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What project management delivers to engineer-to-order? An analysis of a furniture company

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Abstract. Over the past few decades, the industrial sector has witnessed a growth and economic instability in the current market. The need for sustainable efficiency has emphasized the importance of improving the production process to maintain or open domestic and foreign markets. Strategies like cost reduction, increased quality, production efficiency, and waste reduction are some initiatives considered by the industrial sector to overcome the challenge of improving efficiency in industrial activities. This paper aims to analyse the parallel between the require-

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ments of Engineer-To-Order (ETO) production systems and Project Management processes to better understand how project management can support the production process in industrial sector companies. The established parallel is demonstrated by dividing it into the groups of project management processes in conjunction with literature related to ETO. Starting with a trace of the current state of a case study in a furniture company, BPMN was used as a tool to present the company's restructuring processes based on the theoretical parallelism's conclusions. The preliminary results indicate that the proposed processes enable companies to visualize their orders as a project, which can help them become more structured, productive, and efficient, thereby contributing to improving competitiveness.

Keywords: Engineer-to-order; Project management; Furniture.

1. Introduction

Due to the global economic context, new social challenges and technological innovations, competitive markets have become increasingly dynamic, complex and uncertain. In this scenario, companies of all sizes must analyse and reduce costs and waste in all production processes [1]. The case of the furniture industry is no different, especially for small and medium-sized enterprises (SMEs) in this sector. They need to make increasingly faster deliveries to their customers of lower-cost products [2].

The furniture industry in Portugal is well-known for its significant contribution to the country's economy with a long history of manufacturing and exporting high-quality furniture products. Portugal has a strong tradition of craftsmanship and design, which has helped to establish the country as a major player in the global furniture market. According to the report from the National Institute of Statistics [3], almost all the companies in the sector are SMEs being responsible for almost 85% of the jobs in this sector, highlighting their representativeness and importance for the national economy.

Due to the low degree of specialization of the companies in the sector, they generally produce a varied range of products [4]. In this sector, the low level of qualification means that knowledge is mainly acquired through experience and contact with more experienced workers, which can slow down the pace of change. However, they hold a high level of empirical and technical knowledge when working with materials such as wood.

Concerning Portugal companies operating in the furniture sector, they are used to working with custom orders characterizing an Engineer-To-Order (ETO) production system. However, the management of these companies is centralized and without internal production management processes, resulting in wasted time, raw materials,

and non-compliance with customer requirements. Besides these challenges, barriers such as competition for quality, cost, fast delivery, and flexibility in project design are the main barriers faced by furniture companies.

This paper aims to bring project management processes into this context, interconnecting them with ETO-related knowledge. The lack of structure of SMEs operating in the furniture manufacturing sector, combined with such a specific reality, gives this work a potential for practical exploration. Furthermore, the literature that combines academic knowledge to help these small and micro businesses in the sector is still scarce. Thus, this work aims to fill this gap by analysing the parallel between the requirements of ETO production systems and project management processes and creating guidelines for practical and easy management for these companies.

The remaining of the paper is organized as follows. First, a theoretical background of the fundamental themes for the understanding of the proposal presented is introduced in Section 2. It is discussed the differentiation of the ETO in relation to other productive systems, going on to explore its specific characteristics and the project management main areas of knowledge. Section 3 describes the qualitative research approach followed. The main findings related to the interconnection between ETO and project management are presented in Section 4, along with an illustration of its practical benefits in the case-study context. In section 5 a summary of the main conclusions is discussed.

2. Theoretical background

In the manufacturing industry, there are several strategies to achieve the same objective, which would be to create the desired output. For instance, the most traditional strategies in production management are Make-to-Stock (MTS) and Make-to-Order (MTO). To establish a characterization of the production processes, the perspective of the point of insertion of the order in the production process that will be used is the “Order Penetration Point” (OPP) [5].

