

## IMPLEMENTATION AND EVOLUTION OF THE CRITICAL CHAIN METHOD: A CASE STUDY

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The Critical Chain method has been implemented in a wide variety of industries, activities and countries. This article is based on the implementation of this method in two different units of the same company which designs, develops and produces high-tech parts. Even if it is based on the implementation process and its results, the scope exceeds this context. The analysis is made with a time perspective, taking into account not only the implementation but also the evolution following its completion.

As a result, two different sides can be highlighted: the first one concerns the outcomes achieved in each case as a consequence of the implementation of the method, and the second one is related to the key aspects identified in the implementation processes - in particular the success factors. It is of special interest the comparative analysis regarding the results achieved in both cases, in a time period that goes beyond the implementation timeframe. The findings of this work lead to some new aspects concerning the method, which require further research.

**Keywords:** *Critical Chain; CCPM; TOC; Theory Of Constraints; Project Management*

### IMPLANTACIÓN Y EVOLUCIÓN DEL MÉTODO DE LA CADENA CRÍTICA: UN ESTUDIO DE CASO

El método de la Cadena Crítica ha sido implantado en muy diversos sectores, actividades y países. El presente artículo se centra en la implantación de este método a dos unidades diferentes de una misma organización, dedicada al diseño, desarrollo y fabricación de componentes tecnológicos. Si bien se basa en el proceso de implantación y en sus resultados, su alcance excede este ámbito. El análisis se ha realizado con una perspectiva temporal, considerando tanto la implantación como la evolución posterior a su finalización.

En consecuencia, destacan dos vertientes diferenciadas: la primera está relacionada con los resultados obtenidos en cada caso como consecuencia de la implantación del método, y la segunda está vinculada a los aspectos clave identificados en los procesos de implantación - en particular los factores de éxito. Es de especial interés el análisis comparativo acerca de los resultados alcanzados en ambos casos, en un período que trasciende el intervalo de implantación. Los hallazgos de este estudio revelan aspectos novedosos en relación al método y que requieren de más investigación.

**Palabras clave:** *Cadena Crítica; CCPM; TOC; Teoría de las Limitaciones; Gestión de Proyectos; Dirección de Proyectos*

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## 1. Contents

### 1.1 Introduction

Project Management (PM) is a discipline whose origin dates from the mid-20th century (Archibald, 1987), appearing to have reached maturity (Bredillet, 2010). Its growth and development were particularly steep during the second half of the last century, as a result of the growing interest in projects and their management (Kloppenborg & Opfer, 2002). Indeed, many authors agree with this idea due to reasons such as the fact that projects are the means by which strategies are performed (Maruchek, Pannesi & Anderson, 1990), new products are developed and launched (Cook, 1998), or the innovation strategy of a company is implemented and developed (Tatikonda & Rosenthal, 2000). What's more, due to the progressive "projectification" of work, the use of projects seems to keep growing in the future (Stoneburner, 1999; Kloppenborg & Opfer, 2002), confirming the relevance of PM at the present.

Considering the above, the increasing trend towards both the use of PM approaches and the need to address real world problems several perspectives and patterns have arisen in recent years if compared to traditional project management (Goldratt, 1997; Beck et al., 2001), having acquired a great relevance (Pinto 2002). The underlying idea here is that project management can be a competitive advantage for companies if it is properly implemented in the specific context of the performing organization. In this way, they could increase their chances of survival, or even obtain a better competitive position.

This paper is practice-based research about the implementation of one of these methods, Critical Chain, in a company that having tried different approaches unsuccessfully, decided to implement it to solve the problems related to the management of projects and resources in two R+D+I units. In particular, it covers the results and findings achieved during a three-year period that followed the implementation process carried out in both units.

#### ***Background of the Company***

The company analyzed in this enquiry develops and manufactures capital goods for machine automation and control. The 560 people that compound this company are organized into two units, each one being responsible for one product line. They export more than 80% of their production globally, and in recent years they have diversified their activity towards other sectors. But despite this international expansion effort, this company is much smaller than those leading this industry.

