Cross-Functional Coordination Before and After the CODP: An Empirical Study in the Machinery Industry

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Abstract. Cross-functional coordination among engineering, sales and production departments is known to be beneficial for improving order fulfillment processes. In Engineer-to-Order (ETO) companies, sales, design and production activities are strongly interrelated and sometimes they overlap, thus requiring cross-functional coordination. In these companies, design and production activities can be both partially performed before the customer order arrival. ETO companies pursue different objectives and implement different managerial approaches before and after the customer order decoupling point (CODP). However, despite its relevance for company performance, how ETO companies manage cross-functional coordination and how departments are coordinated before and after the CODP is still understudied. This paper sheds light on this topic by investigating 12 case studies in the Italian machinery industry. Results suggest that the coordination mechanisms used before and after CODP are different, and vary depending on the CODP configuration chosen.

Keywords: ETO, cross-functional coordination, machinery industry, CODP.

1 Introduction

The Customer Order Decoupling Point (CODP) is defined as the point in the value chain where a product becomes linked to a specific customer order [1]: before the CODP, activities are forecast-driven, while, after the CODP, activities are planned and controlled based on actual customer orders. CODP positioning is a strategic choice for the company [2], and it has implications on the ability of the company either to provide customers with a high degree of choice (i.e. flexibility) or to maintain high internal efficiency [3].

In Engineer-to-Order (ETO) companies, engineering and production activities have been traditionally considered by the literature as performed after the customer order arrival [4]. However, recently, ETO companies are simultaneously facing the challenges of maintaining high flexibility while reducing costs and lead-times [5]. To face this challenge, changes to company's and supply chain processes are advisable [6]. To addres these challenges, ETO companies started to perform some engineering and production activities to forecast, moving their CODP closer to the customer [7, 8]. This change poses new challenges for ETO companies: among the others, how to guarantee the coordination among engineering, production and sales [9–11]. In particular, Cannas et al. [12], highlighted that, in ETO companies, before and after the CODP the objectives and the managerial practices to be applied to pursue these objectives change, with a consequent need for different coordination mechanisms.

However, to the best of our knowledge, there is little research on how ETO companies are coordinating engineering, production and sales activities before and after the CODP. Thus, the purpose of this research is to explore cross-functional coordination mechanisms between engineering, sales and production functions adopted in ETO companies. In doing so, we aim to answer the following research question (RQ):

RQ: How do ETO companies manage engineering, production and sales processes, before and after the CODP?

The study answers to the RQ by empirically observing and analyzing a specific ETO sector, i.e., the machinery industry, by means of multiple case studies.

2 Background

Coordinating engineering, production and sales processes requires to manage three sets of coordination mechanisms related to, respectively, engineering and production, engineering and sales, and sales and production. As far as engineering and production is concerned, Adler [13] distinguishes among “Standard”, “Schedule and Plan”, “Mutual adjustment” or “Team”. The same interface has been studied when engineering and production activities are performed by different companies Twigg [14]. As far as engineering and sales coordination is concerned, Griffin and Hauser [15] proposed six general approached to integrate the efforts of engineering and sales: relocation and physical facilities design, personnel movement (multi-functional training), informal social systems, matrix organizations and project teams, incentives and rewards, and formal integrative management processes such as phase review process, stage-gate process, product and cycle time excellence (PACE) and quality function deployment (QFD). Finally, Lamberti and Pero [16] discusses marketing, supply chain and product development interfaces in an electromechanical company. Whereas, Tang [17] presented a framework for the sales-production interface models in which he proposed: integrated decision models (mathematical models), balanced scorecards to avoid sub-optimization, cross-functional teams for developing coordinated plans, iterative negotiation and joint planning to move towards a more collaborative relationship among marketing and operations. Some of the mechanisms proposed for these two interfaces, engineering-sales and production-sales, are in common with the one proposed for engineering-production by [13].

In the ETO cross-functional coordination literature, Mello et al. [9] promoted the application of the coordination mechanisms developed by [13] in ETO companies. Mello et al. [10] included the integration of engineering and production activities in the list of principles to improve coordination in ETO supply chains; more precisely, they proposed the following mechanisms to integrate engineering and production: “Co-located teams”, “Integrated IT systems”, “Establishment of common goals”, “Direct communication among the two functions”, “Similar organizational culture”.

Cannas et al. [12] demonstrated that in ETO companies the coordination needs of engineering and production processes change upstream and downstream of the CODP. Upstream of the CODP engineering and production coordination reduces unexpected design updates, reworks and late defects as much as possible, as they cause delays and additional costs. While, downstream of the CODP, engineering and production coordination reduces the risk of exceeding the stock holding costs due to obsolescence, excessive space occupation, etc. or facing stock-outs. Despite this contribution, little studies addressed how ETO companies can manage cross-functional coordination and how engineering, sales and production departments are coordinated before and after the CODP. For this reason, this study empirically analyzes ETO companies operating in the machinery industry, aiming to extend and refine the existing frameworks in the literature and adapt them to the complex ETO context.