According to [6] and [7], in MTS, production is managed through a demand forecast, and all incoming orders go directly from stock to be delivered to the customer. For the case of MTO, on the other hand, all orders placed go directly to the production plan, and there is no finished goods warehouse [6]. In Assemble-to-Order (ATO), production starts by manufacturing key components triggered by a demand forecast, and the final assembly is performed only upon order placement.

According to [8], the ETO production model is characterized by high levels of customization for each product and is usually managed in a project environment with the decoupling point at the design stage. In an ETO production, the entire process is order driven. This means that each new order starts its process in the design phase and fol-

lows the remaining phases until final delivery. With these characteristics of operation in phases and the uniqueness of each product in each order, it is easy to establish a close relationship between the ETO system and Project Management.

To highlight an ETO system has the highest customization capacity, as well as the lowest responsiveness in relation to the other strategies. Moreover, it can be characterized by the manufacture of highly customized products that must be designed and manufactured in detail according to customer specifications [9]. Nevertheless, according to [10], despite the improved responsiveness to varied product orders and the flexibility of processes to meet market needs, companies that have adopted ETO as a production strategy generally become highly complex to manage.

ETO productive systems typically involve a more complex supply chain as each order is unique and requires a customized production plan. In this research, based on the current literature, a set of relevant steps that are suggested for its implementation, for instance, Customer Requirements Analysis, Design and Engineering, Procurement, Production Planning, Manufacturing, Quality Assurance and Shipping and Delivery are the most steps proposed by the current literature.

According to [11], the base of project management involves different stages when developing a project. For instance, the planning, execution, and control of projects that involve the design, production and delivery of output (product or service) are the main aspects to be considered in the development of new projects. Additionally, aspects such as identifying project goals, developing project plans, resource allocation, scheduling, risk management and quality control should be also considered the core of project management.

To enable project management, all processes, inputs, tools, techniques, outputs and life cycle phases related to the project must be identified. However, these should always be adapted to the project specifications, sometimes leading to the need to use specific methodologies. The presence of repetitive elements in project activities and deliverables does not change the fundamental characteristics of the project work [11]. Since each project is unique, not all recommendations presented in will be consistent for all projects. In other words, it is necessary to adapt the recommendations to specific realities.

One of the key challenges in project management is balancing cost, time and quality. The production of furniture involves a complex set of processes and any delays or errors in the process can significantly impact the project timeline and budget. Therefore, effective project management practices are critical to ensure that projects are completed on time, within budget and with the required quality standards.

To establish the relation of project management, this research proposes to use the phases of the project defined by the Project Management Institute (PMI) namely (1) Initiation, (2) Planning, (3) Execution, (4) Monitoring and control and (5) completion.

3. Research method

In this research a case study was used as a research strategy, aiming to analyse relevant information and experiences through a qualitative research approach. The qualitative methodological approach allows researchers to gain a rich and deep understanding of the content and concepts studied, gathering relevant information in a flexible manner [12].

The research was developed in two stages. The first stage consisted of a literature review focusing on the link between the ETO production system and project management. In the second stage, a participant observation of a company from the furniture sector in Portugal was performed. The observation was performed through the prism of the literature and concepts perceived in the initial stage. At this stage, all the processes of the company were identified and analysed, from the moment an order request arrive until it is completed.

In order to identify and represent in a structured way the processes carried out by the company observed and their potential for improvement, it was used the Business Process Modelling Notation (BPMN). This Standardized notation provided a clear and concise representation of the workflow required to complete the project, showing the required activities, the inputs and outputs of each step and the order in which the activities should be performed. The application of BPMN in projects does not mischaracterize the project but allows structuring its development.

4. Main findings

This section presents the main results of this research focusing on the results from the literature related to project management and ETO, additionally, a proposal of a visual analysis of all the relations perceived between the two structures. Then the case of a furniture company operating in Portugal is used to illustrate the application of the links perceived as a proposal to link ETO and project management.

By analysing the project management phases and the steps involved in an ETO productive system in Table 1, it is possible to identify and better understand the similarities and connections between both. From this analysis, Table 1 synthesizes and explain, in a visual way, the perceived connections.