In this context project management performance is a key factor in achieving a competitive advantage or simply surviving, and a proper use of their capacity (resources) becomes essential. Additionally, since the market is evolving continuously they are forced to constantly upgrade their products and to broaden their catalogue by developing new products in order to remain competitive. These features lead to frequent changes and new needs such as technological developments and new trends, thereby causing the portfolio to be very dynamic, and requiring fast responses.

There were some attempts in the past so as to get an approach capable of dealing with this issue, but all of them were unsuccessful. Consequently, there was a lack of information from a managerial perspective, turning difficult to manage the system properly. In addition, some kind of rejection against new improvement attempts turned up among the workers, as a consequence of the time and efforts wasted before. As a first step it was carried out a profound reengineering of the new product development process, defining the framework for projects. Then, it became obvious again that it was necessary to manage projects efficiently. Taking all this into account, the company decided to try the Critical Chain method.

### ***The Critical Chain Project Management (CCPM) approach***

CCPM is a method for managing projects developed by Eliyahu M. Goldratt (1997), founded on the principles of his Theory of Constraints-TOC (Goldratt 1992). Since it was published, it has continuously evolved on the basis of an intensive usage by practitioners in real-world environments, leading to lots of different publications including implementation methodologies and success stories, among others (Leach, 2005; Srinivasan, Best & Chandrasekaran, 2007; Gupta, 2010). The main features of this method can be summarized as follows: firstly, it assumes that uncertainty exists and that it cannot be avoided, even if it can be managed. Secondly, it takes into account the impact of human behavior on projects. Finally, it addresses both single-project and multi-project management.

According to Execution Management approach, “the key to good execution is not detailed planning and control, but coordinating execution priorities across the organization” (Gupta, 2010). This implies implementing “Three Rules”, the Execution Management System and the Active Role of Senior Management, as briefly described below.

Implementation of the Three Rules: the Three Rules are Buffering, Pipelining and Buffer Management. Buffering consists of creating project plans accordingly to CCPM, so as to dampen deviations and prevent project delays by using buffers. The aim of Pipelining is to stagger the projects taking into account resource availabilities, deadlines and global priorities. Finally, through Buffer Management the system looks for a better performance in the operative level by following task priorities and preventing the waste buffers.

Execution Management System: it means synchronizing the whole system consistently with the three rules. Key aspects:

- Operational Goals and Measurements: aggressive operational goals (schedules) and measurements so as to promote execution according to synchronized priorities and early warning signals.
- Management Policies and Processes: needed to, respectively, enforce the new rules of Critical Chain and translate these rules into understandable decisions and actions.
- Execution Oriented Project Schedules: suitable for execution and control according to CCPM.
- Project Management Information System: the means to integrate roles, information and decisions/actions. The software used in this case was Concerto.

Active Role of Senior Management: the direct involvement of top management is a key success factor. As the implementation of CCPM implies a change, the supervision and engagement is essential, especially until the method has been interiorized by people. In addition, only top management can proactively identify and eliminate policy obstacles. Therefore, they must be involved in the implementation.

### **1.2 Aim, methodology and structure of the research**

In spite of the maturity reached by PM, as stated in the introduction, some authors claim that PM research is still in its early stages (Sauser, Reilly & Shenhar, 2009), and calls for a different approach to that provided by the traditional PM research (Ivory & Alderman, 2005; Cicmil, 2006). Furthermore, investigation going beyond existing PM models and more focused on practice is considered very important in order to achieve a deeper understanding of PM (Blomquist et al., 2010). Additionally, O'Neal, Tabatabaei, & Schrottner (2006) revealed that there is a gap between the professional (and dominant) and the academic worlds, as most of the published PM articles belong to practitioners' journals.