3 Methodology

This research was conducted using multiple case studies, taking as the unit of analysis the company’s core product families (the ones that have the major impact on the company’s turnover). This research counts twelve case studies in nine companies operating in the Italian machinery industry. To ensure replication and variations within the sample, the criterion for selecting companies to be included in the sample was including companies operating in different sectors (e.g. machine tools, plastic and rubber, automotive and food) and producing different products (e.g. cutting machines, automated assembly lines, packaging lines and machine tools). In the data collection phase, the main sources of information were: semi-structured face-to-face interviews, official documents and internal documents. Semi-structured interviews (that lasted about 2 hours each), collected information on the core product family of the company interviewed, focusing on how the company coordinates engineering, production and sales activities, before and after CODP. The informants have been chosen on the basis of their involvement in the key processes subject of the analysis (e.g. Operations Manager, Engineering Manager, Sales Manager, Plant Manager, etc.). Each interview was recorded with the informants’ consensus and then transcribed to deeply analyze all the information collected.

4 Findings

The results shown that there is a difference in the coordination mechanisms employed by the companies based on the CODP positioning. In particular, in the sectors analysed, this difference depends on the number of engineering and production activities, performed before and after the order. Accordingly, the units of analysis have been mapped into the two-dimensional (2D) CODP framework proposed by Cannas et al.

[11], which is the most recent taxonomy for classifying CODP positioning strategies in ETO companies (for details on this framework, please refer to this reference). What emerges from these results is that almost all the product families of the interviewed companies fall into the four main decoupling configurations identified by [11], namely: Special Machines (C, H), Customized Machines (E, G), Standard-customized machines (A, D, F) and Modular machines (B, I). Table 1 summarizes the coordination mechanisms adopted by tbe companies in the sample before and after the CODP depending on the configuration.

Table 1. Summary of coordination mechanisms used before and after the CODP

<table>
<tr><th></th><th>Configuration</th><th>Before-CODP</th><th>After-CODP</th></tr>
<tr><td rowspan="4">Engineering-Production</td><td>Special Machines</td><td rowspan="4">Standards</td><td>Teams and Mutual adjustment</td></tr>
<tr><td>Customized Machines</td><td rowspan="11">Mutual adjustment</td></tr>
<tr><td>Standard-customized machines</td></tr>
<tr><td>Modular machines</td></tr>
<tr><td rowspan="4">Engineering – Sales</td><td>Special Machines</td><td>Teams and Mutual adjustment</td></tr>
<tr><td>Customized Machines</td><td>Teams</td></tr>
<tr><td>Standard-customized machines</td><td rowspan="2">Standards</td></tr>
<tr><td>Modular machines</td></tr>
<tr><td rowspan="4">Sales – Produc-tion</td><td>Special Machines</td><td rowspan="4">No coordination</td></tr>
<tr><td>Customized Machines</td></tr>
<tr><td>Standard-customized machines</td></tr>
<tr><td>Modular machines</td></tr>
</table>

4.1 Engineering-Production coordination

The outcomes of the case study analysis show that, in all the cases, the mechanisms adopted to coordinate engineering and production activities, before and after the order arrival, are different. *Before the CODP*, when all the production-related activities are performed internally (cases A, C, E, D), companies adopt coordination mechanisms belonging to the standard coordination mode category, such as: (i) compatible CAD/CAM software through which companies exchange information; (ii) stage-gate process, i.e., a determined set of tasks is performed by a function and reviewed by another function which decide to go/ not to go on; and (iii), visual work instructions software, which is a coordination mechanism not considered in the previous literature, representing a software tool providing work instructions to employees of the assembly department. *After the CODP*, companies providing customers with special machines (C, H) chose mechanisms falling into Team and Mutual adjustment (both meetings and coordination roles). Whereas, companies providing customers with customized machines (E, G), adopt only mutual adjustment mechanisms (both meetings and coordination roles). Finally, companies that provide customers with standard-customized machines (A, D, F) and modular machines (B, I), chose mutual adjustment mechanisms falling only into meetings. Among team mechanisms there are the transition teams, i.e., design engineers are temporarily transferred into the production department to be available in case design reviews are required. Among mutual adjustment mechanisms, the mostly applied are: (i) meetings, such as kick-off, i.e., a first meeting after the order is received in which interest parties gather to analyze order details and plan future activities, and weekly project review to monitor the state of progress of a current order; (ii) coordinating roles such as the line managers, which are responsible for inter-functional communication, and the project engineers, which are technical project managers in charge of coordinating the effort of engineering and production resources of a specific project.

