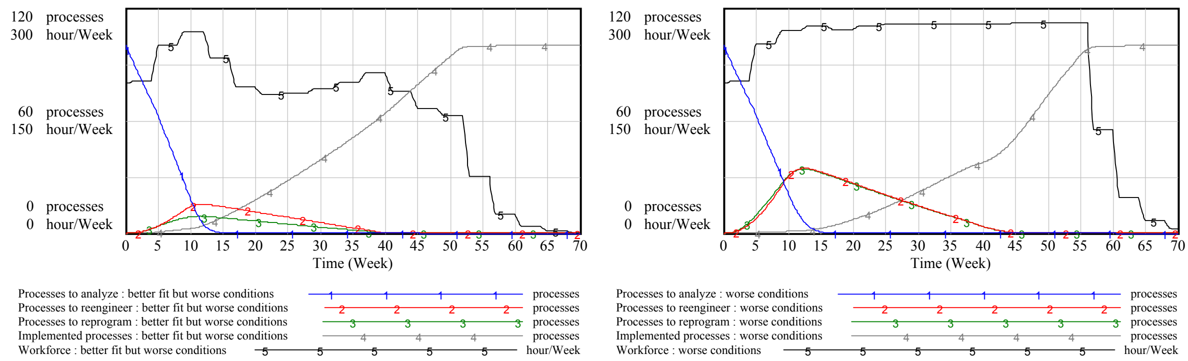

Figure 19. Processes and workforce time evolution in combined experiments

In the Figure 20 the workforce of each case, compared with the standard case, shows an important change in its value in the last part of the project.

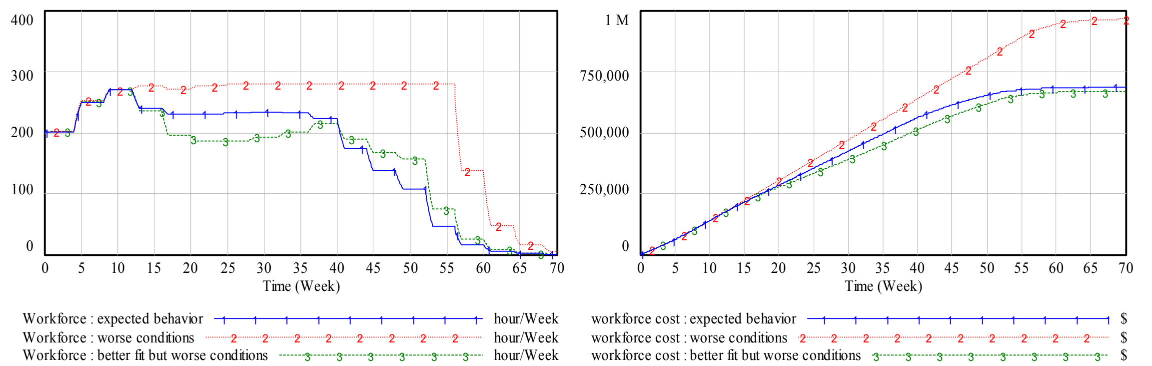

Figure 20. Workforce and cost differences between expected behavior and combined experiments

Lastly, the "better fit but worse conditions" case, is even cheaper (2,6%) than the standard development of the project. However, in the worse condition scenario, the cost increment is about 39,2%.

Conclusions

The developed work has been useful to ratify that the key factors detected by the authors analyzed in the literature review affect to the success or the failure of an ERP implementation project. The model developed in this paper helps to discover relationships among these factors.

The modelling process has proven to be effective in order to facilitate the dialogue between all the agents involved in an ERP implementation. However some real data, obtained from other experiences, could increment the confidence of these agents on the model.

Finally, the key factor that bets for the best fit with the current processes is presented as the most important in the project success, since it muffles the negative effects originated by the lack of the other key factors.

References

Abdel-Hemid, T. S. E. Madnick. 1991. Software Project Dynamics: An Integrated Approach . *Prentice Hall. Facsimile edition*

Al-Mashari, M., A. Al-Mudimigh, M. Zairi. 2003. Enterprise resource planning: A taxonomy of critical factors. *European Journal of Operation Research*. 146: 352-364

Amoako-Gyampah, K. 2004. ERP implementation factors: A comparison of managerial and end-user perspective. *Business Process Management Journal*, 10 (2),: 171-183

Amoako-Gyampah, K., A.F. Salam. 2004. An extension of the technology acceptance model in an ERP implementation environment. *Information & Management*. 41: 731-745

Bingi, P., M.K. Sharma, J.K. Godla. 1999. Critical issues affecting an ERP implementation. *Information Systems Management*, 16 (3): 7-14

Cooper, K.G., J.M. Lyneis, B.J. Bryant. 2002. Learning to learn, from past to future. *International Journal of Project Management*. 20, 213-219

Everdingen Y., J. Hillegersberg, E. Waarts. 2000. ERP adoption by European midsize companies. *Communications of the ACM*, 43 (4): 27-31

Gupta. A. 2000. Enterprise resource planning: The emerging organizational value systems. Industrial Management & Data Systems 100 (3): 114-118

Han S.W. 2004. ERP-Enterprise Resource Planning: A Cost-Based Business Case and Implementation Assesment. *Human Factors and Ergonomics in Manufacturing*, 14 (3): 239-256

Hong, K-K, Y-G. Kim. 2002. The critical success factors for ERP implementation: an organizational fit perspective. *Information & Management*. 40: 25-40

Joglekar, N., D.N. Ford. 2005. Product development resource allocation with foresight. *European Journal of Operational Research*. 160: 72-87

Kræmmergaard, P., J. Rose. 2002. Managerial Competences for ERP Journeys. *Information Systems Frontiers*. 4 (2): 199-211

Kumar, V., B. Maheshwari, U. Kumar. 2002. ERP systems implementation: Best practices in Canadian goverment organizations. *Goverment Information Quarterly*. 19: 147-172

Kumar, V., B. Maheshwari, U. Kumar. 2003. An investigation of critical management issues in ERP implementation: empirical evidence from Canadian organizations. *Technovation*. 23: 793-807

Mabert V.A., A. Soni, M. A. Venkataramanan. 2003. Enterprise Resource Planning: Managing the implementation process. *European Journal of Operational Research*.146: 302-314

Motwani, J., D. Mirchandani, M. Madan, A. Gunasekaran. 2002. Successful implementation of ERP projects: Evidence from two case studies. *Int. J. Production Economics*. 75: 83-96

Pawlowsiki S., M. Boudreau. 1999. Constraints and flexibility in enterprise systems: A dialectic of system and job. *Proceedings of AMICS*

Rajagopal, P. 2002. An innovation-diffusion view of implementing of enterprise resource planning (ERP) systems and development of a research model. *Information & Management*. 40: 87-114

Ross, J.W., M.R. Vitale. 2000. The ERP Revolution: Surviving vs. Thriving. Information Systems Frontiers, 2(2): 233-241

Santos J., J.M. Sarriegui. 2004. MiiSD. Methodology of integrated information Systems Design. *International Journal of Computer Integrated manufacturing*. 17 (6): 493-503.

Sarker, S., A. S. Lee. 2003. Using a case study to test the role of three key social enablers in ERP implementation. *Information & Management*. 40: 813-829

Tchokogué, A., C. Bareli, C.R: Duguay. In press. Key lessons from the implementation of an ERP at Pratt & Whitney Canada. Int. J. Production Economics.

Umble E.J., R.R. Haft, M.M. Umble. 2003. Enterprise resource planning: Implementation procedures and critical success factors. *European Journal of Operation Research.* 146: 241-257