Under these circumstances, real-time case studies and project organization studies are of particular interest. In this case the focus is not on the implementation and its results, but in the post-implementation period and the comparison between two similar organizations (units). Considering the above, the aim of this research is to i) expound a real-world experience, ii) draw valuable findings and conclusions for their use in practice, and iii) contribute to bridging the gap between the academic world and the practitioners' reality. As stated above, the starting point for this research was given by the situation once the implementation project was completed, and this study is limited to the R+D+i units of the company, involving 115 people and explicitly excluding the production side due to its ongoing nature.

**Figure 1: Research Methodology**

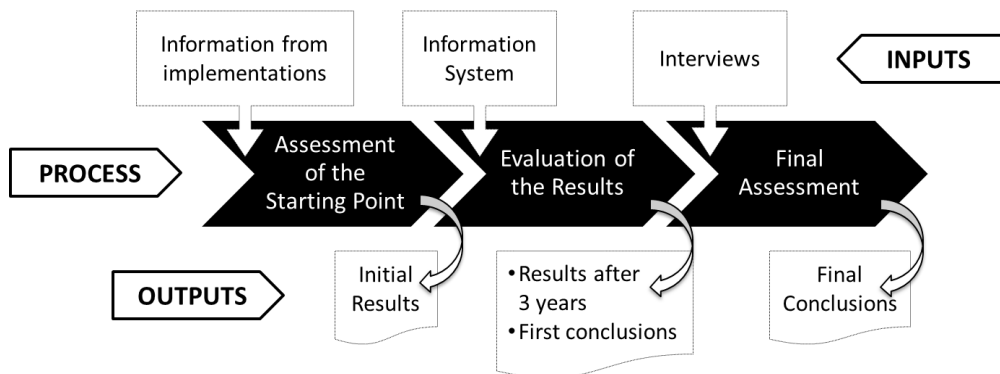


Figure 1 summarizes the process followed to carry out the study. The methodology used is based in case study research (Gummesson, 2000; Yin, 2003) and combines different approaches: starting from the initial results of the implementation, the research addresses the evolution of both units during a three-year period. This involves observation and analysis of i) the results achieved, ii) the evolution of the method and its performance, and iii) the behavior of those directly involved in the management of projects. Since different kinds of information were required for this purpose, diverse sources were used: information from the implementation process, data provided by the information system and formal and informal interviews conducted with employees involved in projects. The stages of the research are detailed in depth in section 1.3.

### **1.3. Research: stages, results and performance assessment**

#### ***Assessment of the Starting Point***

Both researchers were directly involved as implementers in that process. So, all the information collected during the project was available for this purpose. This information included files and records, reports, working-papers, interviews, meeting minutes, etc., the foundation of the stage 1 of this research.

The situation at the beginning of project can be summarized like this: inexistence of a suitable PM methodology and a perceived need for change. It also was found that CCPM was a completely unknown method to almost everybody in the company, becoming even more important to analyze the system so as to understand its needs and limitations, including the features of both projects and resources (Apaolaza 2009). Thus, an initial analysis was performed and as a result valuable information regarding the business and the company was gathered. A summary of the main features of the context are provided below:

- Multi-project environment: different projects performing simultaneously, sharing (and often competing for) common and limited resources.
- Very specialized resources, low polyvalence due to the long time required to get enough experience, and extreme difficulties to get more resources within a short period of time when additional capacity is required.
- Uncertainty: by its very nature, uncertainty is inherent to these projects, thereby making their management more difficult (Shenhar & Dvir, 1996).