Table 1 – ETO vs Project Management

		Project Management phases												
		Initiation									Planning	Execution	Monitoring And Control	
	Scope	Requirements	Schedule	Cost	Quality	Resources	Communication	Risk	Procurement	Stakeholders			Termination	
ETO steps	Customer Requirements	X	X						X		X	X	X	
	Design And Engineering	X									X			
	Production Planning			X			X	X		X	X	X		
	Quality Assurance	X	X			X			X				X	
	Procurement				X		X			X	X			
	Manufacturing								X			X	X	
	Shipping And Delivery								X				X	X

To assure a clear definition of the customer request, the scope is important for a successful implementation. Project management can support the scope definition by identifying the customer requirements and the project’s technical specifications, which enables the project team to develop a detailed and effective execution plan. From the research conducted, the results indicated that the main challenge that ETO projects face is related to the lack of planning and monitoring of the design and engineering step, having, on the other hand, the production normally planned in detail [13]. In these processes before the opening of the project (or, in this specific case, in the processes before the validation of the detailed design by the client) that the biggest inconsistencies are found since once the project is defined and execution has started, it moves forward more smoothly. This occurs because the stakeholders do not value enough the processes linked to design.

In ETO environments, the estimation of the macro activities duration is usually developed in a subjective way by the project manager, or in the case of manufacturing, by the production manager. However, since ETO is a complex customized process, this activity can take longer than conventional manufacturing processes. Project management helps set a realistic schedule and effectively manage time to ensure the project is completed on time and within quality. The estimation will define the schedule and is mostly based on the experience of other similar projects, considering any exceptions and particularities of the new project [14]. Companies operating in an ETO context

receiving multiple orders, often need to work them in parallel. Therefore, it is essential that the sequencing of activities and their durations are defined in the planning stage, along with the combination of resources between the simultaneous projects so that the resources' capacities are not exceeded, which could generate delivery delays. Regarding the contribution of project management for ETO, if the basis and steps are considered, it can deliver positive benefits for both companies and managers. In this research, a set of these benefits are proposed as follows: (1) Cost management: Project management helps to control project costs and ensure that the project is delivered within the defined budget. This is especially important in ETO where costs can be higher due to the customized nature of the manufacturing process; (2) Effective communication management: Project management helps to ensure that communication between the project team, the client and other stakeholders is effective and transparent. This helps avoiding misunderstandings and ensure that all parties are aligned with the project objectives; (3) Risk management: Project management helps to identify and manage the risks associated with the custom manufacturing process. This allows the project team to develop strategies to mitigate these risks and ensure project on time delivery and within budget.

In summary, project management is critical to the successful implementation of ETO. It helps to ensure that the custom manufacturing process is managed effectively, efficiently and within defined parameters.

4.1. An illustration of the benefits of using project management as basis to ETO Activities: the case of a furniture company

A Portuguese company operating in the furniture sector was used as a case study to verify the opportunities of using project management as a basis to structure ETO activities. The company is in a region well known to produce furniture and can be characterized, as most companies operating in the region, as a micro-small company with a small group of workers. The need to structure both the production and the management itself has become crucial strategy for the company. The products manufactured in the company are essentially corporate furniture, all custom made with a high level of complexity.

The company's activity can be divided into four macro-activities: budgeting; order planning; production and logistics. Each macro-activity was analysed and represented in a workflow through BPMN. Please note that the BPMN allows to identify the responsible for each task performed, evidencing the communication between different entities.

From the knowledge acquired in the ETO and project management relationships, improvements to the activities are proposed. One of the macro-activities that lead

to the highest improvements in the company's process structure was order planning. The improvement proposal is illustrated in the Figure 1 whereas the existing steps are represented in yellow, and the new processes are highlighted in green.

The order planning is the most complex macro-activity of the whole network, and it is triggered by the receipt of a customer order. The main problems perceived in this macro-activity are the lack of planning and anticipation in several aspects, as well as the lack of formalization and alignment of requirements and expectations with the customer. This lack of planning almost always generates delays, and in the case of production errors, increased production costs due to the multiple required reworks.