4.2 Engineering-Sales coordination

For what concerns coordination among engineering and sales, coordination mechanisms adopted before and after the order are different and this is true for all the CODP configurations. *Before the CODP*, companies providing customers with special machines (C, H) favor coordination mechanisms based on team, i.e., cross functional teams, and mutual adjustment, i.e., the coordinating role of sales engineers, people with a strong technical background belonging to the sales department supporting sales managers during the negotiation phase, acting as a reference point of the engineering department. This underlines a high coordination effort needed. While, *after the CODP* these companies mainly rely on one-time meetings (i.e. Kick-off), thus indicating a lower coordination effort needed among engineering and sales once the order has been acquired. For companies that anticipate some activities before the order, the coordination effort seems more balanced before and after CODP, but for sure is high *before the CODP*, since they adopt coordination mechanisms based on team, i.e. cross-functional teams and coordinating groups (E and G). *After the CODP*, they rely on meetings because they do not include people with strong technical competences (e.g. sales engineers) into the sales department. Finally, companies that provide customers with standard-customized machines (A, D, F) and modular machines (B, I), *before the CODP*, rely on the use of standard coordination mechanisms such as: (i) design rules, which can be used by product engineers in the design phase to assure the producibility of their designs; (ii) design configurator, i.e., software used by sales managers allowing the automation of the tendering and design phase leveraging on CAD and PLM platforms to generate ready-made bill of materials and product descriptions; and (iii), standard procedures, i.e., commercial offers created using pre-defined standard forms. While, *after the CODP*, they mainly adopt meetings (i.e. kick off and project review meetings). Interestingly, since face-to-face coordination underlines a higher coordination effort, with respect to standard coordination modes, the coordination effort in this case seems to be higher once the order is received.

4.3 Sales – Production coordination

The mechanisms used to coordinate the effort of sales department and internal production vary upstream and downstream of the CODP. Company A, which is totally vertical integrated, employ cross-functional teams *before the CODP* and mutual adjustment, through line managers, *after the CODP*. While, it has emerged that, for all the other cases, which outsource part or most of the production, *before the CODP* there is no coordination among sales and production related activities performed internally. *After the CODP*, the great majority of these cases, adopt meetings (kick-off or project review). Therefore, it is reasonable to assume that the choice of coordination mechanisms, in this case does not depend on the CODP configuration the company adopts. Finally, concerning coordination among sales department and external suppliers, the companies analyzed do not adopt any coordination mechanisms, since the department in charge of managing the interface with external suppliers is the Purchasing department for all the cases.

5 Discussion and conclusions

This paper investigates through a case study research whether and how cross-functional coordination mechanisms vary before and after the CODP. Results show that, *before the order (pre CODP)*, the companies interviewed recognize a high coordination effort needed for engineering-sales interfaces. Thus, they rely on mechanisms belonging to team and mutual adjustment, when customization levels are high; while, moving towards more standard product configurations, cross-functional coordination is achieved through standardization of procedures, sales' experience from previous project, the use of IT tools, which of course correspond to a lower coordination effort to be sustained. Differently, *after the order (post CODP)*, our findings revealed that coordination regards mainly engineering and production activities (both internally and externally performed) and the choice of coordination mechanisms is influenced by the type of products. In particular, also in this case, the higher the customization level of the product, the higher the intensity of coordination. When products are highly customized, after the CODP it is necessary to employ different modes of mutual adjustment (e.g. project engineers, kick-off meetings) and teams. Finally, findings concerning sales-production interface show that coordination happens after the order and only with the internal production. Moreover, for this interface, the mechanisms adopted are the same for each type of product.

The novelty of this study consists of (i) introducing a new temporal dimension when studying cross-functional coordination mechanisms (i.e. pre and post CODP), (ii) studying cross-functional coordination in the machinery industry, and (iii) considering in the same research more interfaces (i.e. engineering-sales, engineering-production and sales-production). The results underline the importance for studies focusing on ETO cross-functional coordination of considering all the possible interfaces, including also the sales department and differentiating between the activities performed before and after the customer order. This can be considered an interesting research direction for future studies. Surely, this study presents also limitations. Although the research was designed considering all the relevant aspects for ensuring the reliability of the results, the focus on one specific industry, as well as the size of the sample, could limit the generalizability of the results. Thus, further research addressing different ETO sectors and/or adopting methodologies that study larger samples, such as survey-based research, are recommended to extend and validate the results of this research.

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