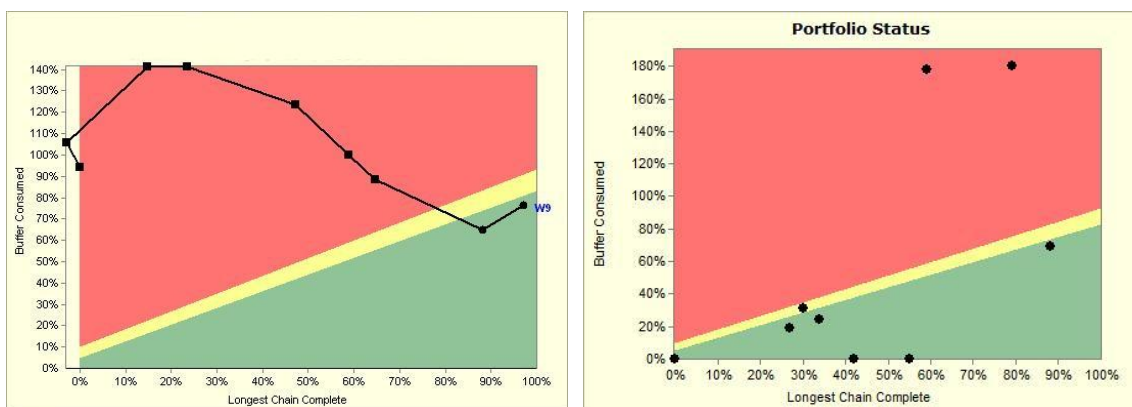
Then, the implementation plan was constructed and accepted by all the parties involved, so completing the buy-in. The plan was made up of three main stages: a pilot test to be run in Unit 1 involving one project, the implementation in Unit 1 (conditioned to the results obtained in the pilot test), and the implementation in Unit 2.

The pilot test was carried out through a representative project, over a three-month period. Figure 2 (left) depicts the evolution of the project that thanks to the decisions made based on the visibility and information provided by the method was completed on time. This brought with it the release of the second stage, involving the whole Unit 1.

The implementation of the method in Unit 1 lasted 4 months, requiring a customization and adapting the generic rules to that specific context. It resulted in the development of a suitable management model that included workload (projects), capacity (resources) and roles and responsibilities. Additionally, the integration of the model, the planning process and the execution management needed some other ingredients. Thus, two specific forums were created: the project tracking committee and the project launching committee. While the project launching committee was responsible for the management of the project portfolio, the aim of the project tracking committee was the monitoring and control of performing projects.

Despite the success of the pilot project, the implementation in Unit 1 didn't progress as expected. Even if it was reached an agreement in the first stage, some kind of rejection to change arose as a consequence of the time and efforts wasted in previous attempts. This lack of commitment led to a misalignment between needs and behaviors, causing the results initially achieved in the pilot test not to be expanded to other projects.

**Figure 2: Examples of results achieved during the implementation.**



Left: it is showed the progress of the project over the pilot test. Right: Project portfolio in Unit 2.

Finally, the implementation in Unit 2 was performed similarly but started later than the previous stage and overlapped with it. Surprisingly, the results achieved there were good, even if it wasn't carried out a pilot trial there. As shown in figure 2 (right), most of the projects progressed well, better than in the past, thereby giving the impression that the method was

suitable for that environment. Moreover, they were aware at all times of delays in some projects. As a result, when necessary they consciously decided which projects would be delayed, when, and how long. Nevertheless, further research was needed so as to confirm or discard these findings and deepen in the causes and key factors that led to such different results.

In view of the very different results obtained it was carried out an analysis of the whole project, covering both units. The report based on this analysis was then presented to the senior management of the company, including managers from both units. There was an agreement on the diagnostic, and the recommendations were very welcome. In summary, this was the content of the report:

Unit 2's success not only showed that the method was applicable to this context, but it provided significant advantages. What's more, there were no significant differences between both units to conclude that it could only work in Unit 2.

Daily reporting and task performance according to priorities were keys to success. The levels achieved regarding them were high in Unit 2 and low in Unit 1, which was a flaw because of its direct consequences over the PM system: lack of visibility, misalignment with priorities, low resource and project performance. Instead, this was considered to be one of the main causes of success of Unit 2.

The engagement of the managers towards the project is other fundamental pillar. Their involvement was high in Unit 2, but the commitment of certain managers in Unit 1 was insufficient. This fact would probably bring negative implications over the behavior of the workers, due to the impact of the poor results over their morale.

As a result, the following was recommended: i) correcting misaligned behaviors in Unit 1, starting with managers, ii) strengthening the performance of the information system, mainly in Unit 1, and iii) expanding the method to other parts of the company.