Due to the importance of planning for the success of the project, some of the activities performed only in the production activity were transferred to this stage. The more robust the planning is, the lower the risks in the production stage will be. Yet, to ensure the alignment of all stakeholders, a meeting is held as soon as the order is received. This task did not exist and is proposed to decrease errors due to miscommunication between stakeholders. Then, a new cost control step is implemented, where a comparison is made between what was previously budgeted and what was ordered by the customer and its requirements. The outcome of the meeting and the comparison between the order and budget is formally sent to the client so that he may approve it and the order may proceed. This formalization will work as the "Project Opening Term".

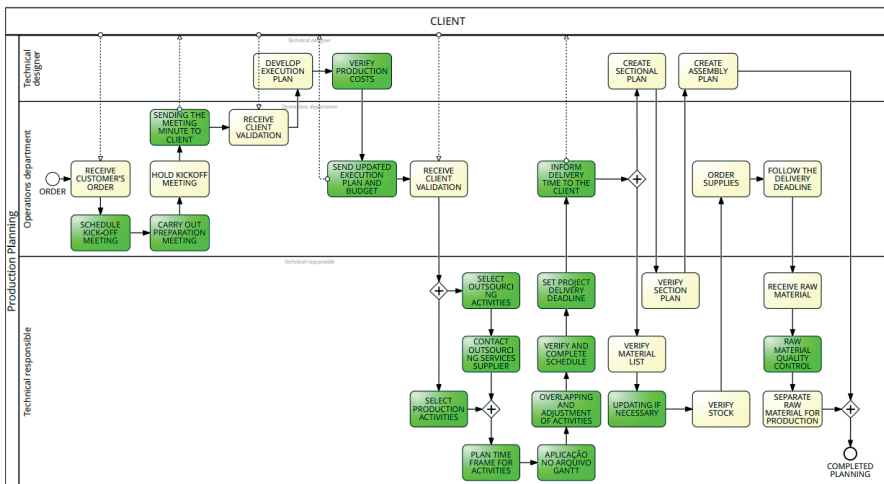


Figure 1 - BPMN Diagram - Production Planning

Previously, the execution duration of the tasks was empirically defined, without a clear definition of the sequence of tasks or resource allocation. To address this, a list of all tasks necessary to produce the order should be created as a Work Breakdown

Structure (WBS), which has the task durations and required resources allocated. This WBS structure will be placed in the global production planning to be combined with other projects that may be produced at the same time. This way, deadlines are more secure and resource over-allocation is avoided.

Drawing the above analysis, the case of a furniture company showed the benefits of the relationship between project management and ETO. The results put in evidence the contribution to the success of the projects developed in the ETO context in terms of efficiency, profitability, as well as responsibility, and trust toward customers.

5. Conclusions

In this research, a case study of a furniture company was used to illustrate the lack of structure of SMEs operating in the furniture manufacturing sector, combined with such a specific reality. This paper aims to bring project management processes into this context, interconnecting them with ETO-related knowledge.

The researched literature gave new perspectives to utilize the link between project management and ETO. From the comparisons and connections made it was possible to propose improvements to the processes of the company studied that could be used by other companies in the same context. Despite being a simple approach, this research calls attention to using project management as a key driver to be considered by companies in implementing ETO. When linking these two approaches, it can support companies to turn their operations more efficiently and competitive in comparison to their competitors.

The work developed in this research aimed to present a new perspective for linking project management and ETO, however, much remains to be done, and this work should be seen as the first step toward disseminating the discussions regarding the positive benefits of using project management as key aspects of developing activities in different contexts. Yet, there are several avenues for future work. Namely, a follow-up to the presented research could focus on the analysis of the performance of the case study company after the implementation of the proposed process improvements to identify the real gains promoted. The knowledge generated from the understanding of the concepts provided may also serve to motivate students and researchers to develop a new study on the theme.

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