### ***Evaluation of the Results***

In order to get a better understanding about the implementation and use of the method, the results must be analyzed from different points of view. What's more, as both units work in very similar context and conditions, their performance in this period can be compared. Thus, this section summarizes the main quantitative and qualitative achievements reached by each unit along this time frame, including a comparison between these results.

#### **Quantitative results**

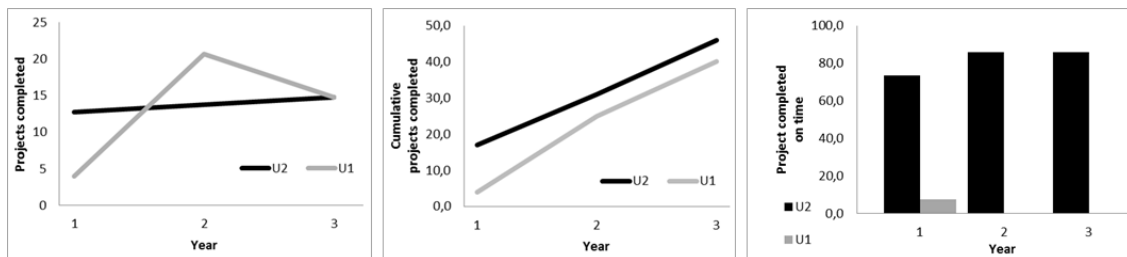
The results achieved once the implementation was completed Unit 2 can be summarized as follows: more projects completed by time unit, shorter lead times, more projects completed on time and dramatic reduction of terminated or postponed projects. On the contrary, even if the context was very similar in both units, none of these results was achieved by Unit 1, reaching only some minor improvements.

- Amount of projects completed in the first year (Figure 3, left): although it was expected that Unit 1 would make more projects than Unit 2 due to the fact that it was bigger, having implemented the method was implemented before, it only completed 4 projects, while Unit 2 finished 13 projects.
- Evolution of performance for the following years (Figure 3, center): it remained steady for Unit 2. Instead, Unit 1 seemed to hugely have improved its performance in the second year, but it decreased again in the third year, going below the performance of Unit 2. The strong increase happened in Unit 1 during the second year was due to the concurrence of lots of delayed projects in their last stages. This fact was proven

during the third year, setting a new decreasing trend that lasted even in the first months of the fourth year.

- Amount of projects completed on time (Figure 3, right): the percentage of projects completed on time, according to the criteria stated by the company 90% in Unit 2 while almost no one project was delivered on time in Unit 1. Besides, delays regarding Unit 2 were of days or weeks at the worst, whereas in Unit 1 they reached months or even more than one year.

**Figure 3: comparative results in 3 years.**



The results achieved by Unit 2 go beyond what the figure 3 seems to mean. By focusing resources in those high priority projects and according to the available capacity, the use of resources is improved, increasing efficiency and preventing resource assignment to low priority or urgency projects. Additionally, since those projects that are terminated or postponed consume capacity that may have been necessary in other projects, they involve a poor resource usage. The performance according to CCPM led Unit 2 to finish all the projects launched without any termination or postponement, thereby improving the productivity also from this perspective. Again, the results in Unit 1 were worse despite the fact that planning was done similarly in both units. The awful execution management caused some projects to be abandoned due to the delay accumulated, performing below its potential.

#### Qualitative results: overall improvement of Project Management

This section gathers the most important results achieved regarding the qualitative side, due to their impact over the quantitative results. Even if the implementation process was almost the same in both units, the maturity and results reached by them were very different. This fact led to the conclusion that only Unit 2 had properly implemented the method. Indeed, they remained very close to execution and were capable of reacting fast, making decisions aligned with the company's priorities and according to the current situation. The key for this was the coherent combination of visibility, flexibility and alignment at all the levels within the organization, as explained below:

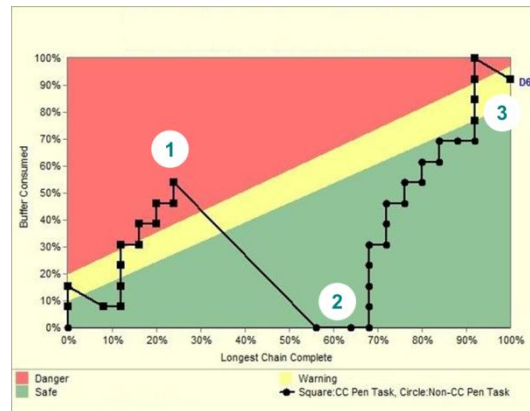
*Visibility:* achieved in the early stages of the implementation, it was progressively improved as the maturity of the company regarding the method was growing. It gave timely and accessible information about the different sides of the project environment, providing the company with the capacity of identifying deviations when they were happening, analyzing problems as soon as possible, and making decisions when necessary. It was the basis for decision making, and this global view was composed of different perspectives depending on the aspect to be observed (e.g. tasks, project progress, portfolio status, etc.). This was supported by the comments of some participants when asked if the method was helpful for the on-time completion of the pilot project, such as "It helps to focus" or "It has forced us to react".

The key here is that, properly used, visibility may be an advantage. But it must be underlined that even if visibility is a necessary condition for improvement, it is not sufficient to achieve

good results: it allows for identifying deviations early, but taking advantage of this also requires decisions and actions. Figure 4 shows an example of this, as happened in a project of Unit 2. This was the main difference between Unit 1 and Unit 2: while Unit 2 used visibility to manage projects and resources from a global perspective, Unit 1 only used visibility to know what the situation of individual projects was. Thus, the quality of the information wasn't good enough, causing the visibility provided by the information system to be inaccurate, leading to late and bad decisions.

*Flexibility and strategy-projects-resources alignment:* visibility was also the base for other improvements. For example, when taking into account visibility and priorities, decisions regarding resources became easier. This information enabled the managers to make decisions aligned with the global priorities, ensuring that resources were always working in the right tasks. In other words, the system was flexible or capable of adapting fast to the real needs given by both, global priorities and current conditions.

**Figure 4: Example of the evolution of one project recovering a delay**



(1) Delays happened as a result of unexpected technical and supply problems. (2) Project on track again after implementing corrective actions (3) Controlled management of the last stage (On time completion).

As projects lasted for months or even years as well as they were ever-changing, fast adaptation to reality was essential. In particular, aspects such as information accuracy and updating frequency determined the potential of the system to identify problems and react fast. For instance, portfolio management required information related to project and resource status, and analysis and decisions related to this were normally made in a monthly basis, but it was also necessary whenever a new project was to be introduced in the system. Instead, single project management had to be closer to execution. Since in this context the duration of tasks could be shorter than one week, task management was better made in a daily basis, requiring also a daily task performance report according to CCPM. As a result, the use of resources and the project flow were improved.

Thus, the management of the planning and execution of tasks, projects and resources, both in the short and the long term became essential to manage the system consistently. The use of this information allowed planning and launching projects properly staggered, consistently with the resources available and aligned with the company's priorities. This approach was also used when new decisions were needed, for example due to changes in dates or priorities, or when new project had to be introduced. And regarding execution, visibility was even more important, especially in the day-to-day level, where problems such as unbalanced resources, delays in programmed task starting dates or variations in deadlines arose, requiring fast responses. To this end, it was vital to have timely (daily) and updated



information about the status of projects and tasks so as to allow the resource managers to keep their resources focused in the right tasks.

*Other results:* The implementation led to partial outcomes that, even if weren't initially set as objectives, were a part of the solution and also welcomed as they were progressively achieved. Similarly, some other improvements were reached, despite the fact that they weren't what the company was initially looking for, as the aim was to manage projects reliably. In fact, while the usual procedure was to launch projects as soon as possible as they were sold, launching projects staggered according to the global priorities and the existing capacity not only led to shorter lead times and better use of resources, but to a considerable reduction of the work in process (WIP).

The implications of this fact, achieved in Unit 2, were diverse. Firstly, the management of the system became easier: there were fewer tasks to pay attention, thereby enabling crystal-clear visibility and simplifying the decision making process. Secondly, the staggering of projects caused also the project expenses to be staggered. As in the new situation projects were launched according to capacity and priorities, the expenses were incurred later, accordingly to the needs and not as soon as possible. Thirdly, the lead time reduction of projects entailed that the incomes came in sooner, as these incomes are often subject to compliance with certain conditions and/or deliveries. Finally, considering both the staggering of expenses and the acceleration of incomes, it is concluded that the cash flow of the unit was also improved.

### ***Performance assessment***

The Performance Assessment stage aimed to evaluate the results achieved by the method from the company's perspective and, therefore, focusing especially in Unit 2. To this end, several interviews were conducted individually. In particular, the outcomes of four of these interviews are showed below because they synthetize the findings. Two of them were structured because the information to get was considered deep and technical - held with the Technical Manager of Unit 2 (TM), responsible for the management of projects, and the Master Scheduler (MS), responsible for the global planning and information system in both units -, and the other 2 interviews were not structured, as it was searched for a more general view - Business Manager of Unit 2 (BM) and a Technical Developer (TD) from Unit 1 -. The key conclusions drawn are the following:

- (TM) The company knows at every moment what the situation is. Therefore, the unit is managed according to the general priorities and results are better.
- (MS) CCPM works and things are clear. The only reason for the different results between Unit 1 and Unit 2 is the involvement, not the method or the context.
- (BM) The method works. The results have been improved. Now it's known how things stand. The key is the personal involvement.
- (TD) The rationale behind the method makes sense and is suitable for the context. The underlying idea probably has been "forgotten".

## **2. Conclusions and future research**

When applying the method to the performing organization, the main issues were two: its applicability and its appropriateness. This research, performed in two similar units of the same company, provides results and conclusions valuable for diverse purposes, as outlined below. It may be helpful as guidance in future implementations. It also gives a different perspective of the method, addressing not only its implementation, but its evolution over

time. Finally, some issues that require for further research in order to increase the knowledge regarding the real-world use of the method are identified.

### **Conclusions**

It is important to note that CCPM is a holistic method that aims to manage the projects and resources involved, consistently with the particular strategy and environment considered. The underlying idea is that when the amount of tasks performing simultaneously is smaller and priorities are clear, it is likely that the finished task and completed project rates will be increased. As in the case of Unit 2, the key for this is to focus on certain aspects stated by the method, such as clear and stable priorities, suitable WIP levels and reduction of multitasking, among others. This enabled a global management of the system, resulting in a better global performance. Thus, the general conclusion derived from the results and findings reached in the three-year period after the implementation of the method can be stated as follows: the implementation of the Critical Chain method in the R+D+i context of the company was suitable, sustainable, and brought it to a competitive advantage if compared to the previous situation. This conclusion is based on the results achieved by Unit 2, which gives a clear and direct response to the concerns of the company in regard to the applicability and appropriateness of the method.

The implementation process and the results achieved in Unit 2 showed that the method not only can be adapted to the particular features of these contexts, but also can be fast implemented. In addition, it was demonstrated that it is sustainable from a usability point of view, as it was reached a balance between the information given by the information system and the work required to maintain it updated. Moreover, on the one hand the information provided by the system was far better than that one formerly available, enabling the organization to react faster and to make more and better decisions. On the other hand, the work required to keep the information system updated wasn't unreasonable. Indeed, Critical Chain advocates for low WIP levels, causing the reporting needs to be also economical.

In fact, if the situation of both units after their implementation projects are compared it is concluded that the proper implementation and use of the method brings a competitive advantage for the company. As for the comparison between the results achieved by both units analyzed if they were competing in the same market, those project management capabilities acquired and developed by Unit 2 would have led it to a better competitive position. But it would also be a major mistake if these outcomes were considered as single improvements. These quantitative results were caused by some underlying factors, the qualitative improvements attained in Unit 2. Likewise, the main factors under this perspective and those reasons because they are so relevant are summarized below.

**Visibility:** it is not an advantage itself, but it is a key contributor for success. It shows the current reality and therefore is the foundation for better decision making regarding the quality and timeliness of the decision – i.e. early decisions based in more accurate and updated information. Hence, it's important to understand that it brings a chance. For instance, if one company achieves visibility but does not act accordingly, it will lose a big part of its potential. Furthermore, this will be especially harmful if visibility is only locally observed, for example, from a single project perspective only, not considering resource status, priorities among projects, etc.

**Flexibility:** the simplicity of the planning and execution management processes given by CCPM is essential for this purpose. It facilitates decisions to be close to the current reality, enabling the connection between the needs and the decisions and/or actions.

**Alignment:** the holistic nature of Critical Chain facilitates the consistent alignment between strategies and actions, projects and resources, and planning and execution at all the organizational layers of the system. All this contexts are provided with the information

needed to individually perform but connected with the rest of the system. This also implies clear priorities, and prevents problems coming from lacks of view, information or coherency between those parts integrating the system, or mitigates their impact. Thus, the positive impact of the individual improvements is enhanced through a global perspective.

Project flow: the increase of the project flow is also a major contributor to the enhancement of the competitive positioning for different reasons: firstly, the time to market for new developments was shortened. Secondly, it was achieved a substantial reduction of the reaction time to address tough situations. Thirdly, the increase of the project flow also entailed an increase of the project completion rate. Finally, the combination of flow increase and project staggering caused the cash flow to be improved, impacting positively over the company's economic side.

In short, all these aspects individually contribute to enhance the competitive position of a company, but the biggest potential comes from the quantitative-qualitative combined contribution. When achieved together and consistently with the strategy and priorities of the company, they certainly can bring it to a better competitive position.

The last conclusion of the research concerns to the key success factors for the implementation of CCPM. The pilot test was performed in Unit 1, achieving tangible results that showed the potential and applicability of the method in that context. Nevertheless, the changes needed inside the unit so that the method was successfully expanded weren't materialized. While Unit 2 was driven aligned with global priorities, Unit 1 lacked visibility and priorities, causing a misalignment between projects, resources and goals. The main reason for that was a lack of engagement and even resistance to change from some people. In particular, the attitude of certain managers that initially agreed to perform in accordance with the method was very harmful for the implementation: not having assumed their responsibilities regarding the method, their staff nor was forced to comply with the requirements of the method. Thus, the method didn't ever properly work in this unit.

So, it is concluded that there are two essential components necessary in an implementation: the adaptation of the method to the context, and the acceptance of the method inside the organization. The adaptation rests on the comprehension of the context and the method, so that a suitable model is created. The acceptance, instead, is related to other factors such as the culture and maturity of the company, their willingness to change and their commitment towards the rigor required by the method. Therefore, it is also concluded that the engagement of all the parties involved is an absolute prerequisite for a successful implementation.

Finally, it must be asserted that there is not any reason to conclude that the particular features of this R+D+I context may recommend not implementing CCPM. In fact, it is not a method designed for a specific industry, and aspects addressed by the method such as lead time reduction, higher productivity or better cash flow are of general interest for companies. Therefore, this approach seems to be particularly interesting for those contexts where multiple projects are performing simultaneously and sharing resources, due to the difficulty of managing them.

### **Future research**

The results achieved by both units and the different behaviors arisen in such similar contexts confirmed that the human side is a key success factor when implementing CCPM. It is clear that the involvement of the senior management is essential, but even this may be not enough. Thus, further research is needed so as to identify those fundamental aspects that can cause such an implementation to fail, even if a success case is being held in another unit of the same company, and find appropriate ways of addressing them.

There is another issue that, even if it wasn't a real problem in the period observed, might become a drawback: the management of resources shared by Unit 1 and Unit 2. Because of the low saturation of these resources, both units were considered to be independent. However, in a different scenario where saturations were higher this could be a major problem: as units were arranged and managed as independent systems, they wouldn't be capable of managing these resources properly, resulting in an internal misalignment of both units and in worse results.

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